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ABSTRACT

The Vancouver International Airport (YVR) is Canada's second-busiest civil airport and is located on the Fraser River delta—the staging and wintering ground for millions of birds representing many taxonomic groups. Consequently, YVR experiences one of the highest bird-strike rates of any airport in Canada. Since 1994, LGL Limited has investigated and monitored avian ecology as it relates to existing and potential hazards to air-traffic safety at YVR. A formalized monitoring program is on-going. The distribution, abundance, and flight patterns of birds are recorded and summarized by individual species or by taxonomic group. Monthly and semiannual reports present information that depict changes in the local bird community regarding spatial, temporal, and behavioural factors. A multi-year database permits the comparison of these factors during a present period to past highs, lows, and averages. Data analyses are complex, but have been streamlined through the development and application of database programming developed specifically for this project. Using this, and other information such as habitat mapping and bird-strike statistics, "hazard maps" are generated. Together with the remainder of the reports, these maps provide the Wildlife Control Program with an objective view of bird hazards at YVR. Among other uses, this information can guide control efforts and gauge the effectiveness of bird control over time.

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INTRODUCTION

The Vancouver International Airport (YVR) experiences one of the highest bird/aircraft collision rates of any airport in Canada. This is primarily due to YVR's location on Sea Island in the Fraser River estuary—a migration staging area and wintering ground for millions of birds including waterfowl, shorebirds and raptors—and to the fact that YVR has the second highest number of annual aircraft movements in Canada. As a means of mitigating local bird-hazards, YVR is one of only a few commercial airports in Canada that have a full-time bird-control program.

Since 1994, biologists with LGL Limited have investigated and monitored avian ecology as it relates to existing and potential hazards to air-traffic safety at the Vancouver International Airport (YVR) (see Bibliography). From this data it is evident that the abundant and diverse avian community near Sea Island varies on time scales ranging from hourly through yearly. As a result of this variation, continued monitoring is the most practical way of dynamically assessing local bird hazards to aircraft. This paper describes the bird-hazard monitoring program at YVR. It does not describe bird ecology or specific hazards per se. For detailed information on the latter two issues, refer to the Bibliography.

STUDY AREA

The Vancouver International Airport (YVR) is located on Sea Island; a dyked deltaic deposit centred at approximately 49° 11' N, 123° 10' W (Figure 1). Sea Island is situated in the northwestern part of the Fraser River delta between the north and middle arms of the Fraser River and is the second

Figure 1 to be inserted here

largest island (1538 ha) in the Fraser Estuary. It is bordered to the northwest by Iona Island and by the mainland to the north. The mainland is an extensive glacial outwash and till deposit that rises up to 75 m above sea level. To the east and south, other dyked deltaic deposits include Lulu Island (the largest deltaic deposit in the Fraser Delta) and the Reifel-Westham Island complex. The western foreshore of the delta is fringed by a brackish marsh and the extensive tidal mudflats of Sturgeon Bank (north) and Robert's Bank (south).

The Fraser River delta is the largest estuary on Canada's Pacific coast. It covers approximately 680 km^2, stretching 30 km from New Westminster westward to Sand Heads Lighthouse and from Point Grey southward to the international boundary (Butler and Campbell 1987). At a global scale, the Fraser Delta is a critical link in a series of habitats used by millions of birds along the Pacific Flyway between the arctic breeding grounds of North America and northeast Asia, and wintering areas in southwestern North America, Central America, and South America. Sea Island and its adjacent environments are critical components of the Fraser Delta. The vast food resources of the delta provide many staging birds with the energy essential for migration. For species such as the lesser snow goose, the Fraser Delta is used both as a staging ground and as a wintering ground by different segments of the same breeding population. The delta supports some of the highest densities of wintering waterfowl, shorebirds, and raptors in Canada (Butler and Campbell 1987). Agricultural fields and urban areas also present resident, staging, and over-wintering birds with suitable habitat.

