Inventory Methods for Forest and Grassland Songbirds

Standards for Components of British Columbia's Biodiversity No.15

Prepared by
Ministry of Environment, Lands and Parks
Resources Inventory Branch
for the Terrestrial Ecosystems Task Force
Resources Inventory Committee

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Preface

This manual is a newer version of a manual presenting standard methods for inventory of Forest and Grassland Songbirds in British Columbia at three levels of inventory intensity: presence/not detected, relative abundance, and absolute abundance. The current version includes improvements based on comments from field staff and a review by a biometrician. The manual was compiled by the Elements Working Group of the Terrestrial Ecosystems Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methods that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species component of biodiversity.

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for groups of species with similar inventory requirements. The series includes an introductory manual (*Species Inventory Fundamentals No. 1*) which describes the history and objectives of RIC, and outlines the general process of conducting a species inventory according to RIC standards, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis. The *Species Inventory Fundamentals* manual provides important background information and should be thoroughly reviewed before commencing with a RIC wildlife inventory. RIC standards are also available for vertebrate taxonomy (No. 2), animal capture and handling (No. 3), and radio-telemetry (No. 5). Field personnel should be thoroughly familiar with these standards before engaging in field inventories which involve any of these activities.

Standard data forms are required for all RIC species inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in *Species Inventory Fundamentals No.1 [Forms]*. This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem (SPI). For more information about SPI and data forms, visit the Species Inventory Homepage at: http://www.env.gov.bc.ca/wld/spi/

It is recognized that development of standard methods is necessarily an ongoing process. The CBCB manuals are expected to evolve and improve very quickly over their initial years of use. Field testing is a vital component of this process and feedback is essential. Comments and suggestions can be forwarded to the Elements Working Group by contacting:

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report “The Future of our Forests”.

For further information about the Resources Inventory Committee and its various Task Forces, please access the Resources Inventory Committee Website at: http://www.for.gov.bc.ca/ric

Terrestrial Ecosystems Task Force

All decisions regarding protocols and standards are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this version are based on the unpublished draft government report, *A Methodology for Surveying Forest and Grassland Songbirds in British Columbia*, prepared for the Resources Inventory Committee by T. Ethier, J. Cooper, and T. Manning, with assistance from J. Schieck, D. Farr, R. Millikin, I. Hatter, T. Chatwin, S. Cannings, M.Chutter and A. Harcombe and editing by Tom Ethier and Erica McClaren. Helpful comments on version 1.1 were submitted by Mark Phinney and Mark Robson. John Boulanger provided a statistical review.

This manual and its associated dataforms were edited to their final forms by James Quayle and Leah Westereng.

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1. INTRODUCTION

There are three basic methods for estimating songbird numbers: encounter transects, point counts and spot mapping. Spot mapping is the most labour intensive and is only appropriate for relatively small areas when absolute abundance data are required. Depending on habitat type, spot mapping should usually not be used on areas larger than 20-60 ha. Encounter transects and point counts can cover much greater areas with far less effort. Encounter transects should theoretically sample the greatest number of birds, but point counts are more conducive to standardization. This is because variation in the speed travelled between any two transects, or even within transects, can contribute an undetectable bias; whereas with point counts, the effort spent actually counting birds can be precisely controlled by standardizing the duration of the counts. In addition, point counts are a more efficient method for obtaining large sample sizes than either encounter transects or spot mapping. For these reasons, point counts are recommended for estimating relative bird abundance, both for long term trends and for comparing abundances between habitats. Encounter transects can be useful for presence/not detected (possible) surveys, especially when combined with point counts. Spot mapping is recommended for determining absolute abundance within small areas. Distance methods should be considered as an alternative to spot mapping for absolute abundance estimates.

2. INVENTORY GROUP

Songbirds belong to the Order Passeriformes and are also known as the perching birds or passerines (Gill 1990). They have unique adaptations such as distinctive feet (three toes pointed forward, one toe pointed backward), oil glands, and a reduced number of neck vertebrae. The group consists of five broad ecological forms: thrushes, flycatchers, creepers, warblers, and sparrows. For the purposes of this manual, they are classified as an inventory group as they can be surveyed using similar inventory methods. In British Columbia, passerines make up 40% of the avifauna ranging in size from the Raven to the Ruby-crowned Kinglet. Passerines can be found during the breeding season in almost all terrestrial habitats.

Table 1. Major taxonomic families of songbirds in British Columbia that can be inventoried with survey techniques recommended in this manual.

Family	Common Name
Tyrannidae	Tyrant Flycatchers
Vireonidae	Vireos
Corvidae	Jays, Magpies and Crows
Alaudidae	Larks
Paridae	Titmice
Aegithalidae	Bushtits
Sittidae	Nuthatches
Certhidae	Creepers
Troglodytidae	Wrens
Regulidae	Kinglets
Muscicapidae	Bluebirds, Thrushes and Allies
Mimidae	Mockingbirds, Thrashers and Allies
Sturnidae	Starlings and Allies
Motacillidae	Wagtails and Pipits
Bombycillidae	Waxwings
Parulida	Wood Warblers
Thraupidae	Tanagers
Emerizidae	Buntings and New World Sparrows
Cardinalidae	Grosbeaks and Allies
Icteridae	Blackbirds
Fringillidae	Finches
Passeridae	Old World Sparrows

Although songbirds are the subject of this manual, non-passerine species of birds will likely be encountered when using methods recommended here for songbirds. Observers recording songbird observations are encouraged to record all of the birds, passerine or otherwise, which they see or hear. Because not all of the province’s bird species are the subject of inventory manuals like this one, records from songbird point counts may provide the only evidence of the presence of certain bird species (e.g., hummingbirds).

3. PROTOCOLS

3.1 Sampling Standards

The following are guidelines for conducting standardized songbird inventories in the province. Close adherence to these guidelines will permit the collection of reliable data that should satisfy individual and corporate inventory needs, as well as contribute to biodiversity monitoring at local, regional, and provincial scales.

3.1.1 Personnel

Probably the most essential component for the collection of accurate data is a competent observer. This cannot be overemphasized. Proficient bird observers obtain species estimates within 90% and abundance estimates within 80% accuracy (Ralph *et al*. 1993). Various studies have shown that observer bias is one of the most noteworthy bias factors in trend analysis of songbird populations. In fact, one study suggests that a potential reason for the apparent recent increase in some songbird populations (as determined by breeding bird surveys) is the apparent increase in skill of bird watchers (Sauer *et al.* 1994). In another study, it was found that a significant change in trend resulted if individual observers first year of observation in a breeding bird survey was removed (Kendall *et al.* 1996).

As well as being able to visually identify birds, field workers must be proficient at identifying species by their songs and calls. Therefore, recordings of birds in the study area, especially for the less common or unexpected species should be provided for surveyors. Inventory personnel should be tested frequently on their ability to identify bird calls. The quality of the observer will determine the quality of the data.

Time should also be invested in training personnel to estimate the distance from themselves to singing birds within different habitats. This will require training in the field. For inventories which use the variable radius point count method it is recommended that there be a two week training period for novices in distance estimation. This is done by estimating the horizontal distance of a singing bird, and then either pacing the distance or using a rangefinder to derive the actual distance. Note that there is great variability between species in the range travelled by the bird’s song. For example a Winter Wren will be heard more loudly and probably over a greater distance than a Brown Creeper.

Good hearing ability is essential because many birds, particularly in forested habitats, are detected by sound only. Differences in hearing ability between observers may strongly affect survey results (Scott and Ramsey 1981). It is important to rotate observers equally between stations so that observer error is equally distributed.

To maintain a high skill level, the project leader should assess all potential workers, and provide guidance where needed. Field training sessions should be held prior to data collection to increase observer expertise and to evaluate and correct for differences between observers (*e.g.*, Kepler and Scott 1981). The performance of observers should be recorded for possible use as a weighing factor or criteria for stratification in the analysis of data. These tests should be done prior to surveys. Data sets can be tested for observer effects through stratification by observers (ANOVA) (Buckland *et al.* 1993) or addition of covariates or weighing factors for trend models (Sauer *et al*. 1994, Thomas 1996, Link and

Sauer 1997). However, this is not necessarily a good strategy for a reduction in the power of tests and precision of estimates may result with the addition of covariates (to trend analysis) or strata (to ANOVA) designs. Power analysis can be used to explore this problem (see manual No.1, *Species Inventory Fundamentals*, Appendix G). The best strategy is to train observers adequately to minimize potential bias rather than rely on complex statistical analysis.

3.1.2 Weather

Poor weather such as high winds, rain, and fog can inhibit both bird behaviour and observer ability. Refer to Table 2 for weather standards.

Table 2. Acceptable and unacceptable weather conditions for songbird surveys.

