ENVIRONMENTAL MITIGATION PROGRAM SUPPORTING MILITARY FLYING ACTIVITY IN GOOSE BAY, LABRADOR

Assessment of Breeding Waterfowl Populations in the Labrador Low Level Flight Training Area

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Abstract

In 1995, the Canadian Wildlife Service and the Department of National Defence initiated a two part study to examine the effects of low-level jet flight training on waterfowl in Labrador. This report pertains to the assessment of effects of low-level jet overflights on breeding population densities. Breeding pair surveys recorded numbers of breeding waterfowl on selected study plots in areas of no overflights and with high frequency of overflights. Six plots (10km x 10km) were surveyed for spring breeding waterfowl from 1995 to 1998. There was a total of three control survey plots (no jet overflights) and three survey plots which were exposed to a high frequency of overflights (>4 per day). The surveys were based on the Black Duck Joint Venture breeding pair survey procedures and were therefore timed to accurately assess the densities of early breeding species, primarily Black Ducks and Canada Geese.

Data analysis consisted of examining differences in the densities of certain waterfowl species in each category between years and among plots. In 1996 there was one jet overflight over the control plots during the waterfowl breeding season. The number of flights ranged from 507 to 989 over the high frequency plots. Black Ducks and Canada Geese were the most numerous species on all plots.

The numbers of indicated pairs of Black Ducks on the control plots averaged 5.7 per 100 km^2 in 1995, 6.3 in 1996, 3.0 in 1997 and 5.0 in 1998. The densities of Black Duck pairs on the high frequency plots averaged 8.5 per 100 km^2 in 1995, 18.3 in 1996, 10.7 in 1997 and 14.3 in 1998. Indicated pairs of Canada Geese on the control plots averaged 7.3 in 1995, 11.0 in 1996, 9.0 in 1997 and 12.3 in 1998. Canada Geese breeding pairs on the high frequency plots averaged 7.0 per 100 km^2 in 1995, 11.7 in 1996, 13.7 in 1997 and 13.7 in 1998.

High densities of waterfowl on the high frequency plots compared to the control plots suggest that Black Ducks and Canada Geese can use habitat that is being subjected to low-level jet overflights at a high frequency. High spatial and annual variation in Black Duck and Canada Geese breeding densities reduces the probability that changes in pair density can be correlated with low-level flying activity. Results from this study to date show differences in densities of Canada Geese and Black Ducks among plots but no linear trends over time in either the high frequency or control plots.

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1. INTRODUCTION

Military flying activity has occurred in Goose Bay, Labrador since the Second World War. Commencing in 1981, extensive low-level military jet aircraft training began in a 100,000 km^2 area covering part of the Quebec-Labrador peninsula (Department of National Defence (DND), 1995). These low-level flight activities are taking place under the authority of a Multinational Memorandum of Understanding signed by Canada (DND) and its NATO allies in 1986. Low-level flight training involves navigating and manoeuvring jet aircraft while flying below 300 metres (1000 feet) above ground level. Within the training area, pilots are permitted to fly as low as 30 metres (100 feet) above all obstacles, however supersonic flight is not permitted. Current operations within the training zone involve 7000 to 8000 flights over a period of 28 to 31 weeks, which equates to about 96 percent of the training area receiving less than two overflights per day (DND, 1995).

In 1995 DND submitted an Environmental Impact Statement (EIS) for review as part of the Federal assessment of the military flying activity in Labrador. This EIS identified several issues of concern to the scientific community, stakeholders, and the public at large in respect to the low-level flight training program in Labrador. The prime environmental issue identified was the effect of jet aircraft noise on wildlife. One group of wildlife of particular concern was waterfowl. Consequently, the panel recommended there should be a thorough investigation of the populations of waterfowl in the reconfigured training area and a study of the effects of low-level flights on waterfowl behaviour (DND, 1995).

Labrador provides habitat for approximately 25 species of waterfowl during the ice-free months. The fall migration out of Labrador is estimated to make up 80 percent of the regional Canada Goose numbers, 99 percent of Scaup, 80 percent of Red-breasted Mergansers, 57 percent of Green-winged Teal, 38 percent of Pintail, 35 percent of Common Goldeneye, and 20 percent of Black Ducks (Erskine, 1987). These numbers are significant not only in a regional context, but to the other states and provinces that comprise the Atlantic Flyway. Canada Geese from Labrador, for example, make up approximately 80 percent of the North Atlantic Population.

Much of the work done on the effects of disturbance on waterfowl has examined impacts caused by sources other than jet planes, such as fixed-wing aircraft and helicopters, hunting and boating. This work has demonstrated that some sources of noise disturbance can cause changes in the normal activities of waterfowl (Dzubin, 1984; Belanger and Bedard, 1989; Havera et al., 1992). Other authors have concluded that disturbance caused by some types of aircraft has minimal impact on waterfowl behaviour (Gollop et al., 1974; Fleming et al.,1996).

The effects of aircraft disturbance on breeding waterfowl are not well known, although several studies have demonstrated that noise disturbance can affect the normal activity patterns of ducks and geese (Dzubin, 1984; Belanger and Bedard, 1989; Havera et al., 1992). Excessive disturbance has been shown to drive waterfowl out of an area causing short term local declines in populations (Barry and Spencer, 1976; Dufour, 1980; Schweisburg, 1974). Waterfowl often return to breed in areas where they have previously nested (Malecki and Trost, 1985; Batt et al., 1992). Breeding site fidelity is probably advantageous to waterfowl since they return to familiar areas and are better able to exploit food resources and avoid predation (Batt et al., 1992). Thus, if disturbance affects the normal breeding distribution and behaviour of ducks and geese there is the potential for reduced recruitment and population size.