Methods

The monitoring program consists of four parts:

1. Observations of diurnal raptors in the Sea Island Conservation Area (SICA)
2. Distribution and abundance of all birds near YVR (non breeding bird surveys)
3. Distribution and abundance of flying birds near YVR (bird movement surveys)
4. Analysis of information and production of monthly and semiannual reports

Bird Identification and Species Groupings

Birds are identified to species whenever possible. However, because many observations are made at twilight, at great distances, or when the observer does not have adequate time to accurately identify each bird within a flock, some birds are assigned to a higher taxonomic group (e.g., "gulls" cf. "Thayer's gull"). When possible, the sex and age of birds (primarily raptors) are also recorded.

Species groupings were established to simplify and clarify some of the presentations and analyses. Such groupings are based on taxonomic similarities (e.g., gulls), absolute abundance detected during the course of the study, and similarities regarding effective means of hazard abatement due to similarities in behaviour and subsequent risks to air-traffic safety. The following species groupings are used: Cormorants, Northwestern Crow, Doves and Pigeons, Dabbling Ducks, Other Ducks, Bald Eagle, Falcons, Canada Goose, Snow Goose, Grebes, Gulls, Northern Harrier, Red-tailed Hawk, Rough-legged Hawk, Great Blue Heron, Loons, Mergansers, Owls, Ring-necked Pheasant, Shorebirds, European Starling, Swallows, Swans, and Terns.

Observations of Diurnal Raptors

The Sea Island Conservation Area (SICA) is situated along the northern edge of Sea Island. It was established to compensate for raptor and great blue heron habitat lost to construction of the Parallel Runway in the mid 1990s. Because of concerns about air-safety hazards posed by diurnal raptors attracted to SICA, a monitoring program was initiated. Two types of data are collected for each bird: focal sampling data and interval sampling data. Focal sampling involves recording data whenever a change in location is observed. Interval sampling consists of recording the measured parameters at 5-min intervals.

During focal animal sampling, the following information is recorded for each bird:

- species;
- sex;
- age (adult; immature; or unknown);
- time of observation; and
- location.

In addition to these data, the following data are recorded for each bird during 5-min interval sampling:

- time;
- habitat;
- behaviour;
- direction of flight out of observer's view; and
- written comments relevant to each observation.

Mutually exclusive areas are identified from north to south as:

- north of North Arm of the Fraser River;
- North Arm of the Fraser River;
- SICA;
- Commercial Development Zone (CDZ);
- over Parallel Runway (Runway 08L/26R);
- south of Parallel Runway; and
- airside (of the existing facility).

To begin focal and interval sampling, the observer selects any raptor located in SICA. That raptor is observed continuously until it moves out of sight or until the observer terminates the observation session. Some observations are made from a vehicle near main roads to minimize any observer effects on raptor behaviour. When observations are made outside a vehicle, the initial distance between the observer and raptor is >200 m. During focal sampling, each time the bird crosses a boundary between locations, the time and new location are recorded. To clarify this, two examples are given. Example 1: a bird is located in SICA and does not move out of SICA during the observation period; one location is recorded. Example 2: a bird initially in SICA flies south over the CDZ and Parallel Runway, then back to SICA, remaining there for the rest of the observation period; five locations are observed (i.e., SICA, CDZ, Parallel Runway, CDZ, SICA).

Because the numbers of raptors on Sea Island exhibit a large amount of seasonal variation, with numbers being lowest during the non-winter period, "observations of diurnal raptors" during the non-winter period are conducted during one day per month and four days per month during the winter period. This reduction in the frequency of surveys reflects the reduced air-safety concerns regarding raptors during the non-winter period.

Non-Breeding Bird Surveys

Four non-breeding bird surveys (i.e., two pairs) are conducted monthly from October through March, and one pair is conducted from April through September along an established route. These surveys are conducted from a vehicle traveling at approximately 30 km/hour. In addition to observations from the vehicle, the observer stops at set countpoints and scans the area with binoculars. The first survey of each pair begins in the afternoon and ends before dusk. The second survey begins the following day near dawn. Each survey takes from 5 to 6 hr to complete; depending on the number of birds present and, therefore, the amount of time required to record all observations. The observer records all birds within the survey area, with the usual exception of small birds in flocks of <10 individuals. All bird locations are recorded by noting the distance and direction of the bird's position in relation to the nearest countpoint. Bird behaviour and habitat type are also recorded.