	Acceptable	**Unacceptable**
Wind	Beaufort 0 (< 2 km/hr). Calm. Beaufort 1 (2-5 km/hr). Light air. Beaufort 2 (6-12 km/hr). Light breeze, leaves rustle.	Beaufort 3 (12-19 km/hr). Gentle breeze, leaves and twigs constantly move. Beaufort 4 (20-29 km/hr). Moderate breeze, small branches move, dust rises. Beaufort 5 (30-39 km/hr). Fresh breeze, small trees sway. Beaufort > 5
Precipitation	None Fog Misty drizzle Drizzle	Light rain Hard rain Snow
Temperature	> 7 ^{0}C (breeding) > 3 ^{0}C (breeding in central & northern interior of BC) > 0 ^{0}C (winter coast) > -10 ^{0}C (winter interior)	< 7 ^{0}C (breeding) < 3 ^{0}C (breeding in central & northern interior of BC) < 0 ^{0}C (winter coast) < -10 ^{0}C (winter interior)

3.1.3 Time of Year

Breeding Season

- The majority of bird surveys are conducted during the breeding season, when most species of songbirds are on territory and singing (Ralph and Scott 1981; Verner 1985; Bibby *et al*. 1992). Ralph *et al.* (1993) recommend field work for population surveys in temperate North America be conducted from May 1 to June 19. For British Columbia, especially at the northern latitudes (and higher elevations), this period can be extended into the first week of July (*i.e.*, May 1 to July 10). Note that the breeding season may not start until mid- to late May for most species in the north.

Migration

- Surveys of migrating songbirds can provide data on timing of migration, relative abundance, and species composition. Bird identification during fall migration can be difficult for observers. Many of the brightly coloured males of the breeding season have moulted into non-breeding plumage, and juvenile birds have yet to take on their adult plumage. It is difficult to produce estimates of abundance at this time of year unless birds possess individual markings.

Non-breeding Season

- Songbirds are typically less common and non-territorial during the winter season. Although numbers are lower, survey results still have high management value since the birds surveyed are resident, and winter is often a limiting time due to factors such as extreme cold and low food availability (Manuwal and Huff 1987; Huff *et al*. 1991; Ralph *et al.* 1993). Point count surveys outlined in this manual are sufficient for determining presence or relative abundance during the non-breeding season.

3.1.4 Time of Day

- All breeding bird surveys should be conducted within the first three to four hours after sunrise. Singing rate is thought to be highest just before official sunrise and then declines slowly for the next four hours. Ralph *et al*. (1993) believe the best time for surveys is within these four hours because the singing rate is most stable.
- Until evidence shows otherwise, winter bird surveys should begin at official sunrise and continue for four hours. More work needs to be done regarding the best time for winter inventory. Birds in winter do not exhibit a diurnal song pattern as do breeding birds. However, activity is greatest in the first few hours of the morning.

3.1.5 Habitat Data Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most, provincially-funded wildlife inventory projects deal with terrestrially-based wildlife, standard attributes from the terrestrial Ecosystem Field Form developed jointly by MOF and MELP (1995) will be used. The manual, *Species Inventory Fundamentals (No.1),* contains a generic discussion of habitat data collection as well as a list of the specific requirements for songbird surveys (Appendix E).

Most studies are interested in correlating bird occurrence and abundance with habitat attributes and types. Ralph *et al.* (1995) summarize these two approaches: A random or systematic sampling of bird communities across the entire landscape will cause some stations to fall on or near the boundaries of habitat types. These data can be used to form *post hoc* associations with habitat and will reflect the variation in habitat conditions within a landscape and along the continuum of habitat. Under some circumstances, a better design would be to systematically place sampling stations (units) within the interior of habitat types so as to sample only those well defined habitats.

3.1.6 Survey Design Hierarchy

Songbird surveys follow a survey design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 1 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for a variable radius point count survey. A survey set up following this design will lend itself well to standard methods and RIC data forms.

For each survey method, details are provided on how to stratify the Project Area, determine Study Areas, and the type of Design Component(s) that will be used.

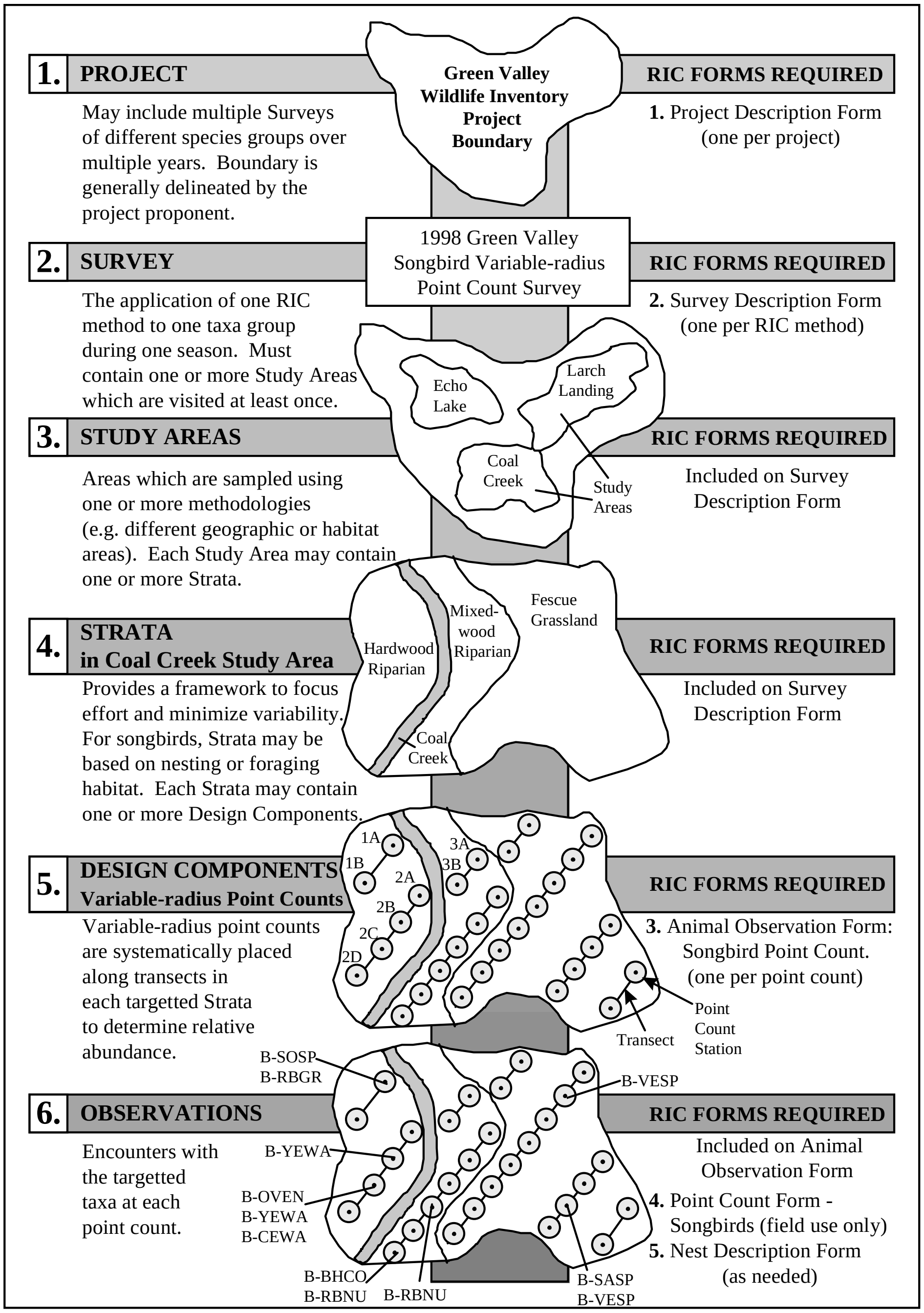


Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Inventory Surveys

The table below outlines the type of surveys that are used for inventorying songbirds for the various survey intensities. These survey methods have been recommended by wildlife biologists and approved by the Resources Inventory Committee.

Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	Forms Needed	*Intensity
Encounter Transect & Simple Point Counts	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form- General • Animal Observation Form- Songbird Encounter Transect & Simple Point Counts • Point Count Data Form-Songbirds (optional)	• PN
Variable Radius Point Counts	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form- General • Point Count Data Form- Songbirds • Animal Observation Form- Songbird Point Count	• RA
Spot Mapping	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form- General • Animal Observation Form- Songbird Spot Mapping Summary	• AA
Any Survey Type	• Nest Site Description form - used when a nest is located.	• All

* PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance

There is not enough information on the logistics of surveying particular songbird species to recommend species-specific methods. Therefore, the above methods may be used for surveying multiple species at one time or for surveying a single species.

3.3 Presence/Not Detected (Possible)

Recommended method: A combination of simple point counts along an encounter transect.