CWS, as the resource manager for waterfowl, has participated in DND's environmental mitigation program since 1992. In 1995 CWS completed a compilation of available waterfowl information for Labrador (Bateman and Hicks, 1995). This report provided baseline information from which waterfowl protection areas were established to minimize potential disturbance from low-level jet training in the Quebec-Labrador training area. However, the "avoidance criteria" applied to protect important waterfowl breeding and staging areas had been derived from very little information on the potential effects of aircraft disturbance on waterfowl. Consequently, CWS in participation with DND initiated a two part study in 1995 to investigate possible impacts of low-level jet flight training on waterfowl in Labrador. This study was developed to address the concerns that low-level flight may be detrimental to waterfowl in Labrador during their breeding and moulting periods. The project consisted of two components: 1) a behaviour study examined the immediate effects of overflights on moulting and staging waterfowl and 2) surveys examined the use of low-level flight training areas and control areas by breeding waterfowl.

This report presents results to date from the breeding waterfowl study. The objective of the study was to determine the effects of low-level jet overflights on breeding population densities. The method used to monitor populations of breeding waterfowl was to count pairs upon arrival on the breeding grounds in the spring (Dunn et al., 1993). **The hypothesis tested in this study was: there is no significant decrease in the number of breeding pairs of waterfowl as a result of disturbance by low-level jet overflights.**

1.1 Description of study area

Labrador encompasses an area of approximately 288,000 km^2 and is predominantly in the Boreal Forest Region of Canada (Lopoukhine et al., 1977). Mean annual temperature of Labrador ranges between 0^{0}C and 5^{0}C, and mean annual precipitation ranges from 600 mm at northern latitudes up to 1200 mm at the Quebec-Labrador border in the south. The vegetation of the Labrador region lies within the Boreal Forest Region and the Tundra Region as classified by Rowe (1972). Within Labrador there are 27 Land Regions and 168 Land Districts which are characterized by vegetation, topography, geology and geomorphology (Lopoukhine et al., 1977).

Densities of breeding waterfowl have been sampled and reported by Land Region (Bateman and Hicks, 1995). Data from staging and moulting areas were compiled from existing data and new surveys to produce the best description of waterfowl in inland Labrador that was possible (Bateman and Hicks, 1995). The mean number of dabbling duck pairs per 100 km^2 range from a high of 33 in the most productive Land Region to a low of 3.4 in the least productive Land Region sampled (some mountainous regions provide negligible waterfowl habitat). The mean number of diving duck pairs per 100 km^2 range from a high of 49 in a productive Land Region to a low of 8 in a Region of low productivity.

Based on the available breeding waterfowl information, including the 1995 surveys, the plots (Figure 1) for the breeding pair monitoring study were located in Postville, Nipishish Lake, Churchill Falls, Eagle Plateau and the Smallwood Reservoir Ecoregions. On average these Regions had the highest densities of breeding ducks and geese in Labrador (Bateman and Hicks, 1995). The Postville Ecoregion covers an area of 18,140 km^2 and is characterized by sand and gravel plains, deltas and rugged hills, with slow growing spruce and balsam fir forests (Lopoukhine et al., 1977). This Region also contains alluvial valley sites and enriched swamp/marsh deltas which have high capability for waterfowl production (Goudie and Whitman, 1983). Nipishish Lake encompasses an 18,900 km^2 area located within the vicinity of Lake Melville. The area is primarily glaciated plateau with numerous string bogs and large lakes. Churchill Falls is a forested Region covering 23,490 km^2 and extending east from Churchill Falls to the headwaters of the Kenamu River. Lichen and black Spruce woodlands are typical. Eagle Plateau covers a 14,945 km^2 area south of the Mealy Mountains. Lakes and esker complexes are common in this Region. String and blanket bogs are also prevalent, consequently, this Region has a high waterfowl capability rating (Lopoukhine et al., 1977). The Smallwood Reservoir Region is the largest (36,300 km^2) in Labrador and is centred on the Smallwood Reservoir. Esker, drumlin ridges, string bogs and fens are characteristic. Open lichen woodlands and black spruce forests are also typical. This Region has the best waterfowl habitat in Labrador (Goudie and Whitman, 1983).

2. METHODS

2.1 Study design

Areas of Labrador which had been previously surveyed by CWS and known to contain high densities of waterfowl, were delineated according to the density and history of jet overflights. Areas were designated as control areas (no overflights) and areas where a high frequency (>4 per day) of overflights was expected. A sampling framework of six 100 km^2 plots was selected (Table 1). An attempt was made to select plots with comparable densities of waterfowl within the limitations of other variables.

The three plots selected for controls (Figure 1) are located in the Eagle Plateau (DND 9), Nipishish Lake (DND 10) and Smallwood Reservoir (WL 15) Ecoregions and were surveyed in 1995, 1996, 1997 and 1998. The three plots selected to represent areas of high frequency of overflights were in the Eagle Plateau (DND 1), Churchill Falls (DND 3), and Postville Ecoregions (DND 8). Study plot DND 1 was surveyed in 1994 but not in 1995. The 1994 data are not included here but all data from 1995, 1996, 1997, and 1998 were used in the analyses.

2.2 Survey methods

Surveys were conducted according to the Black Duck Joint Venture survey methodology. Each plot was surveyed from a Bell 206-LR helicopter in the appropriate breeding period for Black Ducks (May to June). Surveys were conducted so as to begin no earlier than one hour after sunrise and end no later than one hour before sunset. The surveys were also conducted under appropriate weather conditions (winds less than 22 knots, good visibility). All water and wetlands within each 100 km^2 plot were flown at a ground speed of 30 to 50 knots and a height of 15 to 45 metres (50 to 150 feet) above ground level to ensure accurate identification of all waterfowl species. All waterfowl observed were recorded by species on 1:50,000 topographical maps. Individuals and flocks were recorded separately from pairs. An observation was recorded as a breeding pair when the pair was observed or a single male was observed (Black Duck Joint Venture Standard Operating Procedures, 1990). All ducks observed in the survey plots were recorded to provide indices of total numbers of all waterfowl species within the study sites.

A log of jet aircraft flight track data provided by DND provided numbers of overflights at each plot location during the 1996 flying season.

2.3 Data compilation and analysis

The data were compiled both as total birds for each species and indicated pairs for species where timing of surveys justified use of pair data. Incomplete randomized block design analysis of variance was conducted for Black Duck and Canada Goose data on the high frequency and control plots. A power analysis using significance level alpha = 0.05 tested for effect pattern and effect size on the impacted data. For more details on data analyses see Appendix A.