Bird Movement Surveys

Bird movements are documented by observations from ground stations on Sea Island. Three pairs of north-south aligned countpoints were established along the north and south parts of Sea Island. Observations are made at each site for 1.0 hr twice each day (morning and evening), weekly from October through March, and biweekly from April through September. Morning observations begin 0.5 hr before sunrise and evening observations are timed so that the final observation period ends 0.5 hr after sunset. The starting order of sites is rotated. Observations are conducted regardless of weather conditions. During the observation periods, the observer scans the 360° horizon with binoculars, attempting to collect data on as many flying birds as possible with no upper limit on distance from the observer. Short movements by birds (e.g., <100 m; typical of many passerine and waterfowl species) or movements by small birds when flocks contained <10 individuals (e.g., hummingbirds, swallows, sparrows) are not recorded. During times of intense bird movements, observers give priority to larger birds and larger flocks. In addition to weather data, the following data are recorded for each observation:

1. time;
2. species;
3. actual or estimated number of individuals observed;
4. age (adult, immature, unknown);
5. sex;
6. estimated height above land or water;
7. behaviour at first sighting;
8. major changes in behaviour
9. estimated distance from observer;
10. approximate direction from observer;
11. approximate direction of bird movement;
12. habitat beneath bird at first sighting; and
13. association with other individuals.

Data Handling

Field data are entered into one of several Visual Foxpro databases. Initial data summaries are produced by programs written in Visual Foxpro. Non-spatial summary databases are then opened in MS Excel where macros written in Visual Basic produce charts from defined templates. Spatial data are geocoded in MapInfo, which is used to produce thematic maps.

Hazard Assessment

A species or group is considered to present a hazard to aircraft if its members occur in the immediate vicinity of YVR where they could potentially collide with an arriving, departing, or taxiing aircraft. The risk of a given hazard is taken as the perceived likelihood of a collision; it is not based on a formal risk assessment procedure. Hazards are rated as extreme, high, moderate, low, or negligible. Ratings are subjective; incorporating information on bird abundance and movement patterns, in addition to local bird-strike data. Further, ratings do not connote the potential severity of a strike with regard to life or property. The rating scheme is intended to identify which species or group present a considerable hazard to aircraft and to compare relative levels of hazards during the present period to those during the past.

Discussion

Once field observations have been entered into a database and summary databases have been generated, monthly or semiannual reports are produced. Semiannual reports are produced for each of the two periods of October through March (winter) and April through September (summer). Although there is considerable overlap in the content of monthly and semiannual reports, semiannual reports are more comprehensive and present a wider array of data.

Report Structure

Raptors in SICA

Information collected from raptors in SICA is presented first and is only presented in semiannual reports. Data are presented in three tables and one figure. The first table summarizes the number of observation events for each species, the total time each species was observed, and the mean and standard deviation of the duration of each observation event. The second table summarizes the numbers and proportions of observation events for each species where the bird remained in SICA during the entire observation period or for which SICA was the last known location of a bird. The third table summarizes the general directions in which birds flew out of the observer's view, thereby ending the observation period. The figure presents the frequency of geographic locations used by birds that flew out of SICA at least once during the observation period (Figure 2).