A combination of unlimited radius point counts with connecting encounter transects will maximize species detection. Thus data are collected at point count stations and while travelling between stations (provided that you travel by foot).

3.3.1 Simple Point Counts along an Encounter Transect

Office procedures

- Review the introductory manual No.1, *Species Inventory Fundamentals.*
- Obtain maps for Project and Study Area(s) (*e.g*., 1:5,000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). Any map which is used to record data should be referenced to NAD83.
- Outline the Project Area on a small to large scale map (1:250,000 – 1:20,000).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the Project area from maps.
- Delineate one to many Study Areas within this Project Area. Study areas should be representative of the Project Area if conclusions are to be made about the Project Area. For example, this means if a system of stratification is used in the Sampling Design then strata within the Study Areas should represent relevant strata in the larger Project Area.
- Based on the maps and other knowledge of the Study Area (previous reports, local resource specialists) identify strata which are of most interest for surveying.
- Compile a list which includes all potential songbirds for the Study Area.

Sampling design

- Stratify habitat according to objectives.
- Systematically sample within strata using transects and point counts with unlimited radius. [The Design Components for this survey are transects and point count stations.]
- When possible, randomize or change observers between transects / stations to minimize recurring bias in any segment of a survey.

Sampling effort

- To assess whether enough effort was spent in an area to determine presence/not detected, graph the number of species versus the number of point counts, and/or distance travelled along the transect. When the graph reaches an asymptote (levels off), it can be assumed that most of the species have been detected. A graph of species detected as a function of point counts or distance travelled will approximate optimal search effort to detect species. However, these results will only be applicable to the season, and area in which the survey was conducted. Other factors such as weather, observer, and habitat types will also affect the number of species detected. Therefore optimal sample effort should be determined on a study specific basis. For individual species it is possible to calculate optimal effort using the negative binomial distribution as detailed in manual No. 1, *Species Inventory Fundamentals*.

Personnel

- The crew leader should be a qualified biologist with experience in encounter transects and simple point count methods.
- Field crew must be competent in identifying birds by sight and song.

Equipment

- Maps
- GPS (use NAD83)
- Compass
- Hip chain (Remember to gather all the string between stations; failure to do so can result in the death of many birds)
- Measuring tape
- Flagging tape
- Binoculars
- Data forms
- Clipboard
- Tape recorder for field if desire
- Digital watch
- Thermometer
- Field guide(s) for species confirmation
- Bird song tapes for training

Field procedures

- Record transect and point count station information and observations on the dataform: *Animal Observation Form - Songbird Encounter Transect & Simple Point Counts.*
- Use the standard five letter species code (class code and the first two letters of each word *e.g.*, American Robin is B-AMRO; species names with hyphens *e.g.*, Chestnut-backed Chickadee is B-CBCH). See *The Vertebrates of BC: Scientific and English Names*, manual No.2 of the CBCB series for standard codes.
- For each bird encountered, record species, age, sex and activity.
- When a nest of interest is located during a survey, refer to the *Nest Site Description Form* to determine the data attributes to be collected.
- Refer to Figure 2 for a visual representation of the field procedures.

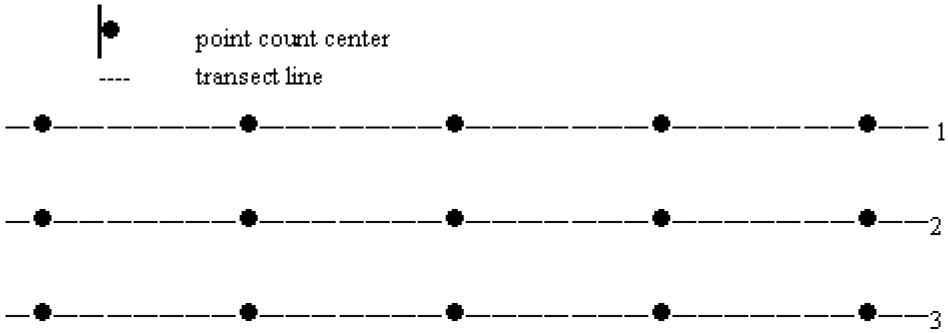


Figure 2. Sample layout for a presence/not detected survey of songbirds using a combination of encounter transects and point counts.

- ***Encounter transects***
  - Using the prepared base map identify (preferably randomly) the starting point of the transect. Before starting your survey, record the required transect information and weather conditions at the top of the dataform: *Animal Observation Form - Songbird Encounter Transect & Simple Point Counts.*
  - Walk at a rate of 0.5 - 2 km/hr, stopping (at most 30 s) when appropriate to record data, identify birds, or listen.
  - For each bird detection, record the distance traversed along the transect. In situations where there are large numbers of birds, break the transect down into 50 m recording sections.
  - Note that all birds encountered along the transect must be recorded. It is not required that the distance from the transect to the observed birds be recorded for presence/not detected surveys.
  - Each transect should be short enough that it may be surveyed in one morning.
- ***Point Counts***
  - Place the first point count station at the start of the transect.
  - Space point count stations a minimum of 200 m apart. Point counts should be spaced far enough apart so observations at each point are independent from other stations.
  - Wait one minute after arriving at the station before beginning to count all the birds detected. Create a label on your dataform for each Point Count Station so that observations can correspond with it.
  - Count detected birds for a set time period. The standard period is five minutes per point count. Some surveys may want to use a shorter (minimum three minutes) or longer time period. This is acceptable, provided detections are categorized into the standard time intervals of zero to three minutes, three to five minutes and five plus minutes.
  - Count and record all birds, regardless of distance detected from the point. For presence/not detected surveys, the radius of detection is unlimited. (Note: if the objective of the inventory is presence/not detected in a small, narrow or very patchy habitat, the detection radius should reflect this.)

Data Entry

The Design Components for this survey are transects and point count stations. However, in this case observations are grouped by transect. When digitally entering your survey data, choose ‘Transect’ from the ‘Design Component Type’ picklist.

Data Analysis

The analysis with presence/not detected data depends on the objective of the inventory effort. The table below highlights suggested analysis methods for the given RIC objectives.

Table 4. RIC objectives and analysis methods for presence/not detected data.

RIC Objective	Analysis methods	Program
• Document species range	• Analysis to ensure adequate effort. Negative binomial estimate1	• See RIC manual No.1, Section 5.2
• Determine habitat associations	• Logistic regression	• Generic statistical analysis software
• Detect change in distribution over time	• Use relative abundance methods and regression techniques.	• Generic statistical analysis software

[1] See RIC manual No.1, Section 5, for more details on negative binomial methods.

Quantifying probability of detection: The main purpose of these methods is to document species geographic ranges. From a statistical point of view it is important to attempt to quantify the detection probability (as a function of population density, population spatial distribution, detection probability, sampling effort, and other covariates) for a species to allow a general estimate of the optimal amount of effort needed for surveys. Also, if an attempt is made to quantify probabilities of detection, a more statistically conclusive statement can be made about possible reasons for not detecting a species as opposed to a simple “none were found” conclusion. A simple way to estimate probability of detection is through the use of the negative binomial distribution with data from relative abundance surveys. This procedure is detailed in RIC manual No.1, Section 5.

Documenting changes in species distributions: If the objective is to detect changes in geographic distributions over time, a more intensive survey regime using relative abundance methods is recommended. This will allow a probability level to be associated with changes in distribution or apparent local extinction. A conclusion that species have become extinct in an area using presence/not detected methods will be difficult given that no estimate of survey precision is possible using current methods. More exactly, it will be difficult to determine if a species is not detected is due to lack of sample efficiency or actual demographic extinction.

Documenting habitat associations: If determining habitat associations is an objective, it will be important to document habitat types at the scale of songbird home ranges.

3.4 Relative Abundance

Recommended method: Variable radius point count.

The main assumptions of relative abundance surveys are:

1. Identical or statistically comparable methodologies are used when comparison between areas or monitoring trends in one area over time is an objective of inventory effort.
2. Environmental, biological, and sampling factors are kept as constant as possible to minimize differences in survey bias and precision between surveys.
3. Surveys are independent; one survey does not influence another.

If these assumptions are met then each replicate survey should show (on average) the same relative bias allowing calculation of trends and comparison between areas.

However, each assumption should be scrutinized carefully when investigating the applicability of count-based methods, like point counts. Of particular importance is the assumption of equal bias between surveys. Factors such as variable weather and changes in observers can influence whether this assumption can be met. As an alternative, surveyors may opt to use distance-based point count methods as described in the section 3.5.2. In comparison to traditional point counts, the only additional measure needed for the use of distance methods is the distance of individuals (or clusters of individuals) from the survey center. Distances can be measured in terms of distance categories or groupings (e.g., 40-50 m) when it is difficult to get exact distances. Buckland *et al.* (1993) believe that in many cases distance methods can be employed in field situations with little extra effort.