3. RESULTS

3.1 Numbers of waterfowl on all plots

The most numerous species (total birds and pairs) on the control plots were Black Ducks and Canada Geese (Tables 2, 3). Green-winged Teal, Red-breasted Mergansers and Surf Scoters were also relatively numerous. Black Ducks and Canada Geese were the most abundant species observed on the high frequency plots, however a substantial number of Surf Scoters and Scaup also occurred.

Black Ducks and Canada Geese were encountered on all of the plots which were surveyed in 1995, 1996, 1997 and 1998 with the exception of plot DND 9 which had no Black Ducks observed in 1995, 1996, or 1997 (Tables 4, 5, 6, 7). The species composition of waterfowl between plots in any one year was highly variable. However, the species composition of waterfowl on each individual plot remained relatively consistent from year to year. Plot number DND 8 contained high numbers of Scaup. Harlequin Ducks were observed on Plot DND 3 and DND 8 in 1997. No Harlequin Ducks were observed on the surveys in 1995 or 1996.

3.2 Waterfowl densities

Mean densities of indicated Black Duck pairs on the control plots were 5.7 per 100 km^2 in 1995, 6.3 in 1996, 3.0 in 1997 and 5.0 in 1998 (Table 3). Mean indicated pairs of Canada Geese were 7.3 per 100 km^2 in 1995, 11.0 in 1996, 9.0 in 1997 and 12.3 in 1998. Mean densities of Black Duck indicated pairs on the high frequency plots were 8.5 per 100 km^2 in 1995, 18.3 in 1996, 10.7 in 1997 and 14.3 in 1998 (Table 3). Canada Geese breeding pairs on these plots averaged 7.0 in 1995, 11.7 in 1996, 13.7 in 1997 and 13.7 in 1998. Results of the analysis of variance for Canada Goose numbers on the control and high frequency plots showed differences among the high frequency plots but not among the controls. Analysis of the Black Duck numbers showed differences among plots in both categories. There were differences among years but no evidence for a linear trend in either category of treatment for either species (Table 8). For a more complete description of data analyses see Appendix A.

3.3 Number and altitudes of jet overflights on survey plots, 1996

There was a total of four jet overflights on the control plots in 1996. There was one overflight on plot WL 15 (Tables 9, 9a, 9b, 9c, and 9d). No overflights were recorded during the 1996 flying season on plot DND 9. On plot DND 10 there were three overflights at an altitude over 750 m (2500 ft.) which occurred late in the season (September 2 - October 31).

In the 1996 flying season there was a total of 2440 jet overflights over the high frequency plots. There were 243 overflights on these plots from April 22 to May 19, 706 overflights from May 20 to June 30, 562 flights from July 1 to September 1 and 929 flights from September 2 to October 31. Fifty percent of the jet overflights on the high frequency plots occurred at an altitude below 75m (250 ft.).

4. DISCUSSION

The densities of waterfowl on the high frequency plots before low-level jet overflights is not known and the potential exists that densities were different prior to jet training. However, it must be noted that the highest densities of Black Duck pairs observed during the study were on high frequency plots. Canada Goose use of these plots appeared to increase over the three years but there was no statistically significant linear trend. The current data suggest that high frequency plots can support high densities of waterfowl. However, since the effect of disturbance on breeding waterfowl may be related to reduced breeding success (Fleming et al., 1996; Lamp, 1989) four years of surveys are insufficient time to detect population changes as a result of reduced recruitment.

In studies which have examined the effects of disturbance on waterfowl during the breeding season the result has been increased time off the nest exposing nests to higher predation rates (Barry and Spencer, 1976), a reduction in the number of birds observed in an area in the Spring (Belanger and Bedard, 1989) and reduced growth rates in juveniles (Fleming et al., 1996). Due to the size, terrain, and relatively low densities of nesting waterfowl in Labrador it would be virtually impossible to evaluate nesting success of waterfowl in this area. The only reliable method to assess recruitment of breeding ducks and geese in this region is to continue long term breeding pair surveys. We assumed that detection of a difference of one pair of birds (Canada Geese or Black Ducks) per 100 km^2 per year was adequate power for the hypothesis being tested. The surveys in place will detect that difference in the high frequency plots compared to the controls with six years of data with 80 percent power for Canada Geese and 96 percent power for Black Ducks. If we wish to detect a difference of four birds (Canada Geese or Black Ducks) per 100 km^2 per year between the high frequency and control plots, six years of data collection will give us a power of 99 percent for Black Ducks and 100 percent for Canada Geese. We recommend that these surveys be conducted for two more years.

5. SUMMARY

1. Six plots (10km x 10km) were surveyed for spring breeding waterfowl from 1995 to 1998. The plot locations were selected based on the history of low-level jet overflights, waterfowl densities and logistical considerations.

2. There was a total of three control plots (no overflights) and three plots which were exposed to a high frequency of overflights (>4 per day). One of the high frequency plots was not flown in 1995.

3. The surveys were based on the Black Duck Joint Venture breeding pair survey procedures, and were therefore timed to accurately assess the densities of early breeding species, primarily Black Ducks and Canada Geese. Data analysis consisted of incomplete randomized block design analysis of variance testing for differences in trends between numbers of Black Ducks and Canada Geese on control plots and high frequency plots.

4. There were differences in numbers of Canada Geese and Black Ducks among years on both the control plots and the high frequency plots, but no evidence of a linear trend in numbers of birds in either treatment.

5. The number of jet overflights in the high frequency survey plots ranged from 507 to 989 during the 1996 flying season. The majority of the overflights were less than 150 meters (500 feet) above ground level. The control plots were only exposed to one jet overflight at an altitude of over 150 metres (500 feet)above ground level, during the waterfowl breeding season.