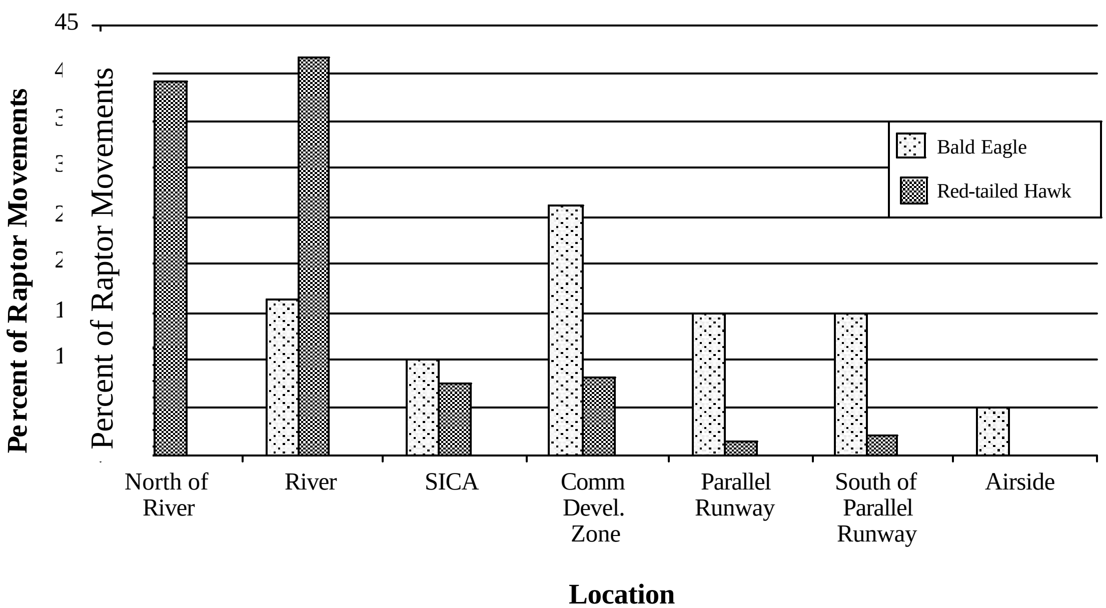

Figure 2. Frequency of locations used by bald eagles and red-tailed hawks that left SICA at least once during the observation period (*i.e.,* raptors that remained in SICA during the entire observation period are not included). Observations in the category "SICA" represent only raptors returning to SICA from another location. The "River" and "North of River" locations are north of SICA, all others are south of SICA, with increasing distance from SICA moving from the "Commercial Development Zone" to "Airside". "Airside" refers to that area which was airside prior to construction of the Parallel Runway. Period covered: October 1996 through February 1998. Observations from 35 bald eagles and 129 red-tailed hawks.

Hazard Summary

This section consists of: (1) a hazard assessment table that lists groups, their hazard level during past and present periods, and a map location identifier, (2) a map indicating the location of hazards listed in the previous table as per the numbers given in that table, and (3) a concise written description of significant hazards; e.g.,

Canada Goose

Decreased abundance and reduced movement rates likely served to reduce the risks of the hazards posed by this species compared to average conditions during the same period in past years. Hazards occur throughout the monitored area, but are likely greatest for aircraft using the Parallel Runway.

Distribution, Abundance, and Movement

The abundance, distribution, and flight patterns of birds are summarized by individual species (e.g., great blue heron) or by taxonomic group (e.g., gulls). The first page provides information on how the current period compares to past periods regarding each group. An assessment of hazards is also given as are any relevant comments.

The first chart of each of these sections presents abundance information for each week of the year. Within each week, the past highest, past lowest, past average and present numbers of birds are plotted. The numbers of birds during weeks when no surveys were conducted are interpolated between survey dates (Figure 3).

Figure 3 to be inserted here

Figure 3. Weekly abundance measures of a selected species.

Bird-strike information is also plotted on the same sheet. Data are obtained from Transport Canada, and represent the number of strikes and the number of birds struck. Because a single strike can involve one or more birds, the number of strikes does not necessarily equal the number struck. Not all strike data are plotted. For example, birds identified as “hawks” in the Transport Canada database are not plotted, since it is not what species of hawk was struck.

The next figures show the relative abundance of birds at each countpoint by season (i.e., winter (October through March) and summer (April through September)). Each value represents an average daily number of birds near each countpoint. The “High” value represents the past highest daily average recorded for a given year and season. The “Low” value represents the past lowest daily average for a given year and season. The daily average for the current reporting period is also indicated.