When distance methods are used, all animals sighted (regardless of distance from the survey center) are counted and the sightability of animals is estimated. This allows calculation of an actual estimate of population density (and associated variance). In addition, the assumption that the number of birds counted is linearly related to true abundance is less likely to be violated when distance methods are used as opposed to traditional counts (Burnham and Anderson 1984, Buckland *et al*. 1993). This may potentially contribute to an increase in power and statistical validity with distance methods.

3.4.1 Variable Radius Point Count

Point counts are the most widely used survey method for estimating songbird abundance. They are easy to conduct with an observer recording birds from a single point for a designated time period. Many modifications and alterations of this method have occurred over the years. Most of these were reviewed in the compilation by Ralph and Scott (1981) and by Verner (1985). An important new publication by Ralph *et al.* (1995) reviewed the various point count strategies and attempted to produce a method which could be used for 1) providing trend data for monitoring population changes; and 2) predicting population changes in response to habitat change. The goal of the method is to be flexible enough to accommodate a variety of study objectives in a variety of habitats.

The chief benefit of using a variable radius point count is the ability to accommodate a wide range of bird species, each which possesses a different singing style and each which may occur in a variety of acoustically-different habitats. The variable radius point count operates by essentially allowing the habitat to determine the size of the area being surveyed. This flexibility eliminates the problem of fixing a provincially-common radius for all point counts regardless of application. The maximum detectable distance to a bird may change between different habitats, but the radius of the survey will also change. As an example, surveys of grassland birds can generally cover a larger area per point because of the absence of a screen of trees, and because bird species may be flushed at greater distances in open habitats. The response of birds to the observer will vary in different habitats resulting in certain gregarious species being counted more frequently than more cautious, “long distance callers”. In some cases, fixing a provincially-standard radius may exclude some shy species from surveys altogether. In contrast, a well-designed variable radius point count allows the project biologist to manipulate the sampling design and the maximum point radius to suit the environment and project objectives. As an illustration, very localized sampling of a riparian area might require small radius points and this would be reflected in the sampling design through the spacing of transects and the points along them.

It is important recognize that the objective for this survey is relative abundance and that the distance estimates are only intended to allow the observer to differentiate between the individual birds being counted in order to avoid “double counting”. Thus, the accuracy of the distance estimates is not as critical to a successful survey as it might be to derive an estimate of density. However, it is worth mentioning that if distance estimates can be done with a fair reliability, they will enable comparisons with point count data from a variety of studies by making it relatively simple to distinguish between bird observations made inside or outside of any specified radius. Accurate distance measurements may also improve the quality of data analyses possible, as discussed earlier.

Office procedures

- Review the introductory manual No.1, *Species Inventory Fundamentals.*
- Obtain maps for Project and Study Area(s) (e.g., 1:5,000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). Any map which is used to record data should be referenced to NAD83.
- Outline the Project Area on a small to large scale map (1:250,000 – 1:20,000).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the Project area from maps.

- Delineate one to many Study Areas within this Project Area. Study Areas should be representative of the Project Area if conclusions are to be made about the Project Area. For example, this means if a system of stratification is used in the Sampling Design then strata within the Study Areas should represent relevant strata in the larger Project Area.
- Compile a list which includes all potential songbirds for the Study Area.

Sampling design

- Based on the maps and other knowledge of the Study Area (previous reports, local resource specialists), stratify by habitat types (with different bird densities).
  - To ensure coverage throughout the Study Area use a systematic sampling design. Establish the first point count randomly and all other point counts following at a set distance. [The Design Components for this survey are Point Count Stations.]
- Barker *et al.* (1994) conducted a detailed investigation into modeling optimal point count study designs. They found that the optimal study design and sample size were a function of 1) variance of estimated population change; (2) variance of average count; (3) maximum expected total count; or (4) power of a test for differences in average counts. They found that optimal duration of counts was different for trend analysis over time compared with comparisons between areas at one point in time. It is recommend that biologists consult Barker *et al.* (1994) when formulating point count strategies.
- If the objective is to estimate bird abundances for large areas such as watersheds or management areas then stratification may not be necessary. However if their is prior knowledge of abundance varying with habitat types than stratify accordingly.
- To understand bird habitat relationships, there are two approaches. One is to describe the habitat at the point count and correlate bird abundance with the habitat *post hoc*. Another approach is to categorize the available habitat types and place the point counts in these habitat types. However, this approach ignores important habitat gradients such as edges and ecotones. Ralph *et al.* (1995) recommend stratifying the habitats and placing edges and other questionable areas into a separate strata. Location of stations should be constrained so that they are no closer than 100 m from a habitat boundary.
- When possible, randomize or change observers between stations when resampling to minimize recurring bias in any segment of a survey.

Sampling effort

- If the objective is a snapshot of the community at any given time:
  - Conduct a minimum of two visits per site as close together as possible. This will accommodate a nested ANOVA design so that variability among observers can be estimated as well as variability among sites. This is important as observer variability is one of the greatest sources of imprecision in bird surveys.
- If the objective is to compare abundances between habitat types:
  - It is necessary to sample at each point throughout the breeding season, migration period or winter season. During the breeding season spacing of visits is important to accommodate the different breeding phenologies. If the objective is to document abundance over the breeding season, a minimum of three to four visits well spaced in time (>1 week apart) are required, and six to eight visits are better.
  - Surveys should be replicated over time if general habitat inference is an objective. However, it will also be important to stratify by season, or appropriate unit in the eventual analysis to avoid excessive variance caused by temporal effects. The actual

number of visits can be determined by power analysis. Most power analysis packages have the ability to perform power analysis for stratified ANOVA designs.

- The minimum number of point counts needed for a habitat type:
  - This is driven by objectives and restrained by logistics and personnel. Sufficient point counts are needed to properly assess the number and distribution of birds in an area. A general rule is that a minimum of 30 point counts are needed per surveyed area such as a watershed (Ralph *et al.* 1993). However, a better approach is to take advantage of a power analysis software package to determine sample sizes needed both for trend analysis and comparison between areas. These are discussed in *Species Inventory Fundamentals*, Appendix G.
  - Replicating counts from an individual site can identify the influence of within-site variability on results using the methods of Link *et al.* (1994). Within-site variability can be defined as variation due to factors such as differences between observers, and short-term variation in population size at a count station or monitoring site. This is not to be confused with between-site variability, which is due to large-scale differences in the spatial distribution of species, and forms the basis for most experimental designs. In general, Link *et al.* (1994) found that if the proportion of within site variation is large, and the cost of replicating a site is small compared to setting up a new site, then it is optimal to replicate counts. If the proportion of within site variation is small, and the cost of replicating a site is equal to that of setting up a new site, then it is optimal to not replicate. Not surprisingly, Link *et al.* (1994) found that counts for birds with lower abundance had the highest percentage of within count variation. It is suggested that biologists consult Link *et al.* (1994) when designing monitoring studies, especially for birds, which show low abundances.

Personnel

- All crew should be competent in identifying birds by sight and song. Training should be provided to assist with properly estimating the distance to a bird which is seen or heard. Competence in these two areas should be demonstrated by each crew member before field data are collected. Crew should be rotated evenly between stations and areas to minimize observer bias in the data.

Equipment

- Maps
- GPS (use NAD83)
- Compass
- 100 m tape
- Hip chain (Remember to gather all the string between stations; failure to do so can result in the death of many birds)
- Flags
- Data forms or tape recorder
- Clipboard
- Digital watch
- Thermometer
- Binoculars
- Field guide(s) for species confirmation

- Bird song tapes of local/regional bird songs for training

Field procedures

Establishing point count stations in the field

- Effort should be made to place the point count entirely within the identified strata, with a minimum of 100 m from any edge. It is acceptable to use less of a buffer when necessary.
- The distance between any two points will depend on the maximum detection radii. The distances between two adjacent detection radii should be a minimum of 50 m, but 100 m is better to avoid double counting of individuals. For example, a survey using a 50 m maximum detection radii with a 100 m buffer would have point counts separated by 200 m.
- Establish stations in the field using a compass and a hip chain. Flag the route between the points if the points are to be revisited throughout the season. Flag the points, and write the number of the point on the flag.
- If possible, place flags at measured intervals (for habitats where they will be visible) or note the distance to prominent landmarks for aiding distance estimates. Tie a marker at the point count station for map orientation. Orientation is usually upslope. This consideration is important in data analysis since birds are more likely to be heard from upslope than downslope.
- Note that if distances are measured in increments (*i.e*., 0-2 m, 2-5 m, 5-10 m, etc.) then it may be possible to apply distance methods which are vastly superior to point counts. See Buckland *et al.* (1993) for a determination of optimal sampling design. Note that with a proper sample design, it is possible to get reliable density estimates with sample sizes below 60 individuals (John Boulanger, pers. comm.).
- The number of stations visited in one day will depend on distance between stations, terrain, total time spent per station, and sample size requirements. A typical goal for point counts should be to complete between eight and ten stations in a morning.

