WATERFOWL SURVEYS ON THE KAWDY PLATEAU, NORTHERN BRITISH COLUMBIA, DURING 1990

James S. Hawkings
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ABSTRACT

During spring and summer 1990, helicopter surveys for waterfowl were conducted using a stratified random sample of 4 km^2 plots on the Kawdy Plateau of northern British Columbia. Total breeding populations in the 1,312 km^2 study area were 5,200-6,400 waterfowl at densities of approximately 4-5 birds per km^2. Estimates of brood numbers were very low by comparison (about 300 total), probably due in part to poor weather during the brood survey. Scaup (likely Lesser Scaup) dominated the community during breeding pair surveys (38-48% of all birds), followed by Northern Pintail (24-35%) and American Green-winged Teal (11-16%). Estimated populations of these three species on the Kawdy Plateau represent three, three, and four percent respectively of the total populations estimated for British Columbia. Cavity nesting ducks (Goldeneye sp. and Bufflehead) were completely absent, and the proportion of Mallards was much lower than at lower elevations in northern B.C. Oldsquaws, Harlequin Ducks, and Red-throated Loons bred in low densities. On the 20 plots which were surveyed, Green-winged Teal and Scaup were the species most highly associated with each other. Of five habitat variables examined, four representing the total area and number of wetlands on each plot were all positively correlated with numbers of waterfowl, while the fifth, elevation, was negatively correlated with numbers of waterfowl. Of the five, elevation and the area of marsh were the best predictors of numbers of Green-winged Teal and Northern Pintails on each plot, while elevation and the area of lakes and ponds were the best predictors of the numbers of Scaup. Stratification based on the number and total area of wetlands in each plot was not very effective in improving the precision of population estimates for this study area, mostly because high numbers of birds were found in a few plots in the low density stratum. The survey method used has a number of advantages over other aerial survey techniques and is recommended, with a few minor changes.

RÉSUMÉ

Au printemps et en été de 1990, des relevés en hélicoptère d'oiseaux aquatiques ont été dffectués selon un échantillon aléatoire stratifié de parcelles de 4 km^2 comptaient 5 200-6 400 oiseaux aquatiques, avec une densité d'environ 4-5 oiseaux par km^2. Les estimations des nombres de nichées étaient comparativement très faibles (environ 300 en tout), probablement et en partie à cause des conditions météo médiocres pendant le relevés des nichées. Le Petit Morillon semblait constituer l'espèce dominant pendant les relevés de paires nicheuses (38-48% de tous les oiseaux), suivie de Canard pilet (24-35%) et de la Sarcelle à ailes vertes d'Amérique (11-16%). Les populations estimatives de ces trois espèces sur le plateau Kawdy représentent respectivement trois, trois et quatre pour cent des populations totales ayant fait l'objet de relevés en Colombie-Britannique. Les canards nichant dans le cavités (Garrot à oeil d'or et Petit Garrot) étaient complètement absents et la proportion de Canard colvert était beaucoup plus faible que dans les régions à plus faible altitude du nord de la Colombie-Britannique. Le Canard kakaw,le Canard Harlequin et le Huart à gorge rousse nichent en densité relativement faible. Sur les 20 parcelles ayant fait l'objet de relevés, ce sont la Sarcelle à ailes vertes et le Morillon que étaient les espèces présentant le caractère associatif le plus marqué. Des cinq variables relatives à l'habitat examinées, quatre, représentant la surface totale it le nombre de terres humides dans chaque parcelle, présentaient une corrélation positive avec les nombres d'oiseaux aquatiques, alors que la cinquième, l'altitude, accusait une corrélation négative avec ces mêmes nombres. Des cinq variables, c'est l'altitude et la superficie des marais qui constituaient les meilleurs prédicteurs des nombres de Sarcelle à ailes vertes et de Canard pilet sur chaque parcelle, alors aue l'altitude et la superficie des lacs et des étangs constituaient les meilleurs prédicteurs pour les nombres de Morillon. La stratification, basée sue le nombre et la superficie totale des terres humides dans chaque parcelle, n'améliorait pas de façon très sensible la précision des estimations de populations pour cette zone d'étude, principalement à cause du fait que des nombres élevés d'oiseaux one été observés dans quelques parclles du stratum de faible densité. La méthode de relevé utilisée présente un certain nombre d'avantages par rapport à d'autre techniques aériennes de relevé. et son emploi est donc conseillé avec quelques modifications mineures.