The next chart shows six figures representing, for weekly periods, the average hourly number of birds flying within 1 km of each of the six countpoints on Sea Island (Figure 4). For each year, the total number of birds seen near each countpoint for each survey (i.e., morning and evening surveys represent separate surveys) was divided by the total survey time, to yield an average number per hour for each survey. The past highest and lowest rates within 7-day periods (i.e., weekly) beginning on 1 October of each year are shown. The rates of birds flying during weeks when no surveys were conducted are interpolated between survey dates. The rates of birds observed during the present reporting period are represented by the greater of the two hourly rates observed during that week (i.e., the greater of the rates according to the morning and evening surveys at each countpoint for that week).

Figure 4 to be inserted here

Figure 4. An example of bird movement rates past one of the six countpoints on Sea Island.

A certain proportion of the variation in bird movement rates as depicted by the peaks and troughs on these figures is due to the nature of bird distributions and the sampling methodology employed. Not only are birds not distributed uniformly around Sea Island, but their abundance changes on several time-scales. The data clearly depict these changes on a seasonal scale, but changes at shorter timescales are not as clearly represented by the charts. In order to capture some of this variation efficiently, the starting order of surveys at the countpoints is rotated weekly so that each countpoint is sampled at similar times of the day within a monthly timeframe. Because bird distribution changes by location and by time of day, for a given group it is possible to observe a high movement rate one week and a low rate the next, even though the number of birds near the airport may have not necessarily declined. For example, the peak morning movement rate of gulls past countpoint B3 occurs near sunrise. Thus, if B3 is the first countpoint surveyed (i.e., the first survey begins 0.5 hr before sunrise), that movement will be detected. If B3 is the third countpoint surveyed (i.e., the third morning survey begins approximately 2 hr after sunrise), that peak movement is missed, even though it did occur.

Following those charts is a diagram that presents 12 “radar” charts superimposed on two maps of Sea Island (Figure 5). The spikes on each chart represent the percentage of birds during both the morning and evening periods that were observed flying in the direction indicated by the orientation of the spike at each of the countpoints. For example, a spike that runs from a countpoint toward the top of the page indicates northward flights. Other directions can be read from the compass diagram on the figure. The actual percentage can be obtained by comparing the length of a given spike to the corresponding scale shown below each set of charts.

Following the radar charts is a figure with 12 tables. The tables correspond to countpoints for each of the morning and evening periods for each of the winter and summer periods. The outer cells of each table represent the percentage of birds flying in each compass direction as shown:

Countpoint Time of day (AM/PM)

% Flying Northwest	% Flying North	% Flying Northeast
% Flying West		% Flying East
% Flying Southwest	% Flying South	% Flying Southeast

Within each of the 8 **outer** cells there are four numbers, corresponding to different values averaged across seasons:

Low	Median
High	Current

These values are determined by:

$$\frac{\Sigma(\text{number of birds by year, by season, by countpoint, by time of day, and by direction of movement})}{\Sigma(\text{number of birds by year, season, countpoint, time of day})}$$

“Low” represents the past lowest annual average percentage of birds observed flying in that direction at that countpoint during that time of the day for that season.
“High” represents the past highest annual average percentage of birds observed flying in that direction at that countpoint during that time of the day for that season.
“Median” represents the median value of all past annual averages.

Figure 5 to be inserted here

Figure 5. An example of a radar diagram of bird flight directions. Great blue herons during the summer mornings of 1998 are depicted.

"Current" represents the average percentage observed flying in that direction at that countpoint during that time of the day for the current reporting period.

The middle cell of each nine-celled tables contains four values in boldface type. Those values also represent values that are averaged across seasons:

Low	**Median**
High	**Current**

These values are determined by:

$$\frac{\Sigma(\text{number of birds by year, by season, by countpoint, by time of day})}{\Sigma[(\text{number of surveys by year, by season, by countpoint, by time of day})\text{* length of each survey (hours)}]}$$

"Low" represents the lowest annual average hourly number of birds observed at that countpoint during that time of day during that season.
"High" represents the highest annual average hourly number of birds observed at that countpoint during that time of day during that season.