Surveying at a point count station

- Surveys should start at sunrise and may continue for four hours.
- Wait one minute after arriving at the station to allow for return of bird activity before beginning to count detected birds. Use this time to record the required Point Count Station information and weather conditions at the top of the field dataform: *Point Count Form.* Indicate orientation of the field form (and thus bird observations) by marking a ‘north’ arrow on the form.
- Particular care should be given to not disturbing birds when approaching stations. The movement of birds from the survey area can cause biases especially if distance-based methods (such as program DISTANCE) are used for analysis.
- The recommended time period is five minutes per point count. However, it is acceptable to use a shorter or longer time period provided detections are categorized into time periods. To integrate with the Breeding Bird Survey data set birds detected in the first three minutes at a station must be recorded separately from subsequent time intervals. The standard procedure is to record birds in three time intervals, depending on the total length of the point count: 0-3, 3-5, and 5 plus minutes (refer to *Animal Observations Form-Songbird Point Count*).

- Use the *Point Count Form* to plot bird observations. Mapping is an efficient way to record data, especially when counts are longer than three minutes. Shortcuts to keeping track of birds include using standardized behaviour codes for separating birds, recording movements, and showing simultaneous observations. A sample of a schematic map and a system of symbols is given in Figure 3. Note that only one observer counts birds at a single station at one time.
- Estimate the distance from the station center to each bird (at the location it is was first detected). Record bird location as accurately as possible onto the detection circle on the *Point Count Form*. The detection circle is subdivided into concentric rings of 10 m intervals to aid in marking detection locations.
- Note that the concentric rings will need to be adapted if it to be used with program DISTANCE, as distance methods require tighter rings towards the survey center and an expansion of ring width as the distance from the center increases. See Buckland *et al.* (1993) for more details on point count transects.
- Transcribe data onto the *Animal Observations Form-Songbird Point Count*.
- When a nest(s) of interest is located during a survey, refer to the *Nest Site Description Form* to determine the data attributes to be collected.

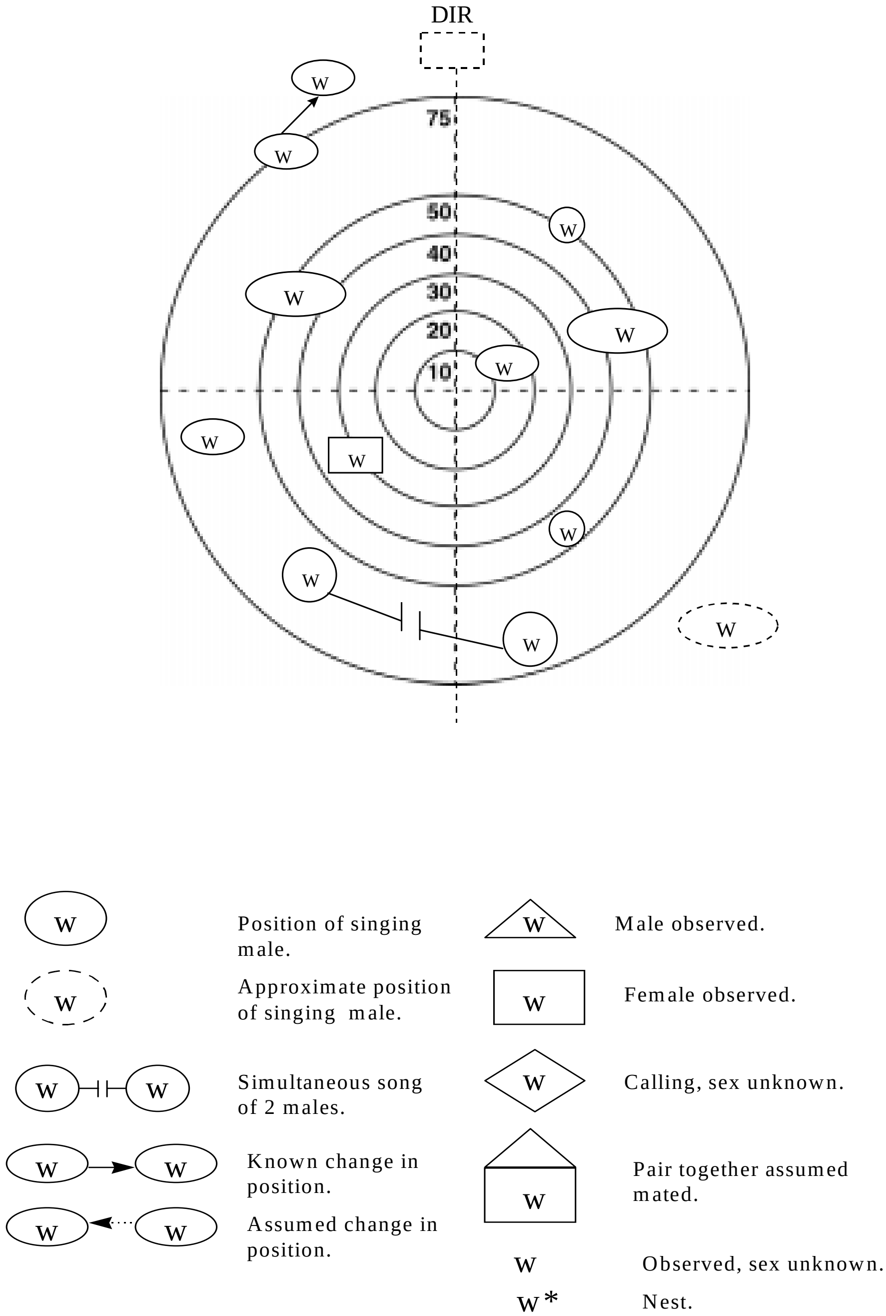


Figure 3. Sample schematic map for plotting the location of songbirds during point counts and the corresponding mapping symbols (from Ralph *et al.* 1993).

Data Entry

- The Design Component for this survey is point count stations. When digitally entering the survey data, choose ‘Point Count Station’ from the ‘Design Component Type’ picklist.
- Transect information for the transects used to layout the stations may also be recorded by choosing ‘Transects’ from the ‘Design Component Type’ picklist. This information can be used on its own as a location reference or it can be used as a way to group associated stations to a transect (optional).

Data Analysis

The quantification of sampling intensity and effort is fundamental to the use of indices and relative abundance measures. This way the assumption of equally bias surveys between areas and over time can be met. In addition, the usefulness of indices depends on the precision of estimates. It is strongly recommend that power analysis procedures be integrated into the study design of all these techniques. As described in manual No.1, Appendix G, programs such as MONITOR, POWER AND PRECISION, and NQUERY are user friendly, and can be easily used in an adaptive fashion to calculate sample sizes needed for the ultimate analysis questions.

If studies are designed appropriately the following general analysis methods can be used (Table 5).

Table 5. RIC objectives and analysis methods for relative abundance data

Objective	**Analysis method**[1]	**Programs**[2]
• Trends in abundance over time	• Sample methods • Regression techniques • Power analysis	• DISTANCE, • Generic statistical packages • MONITOR
• Comparison in abundance between areas	• ANOVA, method • Power analysis	• DISTANCE • Generic statistical packages • Power analysis software
• Determine whether habitat modifications have altered population size	• T-test method • Power analysis	• Generic statistical packages • Power analysis software

[1]See manual No.1, Section 5, for more details on analysis techniques.
[2]See manual No.1, Appendix G, for more detail on software packages.

Difficulties with count data: One inherent problem with count data is that they are rarely normally distributed, which makes the application of parametric statistical methods risky, especially if sample sizes are low. Before data are used in parametric tests, the assumption of normality should be tested. Transformations may make frequencies nearly normal in some cases. For a detailed discussion of analysis of count data, see manual No. 1, *Species Inventory Fundamentals*, Section 5. White and Bennets (1996) introduce an alternative method for point count analysis and use songbird counts as an example of this analysis technique.

Trend analysis: The basic method for determination of trends is linear regression and associated techniques. There are a variety of refinements to linear regression that can be used with data depending on sampling assumptions and other characteristics of the data. Manual No.1, Section 5, provides a detailed discussion of these techniques.

Comparison between areas: Parametric tests and other methods can possibly be used to compare areas if surveys are conducted concurrently. If surveys are conducted non-concurrently (such as in different years), then the results might be biased by population fluctuations. See manual No.1, Section 5, for a thorough discussion of analysis of count data.

Habitat based inference: Logistic regression or similar methods can be used to test for habitat associations, but this approach requires that habitat units be the primary sample unit as opposed to population units.