6. CONCLUSIONS

The hypothesis tested in the breeding waterfowl study was:

> **there is no significant decrease in the number of breeding pairs of waterfowl as a result of disturbance by low-level jet overflights.**

Areas of Labrador which had been previously surveyed by CWS and known to contain high densities of waterfowl, were delineated according to the density and history of jet overflights. Areas were designated as control areas (no overflights) and as sample areas where a high frequency of overflights (>4 per day) was expected. Three high frequency and three control plots with comparable densities of waterfowl (within limitations) were selected for the study. Surveys of all the plots were conducted according to Black Duck Joint Venture survey methodology.

The results of the breeding waterfowl study were:

- The most numerous species (total birds and pairs) on the control plots and the high frequency plots were Black Ducks and Canada Geese, although the high frequency plots also had a substantial number of Surf Scoters and Scaup;
- Densities of waterfowl were consistently higher on the high frequency plots compared to the control plots; and
- There were differences in numbers of Canada Geese and Black Ducks among the four years on both the control plots and the high frequency plots, but there is no evidence of a linear trend in numbers of birds in either plots.

The conclusions of the breeding waterfowl study are:

- To date no trend is emerging which suggests jet overflights are decreasing the density of waterfowl. A lack of trend suggests that waterfowl can inhabit areas being used for low-level jet training without density effects;
- There has been an insufficient number of annual surveys to confidently assess the impact (with statistical significance) of overflights on the density of waterfowl; and
- Two additional years of breeding waterfowl monitoring are required to confidently (with statistical significance) identify if low-level jet flight training reduces the density of breeding waterfowl on plots overflown at a high frequency compared to control plots.

7. RECOMMENDATIONS

1. Based on the conclusions, it is recommended that two additional years of breeding waterfowl monitoring on the same plots be carried out. This will allow the necessary statistical determination if low-level jet flights reduce the density of breeding waterfowl on plots overflown at a high frequency compared to control plots.

2. Although the existing evidence indicates that waterfowl densities are not affected by low-level jet overflights and that straight and level flight could be allowed over waterfowl breeding areas without detrimental effects, it is recommended that the current practice of avoiding waterfowl breeding areas be continued for two more years, until it can be statistically shown that there is no effect.

8. REFERENCES CITED

Barry, T.W. and R. Spencer. 1976. Wildlife response to oil well drilling. Can. Wildl. Ser. Progress Note 67, Ottawa, On. 15 pp.

Bateman, M.C. 1994. Canada Goose breeding ground survey, Labrador, 1994. CWS Unpubl. Rep. prepared for DND Environmental Mitigation Program, Sackville, N.B. 15 pp.

Bateman, M.C. and A.H. Hicks. 1995. Waterfowl populations in Labrador - a data compilation and analysis. CWS Unpubl. Rep., Sackville, N.B. 61 pp.

Batt, B.D.; A.D. Afton; M.G. Anderson; C.D. Ankney; D.H. Johnson; J.A. Kadlec and G.L. Krapu, eds. 1992. Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis. 635 pp.

Belanger, L. and J. Bedard. 1989. Responses of staging Greater Snow Geese to human disturbance. J.Wildl. Manage. 53(3):713-719.

Black Duck Joint Venture. 1990. Standard operating procedures for aerial surveys. Prepared by Black Duck Joint Venture Technical Committee. 10 pp.

Department of National Defence, 1995. Environmental Impact Statement: Military Flight Training in Labrador. 3 volumes; 16 technical reports. Project Management Office Goose Bay, National Defence Headquarters, Ottawa, ON.

Dufour, P.A. 1980. Effects of noise on wildlife and other animals - review of research since 1971. Unpubl. Rep. U.S. Environmental Protection Agency, Washington, D.C. 97 pp.

Dunn, E.H.; M.D. Cadman and J.B. Falls. 1993. Monitoring bird populations: the Canadian experience. CWS Occasional Paper No. 95. 62 pp.

Dzubin, A. 1984. A partially annotated bibliography of disturbance, noise and harassment effects on birds. CWS Unpubl. Rept., Saskatoon, SK. 325 pp.

Erskine, A.J. 1987. A preliminary waterfowl population budget for the Atlantic Provinces 1978 - 1985. CWS Occasional Paper No. 60. pp. 65-72.

Fleming, W.J.; J.A. Dubovsky and J.A. Collazo. 1996. An assessment of the effects of aircraft activities on waterfowl at Piney Island, North Carolina. North Carolina Cooperative Fish and Wildlife Research Unit. North Carolina State University. pp. A1 - J5.

Goudie, R.I. and W.R. Whitman. 1987. Waterfowl populations in Labrador, 1980-1982. CWS Occasional Paper No. 60, pp. 45 - 60.

Havera, S.P.; L.R. Boens; M.M. Georgi and R.T. Shealy. 1992. Human disturbance of waterfowl on Keokuk Pool, Mississippi River. Wildl. Soc. Bull. 20:290-298.

Lamp, R.E. 1989. Monitoring the effects of military air operations at Naval Air Station Fallon on the biota of Nevada. Unpubl. Rep. Nevada Dept. of Wildlife. 84 pp.

Lopoukhine, N.; N.A. Prout and H.E. Hirvonen. 1977. Ecological land classification of Labrador: a reconnaissance. Fish. and Envirn. Can. Ecol. Land Classif. Ser. No. 4. 85 pp.

Malecki, R.A. and R.E. Trost. 1985. Population trends in Atlantic Flyway Canada Geese: Implications for management. In: Canada Geese of the Atlantic Flyway. R.A. Malecki and J.R. Serie eds. 1991. Unpubl. Rep. Atlantic Flyway Council Technical Section. 109 pp.

Rowe, J.S. 1972. Forest Regions of Canada. Can. For. Ser. Publ. No. 1300. 172 pp.

Schweisburg, R.E., M.A. Gollop and R.A. Davis. 1974. Preliminary waterfowl disturbance studies, Mackenzie Valley, August, 1972. Arctic Gas Biological Report Series 14(6):232-257.