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INTRODUCTION

Northern B.C. has been identified as a large unsurveyed area where very little is known about waterfowl populations. Generally the area lacks wetlands of continental significance, but because of its large size, even low densities of waterfowl could be contributing substantially to B.C. waterfowl populations.

In 1989 the Canadian Wildlife Service initiated surveys of breeding waterfowl in low-lying areas of northern B.C. (Liard Plain and Teslin Plateau). The objective of the 1990 survey program was to determine the species composition and densities of waterfowl at higher elevations in northern B.C.

STUDY AREA

The study area encompasses 1,312 km^2 of relatively flat terrain located on the Kawdy Plateau, northwest of Dease Lake, B.C. (Fig. 1) (59 degrees 05 minutes N, 131 degrees W) at an elevation of 1,220-1,600 m. It is bordered by the Tuya Range and Tuya Lake to the northeast, Tuya River to the east, the French and Level Mountain ranges to the southeast and south respectively, and the Atsutla Range to the northwest.

The wetlands in this area are variable, including streams, lakes, ponds, fens, and bogs. Northern ribbed fens and similar peatlands are particularly noticeable compared to lower elevations. The upland vegetation varies from open spruce forest at the lower elevations to alpine tundra and blockfields in high elevations. Birch and willow shrubs are common.

METHODS

Survey Design

The initial sampling design for this study used individual waterbodies as sample units to maintain consistency with the method used in 1989 (Nixon and Majiski in prep). After an initial attempt to survey the area on 28 May this approach was abandoned. A plot based design was adopted, as employed in northern Ontario by Ross (1985, 1987). The entire area was divided into 2x2 km blocks using UTM gridlines on 1:50,000 topographic maps. Several blocks were excluded because they obviously contained no water. The remaining 328 blocks were divided into high density (22 blocks) and low density (306 blocks) strata based on a fairly subjective assessment of the number and size of waterbodies (i.e. potential waterfowl habitat) within each block. A random sample of 6 (22%) of the high and 14 (4.6%) of the low blocks was chosen for surveying, the total of 20 blocks being considered the maximum which could be surveyed with the available resources.

Survey Method

Plots were marked on 1:50,000 topographic maps and on acetate overlays of black and white aerial photographs of the study area (approx. scale 1:60,000). Both maps and photos were used for navigation. A Bell 206B helicopter with a range extender and bubble windows in the rear was utilized for the surveys. For the breeding pair surveys observers were seated left front and left rear in the helicopter with all navigation conducted by the observer in the front. For the brood survey an additional observer was located in the right rear. All water in each plot was surveyed by manoeuvring the helicopter at altitudes of 10 to 50 meters. In some cases it was necessary to hover or recircle the wetland when large groups of birds were encountered. Number, sex and species of waterbirds were recorded into a tape recorder by each of the observers. Wetland characteristics and snow and ice cover were recorded as well as incidental bird and wildlife sightings. Broods were aged according to Gollop and Marshall (1954).