3.5 Absolute Abundance

Recommended methods: Spot mapping or Distance-based Point Counts.

Two methods are recommended to obtain absolute abundance estimates for songbirds. Each method will yield different types of information and so the selection of one method over the other will depend on a project's objectives.

Spot mapping is generally a valuable way to collect detailed biological information on a specific area, providing a map of songbird territories as well as a somewhat informal estimate of density. Comparisons of different spot maps can be a useful, if somewhat qualitative way, to compare songbird abundance in different areas. In contrast, if survey objectives require a more rigorous estimate of actual songbird density, project biologists may wish to consider distance-based point counts. Although the application of a distance method and its subsequent analysis may be challenging, repeatedly mapping bird territories in a spot mapping exercise is also difficult and time consuming. It can be argued that spot mapping is best if a project is focused on breeding birds since it may be harder to detect the breeding portion of the population using distance-based methods which are more constrained in terms of time and area surveyed. However, distance methods may be a better point estimator of overall bird density. In addition, density estimates from a distance-based point count may be as good or better for breeding bird census if it is possible to discern breeders and non-breeders efficiently.

3.5.1 Spot Mapping

Many songbirds are territorial, and defend their territory through conspicuous displays of singing, calling, and territorial defence. Knowledge of this behaviour has given researchers the opportunity to study territory size and through this, obtain population estimates. Spot mapping requires repeated surveys of measured plots, where each bird detected within the plot is registered on a base map. The data recorded include exact location within the plot, species, sex, behaviour, and number. After each survey, registrations are transferred to a separate summary map for each species, and clusters of registrations are identified that are assumed to represent individual territories. Each territory is assumed to contain one breeding pair. For a more detailed description of spot mapping see Bibby *et al.* (1992).

Spot mapping is similar to a total count of breeding individuals in a population. This is not a total count of all individuals since non-breeders or birds without territories can rarely be counted. Therefore, the results of spot mapping should be given as absolute abundance of breeding birds or birds with territories as opposed to the total bird population. In addition, spot mapping counts will be an unbiased and accurate estimate of absolute abundance of breeding birds only if all birds are sighted during a survey effort. This assumption might be violated if birds are sitting tight on the nest, or if heavy foliage influences sightability at some sites. In addition, spot mapping estimates may be biased if the number of breeding birds in areas changes during repeated visits to the area. For example, if floater birds establish territories in the course of spot mapping efforts than the estimate of breeding bird density might be positively biased. In addition, like many field methods which attempt to estimate density, the spot count method is susceptible to edge effects in which edge birds on the periphery of the study are counted therefore inflating estimates further. The probability of overestimate is positively correlated with the overall time in which spot mapping methods are conducted.

Office procedures

- Review the introductory manual No.1, *Species Inventory Fundamentals.*
- Obtain maps for Project and Study Area(s) (*e.g.*, 1:5,000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). Any map which is used to record data should be referenced to NAD83.
- Outline the Project Area on a small to large scale map (1:250,000 – 1:20,000).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the Project area from maps.
- Delineate one to many Study Areas within this Project Area. Study Areas will likely be defined as the portions of the Project Area in which the spot mapping takes place. Study areas should be representative of the Project Area if conclusions are to be made about the Project Area.
- Based on the maps and other knowledge of the Study Area (previous reports, local resource specialists) identify strata which are of most interest for surveying.
- Compile a list which includes all potential songbirds for the Study Area.
- Once spot mapping plots have been selected with strata of interest (see Sampling Design):
    - Prepare data collection ‘base’ maps for each plot on which detections will be registered. One map per plot per visit is required.

- Prepare one map per species per plot to serve as a ‘cumulative’ map of detections at each plot.

Sampling design

- Location of Study Areas should be chosen randomly.
- Develop your sample frame based on the objectives of the study (*e.g.*, bird community in riparian areas) and then randomly select the Study Area(s) from this sample frame.
- Within the Study Area stratify the habitat if necessary by site series. Use the Ecosystem Field Form to capture this data.
- Identify spot mapping plots in areas of homogeneous habitat.
- Mark gridlines for plots on maps according to protocol outlined in *Establishing a spot mapping plot in the field* under the Field Procedures section.
- When possible, randomize or change observers between plots to minimize recurring bias in any segment of a survey. The effect of individual observer bias could be pronounced if some observers are better at identifying and mapping territories than others.

Sampling effort

- The Study Area must be resampled six to eight times throughout the field season, with sampling periods being separated by 7-10 days. Be aware that this long sampling period can potentially inflate density estimates if birds change territories before surveying is complete.
- A 20 ha grassland plot requires about two hours to survey. A 20 ha forest plot requires about three hours to survey. Duration of surveys should be consistent within and among plots.
- The optimal sampling effort will depend on how many birds change territories and would have to be determined adaptively.

Personnel

- The crew leader should be a qualified biologist with experience in spot mapping survey method.

Equipment

- Maps
- GPS (use NAD83)
- Compass
- Hip chain (Remember to gather all the string between stations; failure to do so can result in the death of many birds)
- Flags or stakes
- Data forms or tape recorder
- Clipboard
- Digital watch
- Thermometer
- Binoculars
- Field guide(s) for species confirmation
- Bird song tapes for training

Field procedures

Establishing a spot mapping plot in the field

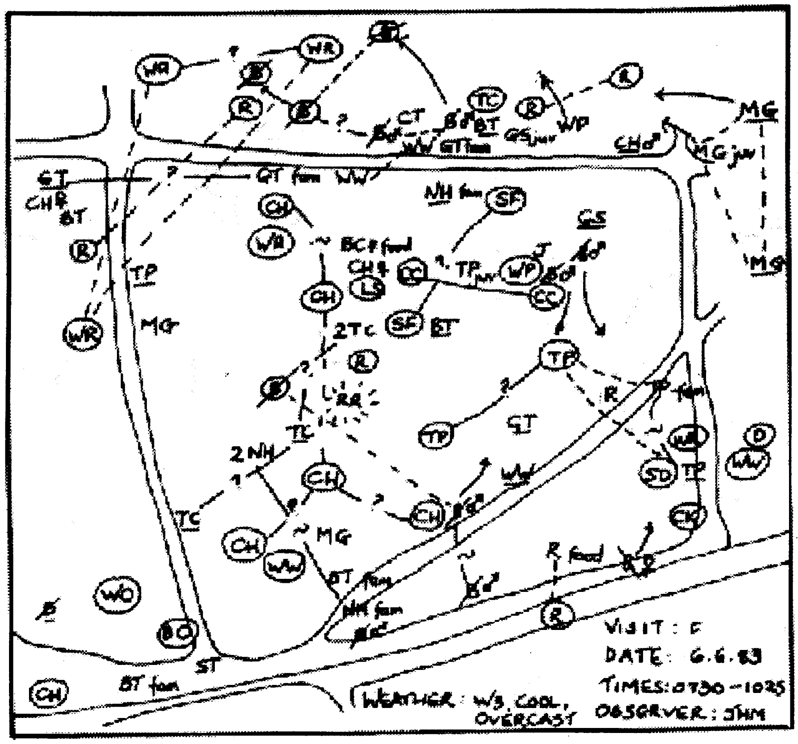
- Locate plot(s) in areas of homogeneous habitat.
- Plots should be 20 ha in size and rectangular or square in shape to facilitate gridding. Smaller patches of habitat down to 10 ha can be mapped, but several biases may begin to influence results and should be accounted for. Larger plots can be mapped as well, but plots over 30 ha often cannot be adequately surveyed because of time constraints, and are not recommended.
- Multiple plots should be of similar area and spaced so that there is little chance of individual territories overlapping between plots.
- Plot borders should be >50 m from the edge of a different habitat type to reduce the likelihood of residual edge effects.
- Mark edges of plots with flags or stakes.
- Mark gridlines, 25 m apart in forested habitats, and 50 m apart in more open habitats, with flags or stakes along one axis of the plot.