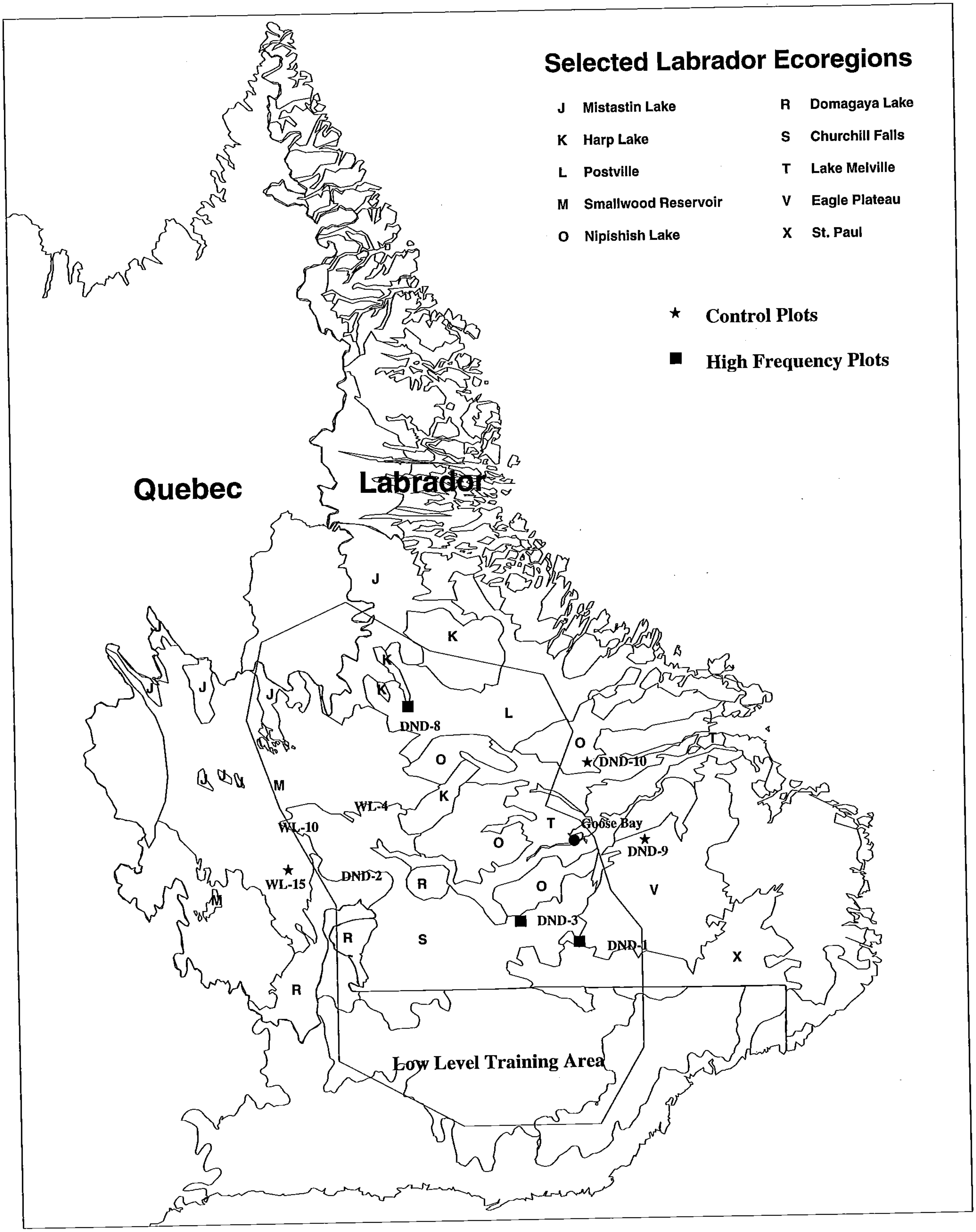

Figure 1. Locations of waterfowl breeding pair study areas surveyed in 1995, 1996, 1997, and 1998 in relation to Ecoregions of Labrador.

Table 1. Overflight category and ecoregion of each study site surveyed during the breeding pair surveys in Labrador, 1995-1997.

Study site	**Overflight category**	**Ecoregion**
DND9	Control	Eagle Plateau
DND10	Control	Nipishish Lake
WL15	Control	Smallwood Reservoir
DND1	High frequency	Eagle Plateau
DND3	High frequency	Churchill Falls
DND8	High frequency	Postville

Table 2. Total numbers of waterfowl observed on 100 km² plots in two categories surveyed by helicopter in Labrador during May-June, 1995, 1996, 1997 and 1998. (n = 3 except n = 2 high frequency plots in 1995).

	1995		1996		1997		1998	
	No. of birds	**$\bar{x}$ /100 km² (± sd)**	**No. of birds**	**$\bar{x}$ /100 km² (± sd)**	**No. of birds**	**$\bar{x}$ /100 km² (± sd)**	**No. of birds**	**$\bar{x}$ /100 km² (± sd)**
Control Plots								
Black Duck	48	16.0 ± 15.0	62	20.7 ± 23.2	41	13.7 ± 12.9	42	14.0 ± 9.3
Canada Goose	37	12.3 ± 7.4	59	19.7 ± 3.3	41	13.7 ± 1.2	64	21.3 ± 8.1
Green-winged Teal	15	5.0 ± 5.7	18	6.0 ± 3.7	12	4.0 ± 2.9	14	4.7 ± 3.8
Goldeneye	13	4.3 ± 3.3	26	8.7 ± 9.6	23	7.7 ± 10.8	17	5.7 ± 4.6
Common Merganser	3	1.0 ± 0.8	28	9.3 ± 5.4	17	5.7 ± 2.5	19	6.3 ± 4.9
Red-b. Merganser	57	19.0 ± 10.2	16	5.3 ± 7.5	40	13.3 ± 7.6	28	9.3 ± 6.6
Surf Scoter	19	6.3 ± 6.9	44	14.7 ± 9.1	34	11.3 ± 5.7	32	10.7 ± 10.0
Other	7	2.3 ± 1.9	15	3.0 ± 5.7	16	5.3 ± 6.1	3	1.0 ± 0.8
High Frequency Plots								
Black Duck	40	20.0 ± 1.0	146	48.7 ± 16.5	82	27.3 ± 12.5	57	19.0 ± 4.3
Canada Goose	24	12.0 ± 6.0	89	29.7 ± 11.0	100	33.3 ± 15.7	68	22.7 ± 23.6
Green-winged Teal	14	7.0 ± 5.0	52	17.3 ± 11.9	29	9.7± 8.7	13	4.3 ± 4.2
Goldeneye	25	12.5 ± 4.5	32	10.7 ± 7.5	43	14.3 ± 11.1	20	6.7 ± 6.0
Common Merganser	6	3.0 ± 1.0	18	6.0 ± 3.3	13	4.3 ± 4.8	21	3.0 ± 4.1
Red-b. Merganser	23	11.5 ± 8.5	25	8.3 ± 11.8	12	4.0 ± 1.6	49	16.3 ± 10.3
Surf Scoter	26	13.0 ± 1.0	136	45.3 ± 25.3	109	36.3 ± 15.6	76	25.3 ± 15.1
Other	75	37.5 ± 30.5	182	60.7 ± 43.8	123	41.0 ± 22.6	114	38.0 ± 32.8