"Median" is the median of all past annual averages at that countpoint during that time of day during that season.
"Current" represents the average hourly rate observed during the present reporting period.

Appendices

Appendix I presents the highest total number of each species for each pair of surveys. The "Number of Records" is the total number of times that species was recorded (including both surveys of each pair) during the present reporting period. The "Rank of Records" ranks the number of events from most records (i.e., rank=1) to fewest records. "Total Birds" is the total number of individuals counted on all surveys. "Rank of Total Birds" ranks all species form most abundant (i.e., rank=1) to least abundant.

Appendix II presents the total number of birds in each taxonomic group observed at each countpoint during each survey for a given period. Refer to information at the bottom of the page regarding the year(s) of coverage.

Appendix III summarizes the percent distribution of taxonomic groups across all habitat types in the study area for each season (i.e., S=summer; W=winter) for each year. All birds, regardless of behaviour are presented.

CONCLUSION

Monitoring the numbers, distribution, and movements of birds on and near airports is an integral component of any bird-control program because monitoring confers many important benefits. First, by collecting data, comparing them to those from a long-term monitoring database, and then reporting the findings monthly, wildlife managers and controllers gain information required to make effective decisions about personnel assignments, tasks, and equipment needs. Second, data presented in a clear, concise, and timely manner can alert wildlife control personnel to potential problems or situations such as unusually high numbers of birds or unusual movements of birds that might require more control effort and/or alternate control techniques. Third, bird monitoring data facilitate post hoc analyses and understanding of the patterns and timing of bird strikes in relation to the distribution, abundance, and behaviour of birds. Such data would be vital for the development of a formalized risk assessment. Fourth, monitoring data are vital to conducting an objective assessment of the overall efficacy of a wildlife control program in addition to providing a measure of the effectiveness of individual program components. Finally, in the event of litigation stemming from a bird strike, it seems reasonable to believe that such data could also be used to substantiate "due diligence" claims in court.

Consistent, long-term bird monitoring is an important tool that is, unfortunately, seldom available to wildlife managers; even where intensive wildlife management is undertaken. We have developed a cost-effective approach to measuring the important aspects of the distribution, abundance and movements of birds near Vancouver International Airport and a structure of reporting this information in a timely fashion to bird-control managers and staff. Bird monitoring has formed an important part of the integrated wildlife control program at Vancouver International Airport since 1994.

Bibliography

Demarchi, M. W. 1996. Avian Ecology and Air-Traffic Safety at Vancouver International Airport: Non-Winter Monitoring, 1996. LGL Report EA636.1. Prepared for Transport Canada. 59 pp.

Demarchi, M. W. and G. F. Searing. 1995a. Assessment of impacts of the Vancouver International Airport on avifauna. LGL Report EA636. Prepared for Transport Canada. 137 pp.

Demarchi, M. W. and G. F. Searing. 1995b. Avian ecology and air-traffic safety at Vancouver International Airport. LGL Report EA636. Prepared for Transport Canada. 100pp.

Demarchi, M. W. and G. F. Searing. 1996. Avian ecology and air-traffic safety at Vancouver International Airport: monitoring. LGL Report EA636.1. Prepared for Transport Canada. 69 pp.

Demarchi, M. W., G. F. Searing, M. K. McNicholl, T. Mochizuki, and P. Wainwright. 1998a. Bird monitoring at Vancouver International Airport: Data report: 1994-97. LGL Report EA636.2. Prepared for Transport Canada.

Demarchi, M. W., G. F. Searing, M. K. McNicholl, and T. Mochizuki. 1998b. Bird monitoring at Vancouver International Airport: Data report: 1994-98 (winter). LGL Report EA1169. Prepared for the Vancouver International Airport Authority.

Demarchi, M. W., G. F. Searing, M. K. McNicholl, and T. Mochizuki. 1998c. Bird monitoring at Vancouver International Airport: Data report: 1994-98 (non-winter). LGL Report EA1169. Prepared for the Vancouver International Airport Authority.