Surveying at a spot mapping plot

- Note: surveys must be completed within four hours after sunrise.
- Select a gridline adjacent to a plot boundary and a direction of travel along the gridline.
- Walk the series of gridlines in an 'S' pattern until all gridlines have been traversed. On each successive visit, reverse the starting point and direction the plot is surveyed.
- Walk at a rate of 0.5 km/hr, stopping when appropriate to record data, identify birds, or listen.
- Record plot data on a 'base' map (one map per plot per visit is required).
- Register on the base map all birds when they are first detected, including species, number, and behaviour. Use codes for notes (*e.g.* , B-SASP (Savannah Sparrow) SM (singing male), but mark location as precisely as possible with an X. Record movement (if any) of the bird(s) with arrows to help delineate territory or home range boundaries. A sample of a spot-map and a system of symbols is given in Figure 4.
- Do not register an individual more than once unless that factor is noted.
- When a nest of interest is located refer to the *Nest Site Description Form* to determine the data attributes to be collected.
- If there are multiple plots to survey during a day, reverse the order the plots are surveyed each day. Two plots per day per person should be a maximum effort to minimize the effects of time of day. Generally this will not be practical except in open grassland habitats.
- After each visit to a plot, add data from the 'base' map used for that day to the appropriate species 'cumulative' map for each plot. Use as many cumulative maps as required, particularly if there are many species and individuals. Ensure that registrations for any given species occur on one 'cumulative' map only. Also ensure that summary information has been recorded onto the *Songbird Spot Mapping Summary Form.*

Data Entry

- The Design Component for this survey is a Plot. Currently Spot Mapping data cannot be entered into the species inventory (SPI) provincial database. However, Wildlife Features (such as nests) and Incidental Observations of note (such as a rare bird) can be included.



W W — An aggressive encounter between two birds of species W.*

W — A simple contact with a bird of species W. This includes sight or sound contact. In the case of a sound contact, this symbol is used when the sound cannot be classified as belonging to any category below or when the sound is not believed to have a high territorial significance, or when activities not covered by the standard symbols should be registered. The sex symbol may be added where appropriate.*

W——W — Two contacts with the same bird of species W. The addition of an arrow can be used to indicate observed movement.*

W — A contact with a bird of species W, giving any vocal utterance (except song) thought to have territorial significance.*

W-------W — Contemporary contact of two different birds of species W. This is used to indicate separate singing males or separate pairs rather than members of the same pair or same family group. In the last two cases, the symbols may be ringed or underlined, or any non-standard symbol may be added.*

(W) — A contact with a singing bird of species W which has been seen or previously located by song.*

W* — A nest of species W. The number of eggs or young or other information on the nest may be added.*

W — A song contact with a bird of species W not precisely located (useful only in the case of birds with large territories or birds heard at a distance).*

Figure 4. Sample spot-map and associated symbols for delineating bird territories during the breeding season (from Bibby *et al.* 1992, Arbib 1970*).

Data analysis

- Determination of territories and number of territories
  - Ensure that all information that has been recorded onto a ‘base’ map from each visit to each plot has been transferred onto the appropriate species ‘cumulative’ maps for each plot. Also ensure that summary information has been recorded onto the *Songbird Spot Mapping Summary Form.*
  - After the survey program is completed, circle clusters of registrations for the same species that are considered to represent one territorial individual, based on the map data and your field observations.
  - Clusters with two or three registrations (depending on the number of valid visits) can be considered to represent one territorial male.
  - For territories that occur along the edges of the plot, estimate the proportion of the territory enclosed within the plot.
- Analysis
  - Calculate abundance of birds per unit area by adding the total number of territories per species of territorial males within the plot (include whole and fractions of territories), multiplying by two (which assumes that each male has one female associated with it) and divide by the area of the plot. This assumption may not be valid for some species. This calculation assumes that all territories occur within the plot area. Edge territories which border on the plot area will be overcounted. It may be possible to partially adjust for this problem by approximating the percentage of a birds territory in the plot area and adjusting the count accordingly. For example, if half of a sparrow's territory is in the plot area then the actual count of the bird would be one half, or the count of a pair of birds would be one as opposed to two birds. Note that the degree of bias with uncorrected counts will be dependent on sampling area size, and the size of individual species territories.
  - To obtain a mean abundance from multiple plots, sum abundance estimates for each species in each plot within a homogeneous habitat type and divide by the number of plots.
  - For statistical purposes, the abundance per species per area for one plot represents only a single data point, regardless of the number of registrations.
  - The statistical analysis of spot mapping data will be identical to the analysis of count data for relative abundance methods.
  - Note: Statistical comparisons can only be made when multiple plots are sampled.

3.5.2 Distance-based Point Counts

Distance-based point counts may be a viable alternative to labor intensive territory mapping in some situations. Point count distance methods allow an estimate of absolute density from point counts. They require that the distance from the bird to the observer at the center of the point count be accurately recorded, which should generally be less time consuming then recording coordinates for spot mapping. The advantage of point count distance methods are:

- Point counts are much less labor intensive than spot mapping, and therefore will allow a greater number of replicates to be collected per unit time.
- Breeding and non-breeding birds can both be counted which may provide a less biased overall population density estimate.
- The decrease in sightability as distance of bird from observer increases can be accounted for statistically using the methods in program DISTANCE.

The disadvantage is the complexity of the analysis, which can be overcome if a statistician is consulted for both the design of the study and for the analysis of data.

The use of point counts for relative abundance is similar to the use of a strip transect for transect methods. In some limited situations, it is questionable whether point count methods can be extended to allow estimates of density using distance methods. Distance methods allow one to estimate the probability of detection, rather than assuming it is constant throughout the surveys. The major difference is that the actual distance of birds from the center of the point count must be exactly recorded (Buckland *et al.* 1993). Point count distance methods have the following assumptions:

> *Objects on the point are detected with certainty*. This assumption is relaxed if the methods introduced in program DISTANCE are used. The actual shape of the detection function is flexible. Many times, the number of species is low closest to the observer and increases as the distance from the observer gets greater, then decreases as the detectability of species diminishes with distance.
>
> *Objects are detected in their initial location*. This assumption will generally be met as long as the observer does not flush birds or they are not attracted to the observer. Buckland *et al*. (1993) introduces various “fleeing” models to also relax this assumption. However, the utmost care should be given to minimizing disturbance of birds prior to surveys. Models which incorporate “fleeing” behavior are more complex than simpler models and therefore will require larger sample sizes.
>
> *Measurements are exact*. This may be a difficult assumption to meet in some brushy habitats. Buckland *et al*. (1993) suggest marking and measuring the distances to the bird’s location after the observation interval of the point count is finished. Note that distance of birds from the objects center can also be marked in groups (*i.e.* 0-1 m, 1-2 m, etc.) using the concentric rings approach introduced in the relative abundance section. The actual intervals should be tightest towards the center of the point count and get larger as the distance from center increases. See Buckland *et al.* (1993) for further discussion on this technique.

A common reason for not attempting to use distance methods is sample size constraints. (Buckland *et al.* 1993) states that most distance models need at least 60 observations to ensure adequate precision. However, if the sightability of birds is high and factors affecting detection rate are not complex (due to proper sampling design), it is possible to obtain adequate results with less than 60 observations (S. Buckland, Mathematical Institute, Univ. St. Andrews, Scotland, pers. comm.).

Program DISTANCE can be used for analyzing data from distance-based inventory methods. The program is quite powerful, and employs parsimonious and robust modeling techniques to allow density estimates from point count data. However, it also has restrictive sampling assumptions and is statistically complex. It is strongly recommended that a statistician trained in distance methods be contacted if this method is considered. See manual No.1 (Appendix G) for more details on program DISTANCE.

Procedures

* See the Relative Abundance section for complete protocol. Only differences in procedures from those found in the Relative Abundance section will be given below.

Sampling design

- The major constraint to this method is sample size. Buckland *et al*. (1993) states that at least 60 animals should be sighted for the use of distance models in program DISTANCE. However, as noted earlier, if the study is designed properly, and factors determining bird detection are minimized, it is possible to obtain reliable estimates with less than 60 observations (S. Buckland, pers. comm.). If extra parameters are added to models to account for "fleeing" then this number will have to be larger. In addition, if birds occur in groups or flocks, additional modeling considerations will have to be employed.
- The best way to determine the applicability of this method is to conduct a well-designed pilot study as recommended by Buckland *et al.* (1993). The data from this study can then be used to determine optimal field efforts and sample sizes.
- Another method to determine the applicability of this method to a particular population is to suggest the proposed study to the DISTANCE Discussion Group, made up of bird researchers using DISTANCE throughout the world. This is an excellent way to get an initial approximation of field efforts needed to employ this method. The DISTANCE Discussion Group can be accessed via the DISTANCE web page. See the *Species Inventory Fundamentals* manual (Appendix G) for details.

Field procedures

- *Record birds at their initial location*. Record the *exact* distance from the center of the Point Count Station to the bird (this may be a difficult assumption to meet in some brushy habitat, especially when birds are audible but not visible). Note that distance of birds from the objects center can also be records using distance classes (*i.e.*, 0-1 m, 1-2 m, etc.) based on concentric rings around the observer (introduced in Relative Abundance section). The actual intervals of the rings should be tightest towards the center of the point count, getting larger as the distance from center increases. See Buckland *et al.* (1993) for further discussion on this technique.

Data analysis

- Use the program DISTANCE for analysis. Point counts should provide better statistical data then spot mapping because detection probabilities can be estimated and more points can be sampled per unit effort. See manual No.1, Appendix G, for more details on the use of DISTANCE.