Table 3. Total indicated pairs and mean densities of Black Ducks and Canada Geese recorded on two categories of survey plots in Labrador, 1995, 1996, 1997 and 1998.

	1995		1996	
	No. of pairs	**x̄/ 100 km²±sd**	**No. of pairs**	**x̄/ 100 km²±sd**
Black Ducks				
Control	17	5.7 ± 4.0	19	6.3 ± 6.9
High Frequency	17	8.5 ± 2.5	55	18.3 ± 11.2
Canada Goose				
Control	22	7.3 ± 3.7	33	11.0 ± 0.8
High Frequency	14	7.0 ± 4.0	35	11.7 ± 6.3

	1997		1998	
	No. of pairs	**x̄/ 100 km²±sd**	**No. of pairs**	**x̄/ 100 km²±sd**
Black Ducks				
Control	9	3.0 ± 2.2	15	5.0 ± 2.9
High Frequency	32	10.7 ± 8.1	43	14.3 ± 7.6
Canada Goose				
Control	27	9.0 ± 0.8	37	12.3 ± 6.0
High Frequency	41	13.7 ± 8.2	41	13.7 ± 13.0

Table 4. Species composition in percent of waterfowl recorded on breeding waterfowl survey blocks in Labrador, 1995.

	Control			High Frequency		
	DND9	DND10	WL15	DND1	DND3	DND8
Canada Goose	6.1	32.5	19.1	-	8.6	11.0
Black Duck	0	30.0	32.7	-	30.0	11.7
Green-winged Teal	0	5.0	11.8	-	2.9	7.4
Northern Pintail	0	2.5	0	-	2.9	0
Ring-necked Duck	4.1	0	0	-	2.9	0
Goldeneye	16.3	0	4.5	-	24.3	4.9
Red-breasted Merganser	65.3	65.3	16.4	-	4.2	12.3
Common Merganser	2.0	2.0	0	-	2.9	2.5
Scaup	0	0	0	-	2.9	40.5
Surf Scoter	0	0	14.6	-	17.1	8.6
Black Scoter	0	0	0	-	0	0
Harlequin	0	0	0	-	0	0
Other	6.1	2.0	0.9	-	1.3	1.2

Table 5. Species composition in percent of waterfowl recorded on breeding waterfowl survey blocks, 1996.

	Control			High Frequency		
	DND9	DND10	WL15	DND1	DND3	DND8
Canada Goose	53.7	21.7	13.9	14.3	16.0	10.8
Black Duck	0	13.0	33.5	23.9	38.0	13.0
Green-winged Teal	4.9	7.3	7.0	9.6	1.0	7.9
Northern Pintail	0	0	1.3	0.3	2.0	0
Ring-necked Duck	0	0	0	3.0	0	0
Goldeneye	9.8	0	13.9	5.3	16.0	0
Red-breasted Merganser	0	0	10.1	0	0	9.0
Common Merganser	26.8	21.7	1.3	3.3	6.0	0.7
Scaup	0	0	1.3	12.6	0	33.6
Surf Scoter	4.9	33.3	12.0	25.3	14.0	16.6
Black Scoter	0	0	3.8	1.3	0	4.0
Harlequin	0	0	0	0	0	0
Other	0	2.9	1.9	0.7	5.0	3.6

Table 6. Species composition in percent of waterfowl recorded on breeding waterfowl survey blocks, 1997.

	Control			High Frequency		
	DND9	**DND10**	**WL15**	**DND1**	**DND3**	**DND8**
Canada Goose	27.3	22.7	12.3	23.0	14.8	17.9
Black Duck	0	15.2	27.2	18.7	13.0	14.3
Green-winged Teal	2.3	4.5	7.0	8.9	0	4.8
Northern Pintail	0	0	0.9	0	0	0
Ring-necked Duck	0	1.5	0	2.1	0	0
Goldeneye	0	0	20.2	5.1	26.9	1.2
Red-breasted Merganser	47.7	4.5	14.0	0.9	3.7	3.6
Common Merganser	11.4	4.5	7.9	0	10.2	1.2
Scaup	0	0	0	12.8	0	38.7
Surf Scoter	9.1	27.3	10.5	24.7	20.4	17.3
Black Scoter	0	0	0	2.6	0	0
Harlequin	0	0	0	0	2.8	0.6
Other	2.3	19.7	0	1.7	8.3	0.6

Table 7. Species composition in percent of waterfowl recorded on breeding waterfowl survey blocks, 1998.

	Control			High Frequency		
	DND9	DND10	WL15	DND1	DND3	DND8
Canada Goose	21.3	33.8	29.5	23.5	7.5	4.3
Black Duck	2.1	28.6	20.0	34.9	28.3	9.0
Green-winged Teal	4.3	13.0	2.1	5.5	0	1.6
Northern Pintail	0	0	0	0	0	0
Ring-necked Duck	0	0	0	5.5	0	0
Goldeneye	8.5	1.3	12.6	6.3	7.5	0.5
Red-breasted Merganser	38.3	2.6	8.4	1.3	34.0	14.9
Common Merganser	25.5	9.1	0	2.9	3.8	6.4
Scaup	0	0	0	0.4	0	36.2
Surf Scoter	0	10.4	25.3	15.1	7.5	19.1
Black Scoter	0	0	0	1.3	0	2.1
Harlequin	0	0	0	0	3.8	0
Other	0	1.3	2.1	3.3	7.6	5.9

Table 8. Results of an incomplete randomized block design ANOVA using Black Duck and Canada Goose numbers from breeding pair plots in Labrador (control plots and plots with high frequency of overflights) surveyed in 1995, 1996, 1997, and 1998.

Species	Treatment	Data Type	Plot p value	Year p value	Linear p value
Black Duck	Control	Pairs	0.0357	0.704	0.501
Black Duck	Control	Individuals	0.0081	0.82	0.572
Black Duck	High Freq.	Pairs	0.0006	0.107	0.213
Black Duck	High Freq.	Individuals	0.0078	0.28	0.616
Canada Goose	Control	Pairs	0.1456	0.425	0.277
Canada Goose	Control	Individuals	0.1565	0.274	0.311
Canada Goose	High Freq.	Pairs	0.0074	0.954	0.762
Canada Goose	High Freq.	Individuals	0.0036	0.44	0.886

Table 9. Number of jet overflights by altitude for each plot April 22 - October 31, 1996. (data from DND flight recording system).

	Number of disturbances in altitude block				
Plots	**30-75 m**	**76-150 m**	**151- 300m**	**301-750m**	**>750m**
Control					
DND 9	0	0	0	0	0
DND 10	0	0	0	0	0
WL 15	0	0	1	0	0
Total	**0**	**0**	**1**	**0**	**0**
High Frequency					
DND 1	481	311	92	30	75
DND 3	242	150	34	44	37
DND 8	501	318	102	8	15
Total	**1224**	**779**	**228**	**82**	**127**

Table 9a. Number of jet overflights by altitude for each plot April 22 - May 19,1996. (data from DND flight recording system).

	Number of disturbances in altitude block				
Plots	**30-75 m**	**76-150 m**	**151- 300m**	**301-750m**	**>750m**
Control					
DND 9	0	0	0	0	0
DND 10	0	0	0	0	0
WL 15	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**
High Frequency					
DND 1	38	18	6	2	2
DND 3	81	23	9	3	3
DND 8	31	22	3	0	0
Total	**150**	**63**	**18**	**5**	**5**

Table 9b. Number of jet overflights by altitude for each plot May 20 - June 30, 1996 (data from DND flight recording system).

Plots	Number of disturbances in altitude block				
	30-75 m	**76-150 m**	**151- 300m**	**301-750m**	**>750m**
Control					
DND 9	0	0	0	0	0
DND 10	0	0	0	0	0
WL 15	0	0	1	0	0
Total	**0**	**0**	**1**	**0**	**0**
High Frequency					
DND 1	154	73	44	14	42
DND 3	16	4	2	16	12
DND 8	177	105	37	2	8
Total	**347**	**182**	**83**	**32**	**62**

Table 9c. Number of jet overflights by altitude for each plot July 1 - September 1, 1996. (data from DND flight recording system).

	Number of disturbances in altitude block				
Plots	**30-75 m**	**76-150 m**	**151- 300m**	**301-750m**	**>750m**
Control					
DND 9	0	0	0	0	0
DND 10	0	0	0	0	0
WL 15	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**
High Frequency					
DND 1	150	73	18	5	16
DND 3	11	4	4	12	13
DND 8	133	81	40	0	2
Total	**294**	**158**	**62**	**17**	**31**

Table 9d. Total disturbances due to jet overflights by altitude for each plot September 2 - October 31, 1996. (data from DND flight recording system).

	Number of disturbances in altitude block				
Plots	**30-75 m**	**76-150 m**	**151- 300m**	**301-750m**	**>750m**
Control					
DND 9	0	0	0	0	0
DND 10	0	0	0	0	3
WL 15	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**3**
High Frequency					
DND 1	139	147	24	9	14
DND 3	134	119	19	13	8
DND 8	160	110	22	6	5
Total	**433**	**376**	**65**	**28**	**27**

APPENDIX A

Power Analysis of Labrador waterfowl surveys prepared by Statistical Consulting Services, Dept. of Mathematics, Statistics and Computing Science, Dalhousie Univ., Halifax, Nova Scotia

Power Analysis of Labrador Waterfoul Surveys

prepared by Statistical Consulting Services, Dept. of Mathematics, Statistics, and Computing Science , Dalhousie Univ., Halifax, Nova Scotia

We report on the power of the CONTROL (3) and HIGH FREQUENCY (3) plots to detect change in population trend. The analysis will be concerned with the power both between and within the CONTROL and HIGH FREQUENCY plots.

Statistical models:

We assume that the count of the number of birds (both individual birds and breeding pairs) at a given location (i), for a given plot (j) and in a given year (k) is denoted by n_{ijk}.

We will model the years in two different ways: a) consider each location separately b) compare the locations. The models are given below for each location:

a)

$n_{ijk} = m + plot_i + year_j + \varepsilon_{ijk}$. for each I and note that **var**$(\varepsilon_{ijk}) = \sigma^2$.

The models for comparing the high frequency plots to the control plots are given below:

b)

$n_{ijk} = \mu + location_i + plot_{j(i)} + year_j + location_i \times year_j + \varepsilon_{ijk}$, with **var**$(\varepsilon_{ijk}) = \sigma^2$.

The models given above are incomplete randomized block designs (see Montgomery, 1984), which enable us to compute estimates for σ^2 which is critical in all power calculations. The plot term in each of the models forms the block.

Each of the above models will be repeated for both Black Duck and Canada Goose.

Descriptive Statistics

The following table gives mean counts of the number of pairs and individuals for each species and location averaged across plots.