Glossary

ABSOLUTE ABUNDANCE: The total number of organisms in an area. Usually reported as absolute density: the number of organisms per unit area or volume.

ACCURACY: A measure of how close a measurement is to the true value.

AVIFAUNA: A community of birds that occur within an area.

BIODIVERSITY: Jargon for biological diversity: "the variety of life forms, the ecological roles they perform, and the genetic diversity they contain" (Wilcox, B.A. 1984 cited in Murphy, D.D. 1988. Challenges to biological diversity in urban areas. Pages 71 - 76 in Wilson, E.O. and F.M. Peter, Eds. 1988. Biodiversity. National Academy Press, Washington, DC. 519 pp.).

BIOGEOCLIMATIC SUBZONE: A geographic area with a uniform regional climate which is characterized by the same distinct climax vegetation on midslope (zonal) sites and relatively uniform mean temperature and precipitation.

BIOGEOCLIMATIC VARIANT: A subdivision of a subzone that is slightly drier, wetter, snowier, warmer or colder within a subzone.

BIOGEOCLIMATIC ZONE: A habitat mapping classification system which divides the province of B.C. into 14 broad, climatically distinct areas usually named after the dominant climax tree species. Zones are differentiated by distinct patterns of vegetation and soil and can be more finely divided into subzones, variants and phases.

BLUE LIST: Taxa listed as BLUE are sensitive or vulnerable; indigenous (native) species that are not immediately threatened but are particularly at risk for reasons including low or declining numbers, a restricted distribution, or occurrence at the fringe of their global range. Population viability is a concern as shown by significant current or predicted downward trends in abundance or habitat suitability.

BREEDING BIRDS: Birds that establish territories for the purpose of nesting.

BROAD ECOSYSTEM UNIT: A permanent area of the landscape that supports a distinct type of dominant vegetative cover, or distinct non-vegetated cover (such as lakes or rock outcrops). It is defined as including potential (climax) vegetation and any associated successional stages (for forests and grasslands). Broad Ecosystem Units are meant to be used for small scale mapping of large areas, mainly at the 1:250,000 scale.

CBCB (Components of B.C.'s Biodiversity) Manuals: Wildlife species inventory manuals that have been/are under development for approximately 36 different taxonomic groups in British Columbia; in addition, six supporting manuals.

CREPUSCULAR: Active at twilight.

CUMULATIVE MAP: A map of one plot with all registrations, over time, for one species.

DESIGN COMPONENTS: Georeferenced units which are used as the basis for sampling, and may include geometric units, such as transects, quadrats or points, as well as ecological units, such as caves or colonies.

DETECTED: Heard or seen by an observer.

DIURNAL: Active during the daytime.

DIVERSITY: The numbers of species and individuals within an area.

ECOPROVINCE: An area with consistent climate or oceanography, relief and plate tectonics, there are nine terrestrial and one maritime ecoprovinces in British Columbia.

ECOREGION: An area with major physiographic and minor macroclimatic oceanographic variation, there are 43 ecoregions in B.C., of which 39 are terrestrial.

ECOSECTION: An area with minor physiographic and macroclimatic or oceanographic variation, there are 110 ecosections in B.C., 100 of which are terrestrial.

EWG (Elements Working Group): A group of individuals that are part of the Terrestrial Ecosystems Task Force (one of 7 under the auspices of RIC) which is specifically concerned with inventory of the province's wildlife species. The EWG is mandated to provide standard inventory methods to deliver reliable, comparable data on the living "elements" of BC's ecosystems. To meet this objective, the EWG is developing the CBCB series, a suite of manuals containing standard methods for wildlife inventory that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species populations.

HOMOGENEOUS HABITAT: Habitat with similar physical or vegetative characteristics and species composition.

INVENTORY: The process of gathering field data on wildlife distribution, numbers and/or composition. This includes traditional wildlife range determination and habitat association inventories. It also encompasses population monitoring which is the process of detecting a demographic (*e.g.*, growth rate, recruitment and mortality rates) or distribution changes in a population from repeated inventories and relating these changes to either natural processes (*e.g.*, winter severity, predation) or human-related activities (*e.g.*, animal harvesting, mining, forestry, hydro-development, urban development, etc.). Population monitoring may include the development and use of population models that integrate existing demographic information (including harvest) on a species. Within the species manuals, inventory also includes, species statusing which is the process of compiling general (overview) information on the historical and current abundance and distribution of a species, its habitat requirements, rate of population change, and limiting factors. Species statusing enables prioritization of animal inventories and population monitoring. All of these activities are included under the term inventory.

NOCTURNAL: Active at night.

OBSERVATION: The detection of a species or sign of a species during an inventory survey. Observations are collected on visits to a design component on a specific date at a specific time. Each observation must be georeferenced, either in itself or simply by association with a specific, georeferenced design component. Each observation will also include numerous types of information, such as species, sex, age class, activity, and morphometric information.

PLAYBACK: A technique of broadcasting a recorded song to entice a bird to respond by singing.

POINT COUNT: a sampling method whereby an observer records detections of birds within an area of fixed radius.

POPULATION: A group of organisms of the same species occupying a particular space at a particular time.

PRECISION: A measurement of how close repeated measures are to one another.

PRESENCE/NOT DETECTED (POSSIBLE): A survey intensity that verifies that a species is present in an area or states that it was not detected (thus not likely to be in the area, but still a possibility).

PROJECT AREA: An area, usually politically or economically determined, for which an inventory project is initiated. A project boundary may be shared by multiple types of resource and/or species inventory. Sampling for species generally takes place within smaller, representative study areas so that results can be extrapolated to the entire project area.

PROJECT: A species inventory project is the inventory of one or more species over one or more years. It has a georeferenced boundary location, to which other data, such as a project team, funding source, and start/end date are linked. Each project may also be composed of a number of surveys.

RANDOM SAMPLE: A sample that has been selected by a random process, generally by reference to a table of random numbers.

RED LIST: Taxa listed as RED are candidates for designation as Endangered or Threatened. Endangered species are any indigenous (native) species threatened with imminent extinction or extirpation throughout all or a significant portion of their range in British Columbia. Threatened species are any indigenous taxa that are likely to become endangered in British Columbia, if factors affecting their vulnerability are not reversed.

REGISTRATION: A record of the occurrence of a bird including species, number, location, and behaviour noted on a map or notebook.

RELATIVE ABUNDANCE: The number of organisms at one location or time relative to the number of organisms at another location or time. Generally reported as an index of abundance.

RIC (Resources Inventory Committee): RIC was established in 1991, with the primary task of establishing data collection standards for effective land management. This process involves evaluating data collection methods at different levels of detail and making recommendations for standardized protocols based on cost-effectiveness, co-operative data collection, broad application of results and long term relevance. RIC is comprised of seven task forces: Terrestrial, Aquatic, Coastal/Marine, Land Use, Atmospheric, Earth Sciences, and Cultural. Each task force consists of representatives from various ministries and agencies of the Federal and BC governments and First Nations. The objective of RIC is to develop a common set of standards and procedures for the provincial resources inventories. [See http://www.for.gov.bc.ca/ric/]

SITE SERIES: Land areas capable of supporting a specific climax plant association and reflecting a specified range of soil moisture and nutrient regimes within a subzone or variant.

SONGBIRD: Bird species that are members of the Order Passeriformes.

SPI: Abbreviation for ‘Species Inventory’; generally used in reference to the Species Inventory Datasystem and its components.

SPOT-MAPPING: A sampling technique whereby the locations of individual territorial birds are registered on maps. Territories are determined after grouping registrations upon completion of a set of surveys over a breeding season.

STRATIFICATION: The separation of a sample population into non-overlapping groups based on a habitat or population characteristic that can be divided into multiple levels. Groups are homogeneous within, but distinct from, other strata.

STRUCTURAL STAGE: One of seven predefined successional stages of an ecosystem.

STUDY AREA: A discrete area within a project boundary in which sampling actually takes place. Study areas should be delineated to logically group samples together, generally based on habitat or population stratification and/or logistical concerns.

SURVEY: The application of one RIC method to one taxonomic group for one season.

SYSTEMATIC SAMPLE: A sample obtained by randomly selecting a point to start, and then repeating sampling at a set distance or time thereafter.

TAXONOMIC GROUP: Related species that are grouped together within genera, related genera within families, and related families within orders, etc.

TERRESTRIAL ECOSYSTEMS TASK FORCE: One of the 7 tasks forces under the auspices of the Resources Inventory Committee (RIC). Their goal is to develop a set of standards for inventory for the entire range of terrestrial species and ecosystems in British Columbia.

TERRITORY: The area defended from conspecifics by an individual bird.

YELLOW-LIST: Includes any native species which is not red- or blue-listed.

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