Species	Location	Count	1995	1996	1997	1998
Duck	Control	Pairs	5.7	6.3	3.0	5.0
Duck	Control	Ind.	16.0	20.7	13.7	14.0
Duck	High	Pairs	8.5	18.3	10.7	14.3
Duck	High	Ind.	20.0	48.7	27.3	38.3
Goose	Control	Pairs	7.3	11.0	9.0	12.3
Goose	Control	Ind.	12.3	19.7	13.7	21.3
Goose	High	Pairs	7.0	11.7	13.7	13.7
Goose	High	Ind.	12.0	29.7	33.3	22.7

ANOVA Tables:

We present the results of the incomplete randomized block designs analysis of variance results for both species and each combination given above. Note that since the design is unbalanced that the F statistics reported are partial F values. Note that the MSE is our "best" estimate of σ^2.

				Plot			Year			Linear			
Species	Location	Count	df	F	Pvalue	df 3	F	Pvalue	df	F	Pvalue	df	MSE
Duck	Control	Pairs	2	6.11	0.0357	3	0.49	0.7044	1	0.51	0.5019	6	12.81
Duck	Control	Ind.	2	11.93	0.0081	3	0.31	0.8203	1	0.36	0.57226	6	101.78
Duck	High	Pairs	2	45.03	0.0006	3	3.46	0.1076	1	2.03	0.2131	5	8.52
Duck	High	Ind.	2	14.88	0.0078	3	1.71	0.2800	1	0.29	0.6162	5	137.96
Goose	Control	Pairs	2	2.70	0.1456	3	1.08	0.4258	1	1.43	0.2772	6	13.44
Goose	Control	Ind.	2	2.57	0.1565	3	1.65	0.2749	1	1.22	0.3119	6	35.44
Goose	High	Pairs	2	15.28	0.0074	3	0.10	0.9548	1	0.10	0.7628	5	25.90
Goose	High	Ind.	2	21.36	0.0036	3	1.07	0.4406	1	0.02	0.8862	5	68.22

The above table indicates that there are differences among the plots within both species (Black Duck and Canada Goose), and Control and High Frequency plots, with the exception of Canada Goose Control plots. We also note that for the majority of scenarios given above there are differences in years, particularly, there does not appear to be any evidence for a linear trend.

Black Ducks

	Pairs			Individuals		
Effect	Df	F	Pvalue	df	F	Pvalue
Location	1	2.36	0.1995	1	1.65	0.2681
Plot(Location)	4	19.95	<0.0001	4	12.73	0.0004
Year	3	2.83	0.0877	3	1.76	0.2121
Linear	1	2.13	0.1723	1	0.64	0.4410
Location x Year	3	0.45	0.7233	3	0.5074	0.6852
Location x Linear	1	0.18	0.6760	1	0.00	0.9507
		MS			MS	
Plot(Location)	4	216.60		4	1505.2	
Error	11	10.86		11	118.2	

Canada Geese

	Pairs			Individuals		
Effect	Df	F	Pvalue	df	F	Pvalue
Location	1	0.2653	0.6336	1	0.92	0.3926
Plot(Location)	4	10.54	0.0009	4	13.36	0.0003
Year	3	0.38	0.7693	3	0.89	0.4754
Linear	1	0.89	0.3658	1	0.56	0.4711
Location x Year	3	0.43	0.7378	3	1.67	0.2300
Location x Linear	1	0.15	0.7051	1	0.23	0.6377
		MS			MS	
Plot(Location)	4	201.29		4	672.72	
Error	11	19.11		11	50.34	

The tests for Location main effect do not use the mean square error as the denominator for computing the F statistic, it uses the mean square for plot within location as its denominator.

Power Tables:

The power of any statistical test depends on three parameters.

The significance level of the statistical test.

The sample size

The effect size, which is a measure of the practically significant difference in relation to the variability, as measured by s^2. Using the notation of Odeh Fox (1991) the effect size is denoted by j and is defined below, depending on whether the design is one factor or two factors.

$$\varphi = \sqrt{\frac{n\sum_i \delta_i^2}{I\sigma^2}}$$

Where δ_i is the difference between the ith year and the average year for the one factor design. A very similar formula holds for the interaction between location and year.

We consider the following scenarios:

Significance level (α): 0.05.

Effect pattern: constant change per year, a linear trend, that is in each year the number of animals decreases by the same amount every year.

Effect size: measured by non-centrality parameter, φ, as defined above.

We present the results for four possible scenarios, Black Duck and Canada Goose: individual birds and mating pairs. Only results for the comparison of slopes between control and high frequency plots will be presented.

The scenarios to be presented are as follows:

1. How many years would it take to detect a difference of: a) 4 Black ducks per 100 sq. km per year or b) 4 Canada Geese per year?

2. How many years would it take to detect a difference of a) 1 Pair of Black Ducks or b) 1 Pair of Canada Geese.

3. How many years would it take to detect a difference of a) 2 Pair of Black Ducks or b) 2 Pair of Canada Geese.

4. How many years would it take to detect a difference of a) 3 Pair of Black Ducks or b) 3 Pair of Canada Geese.

The power for each scenario and each number of years is given below.

Scenario	4 years	5 years	6 years
1 a)	0.591	0.906	0.994
1 b)	0.918	0.999	1.000
2 a)	0.440	0.771	0.959
2 b)	0.276	0.532	0.798
3 a)	0.950	1.000	1.000
3 b)	0.777	0.982	1.000
4 a)	1.000	1.000	1.000
4 b)	0.982	1.000	1.000

The next scenario is to consider how large of a trend could be detected with 10 years of data for both 70 and 80 percent power?

Species	Number	70% Power	80% Power
Black Duck	Pairs	0.29 per year	0.33 per year
	Individuals	0.95 per year	1.08 per year
Canada Goose	Pairs	0.39 per year	0.44 per year
	Individuals	0.62 per year	0.70 per year

Conclusions:

There is reasonable power to detect changes that were given in the above scenarios, however, the actual analysis of the data did not indicate any significant trend differences. This indicates that the present data do not exhibit a statistically significant trend.

References:

Montgomery, Douglas C. (1984) "Design and Analysis of Experiments", John Wiley and Sons, New York.

Odeh, Robert E. and Fox, Martin (1991) "Sample Size Choice: Charts for Experiments with Linear Models", Marcel Dekker, New York.