Reconnaissance surveys were flown on 16 and 28 May and 4 June to determine the

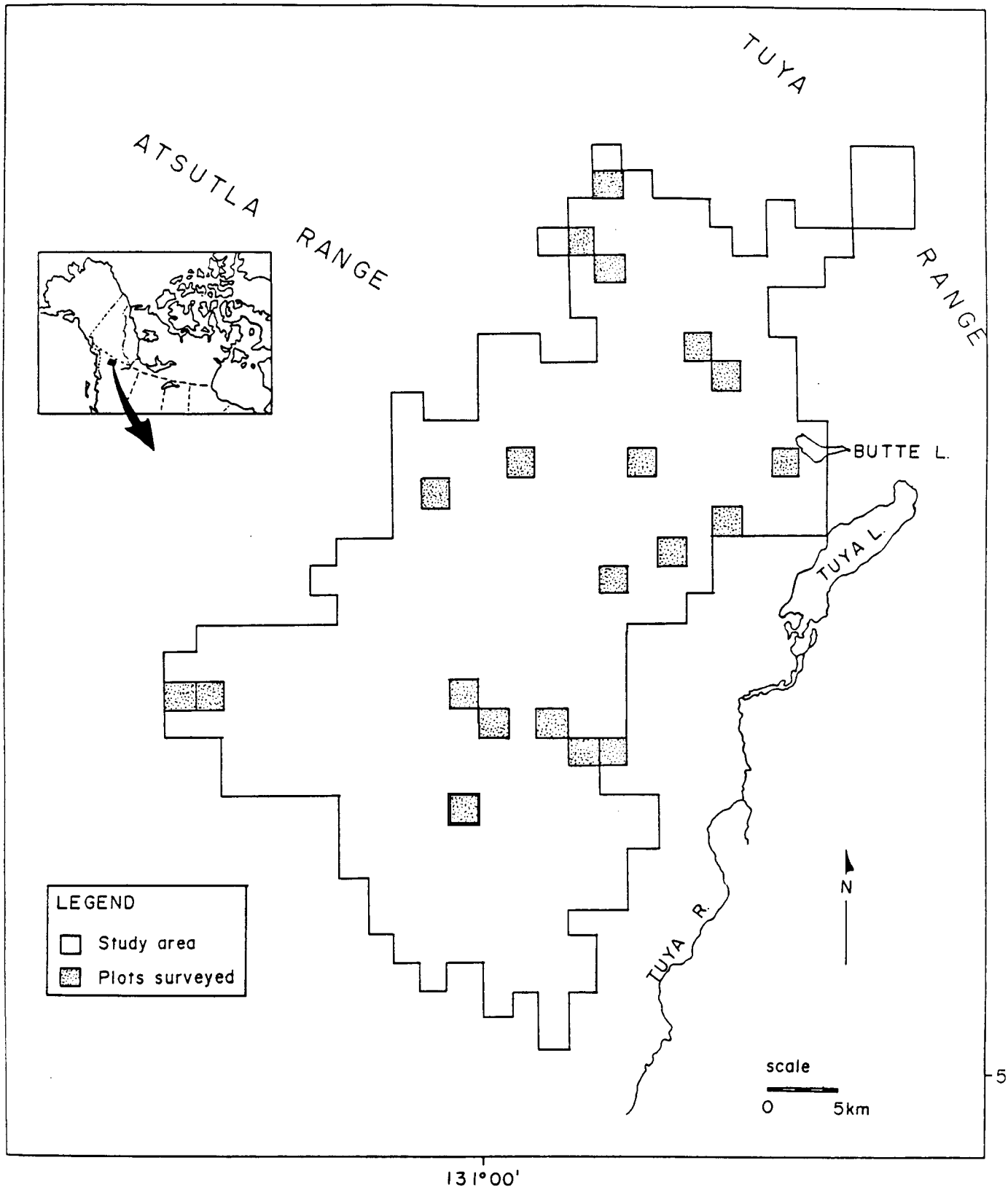


Figure 1. Location of the Kawdy Plateau study area, B.C., and individual plots surveyed during June 1990.

appropriate time for a full scale survey. The 28 May flight was intended to be a full-scale survey, but most of the area was still snow and ice-covered so the survey was aborted. Full-scale surveys were conducted on 6 and 13 June for breeding pairs and on 31 July for broods.

Habitat Data

For each 2x2 km plot surveyed, the following parameters were determined from the 1:50,000 mapsheets: number of ponds and lakes (blue on mapsheets); total area of ponds and lakes; number of marshes (designated by marsh, swamp, or string bog symbols); total area of marshes; total length of creeks, and elevation.

Data Analysis

In the office, data were transcribed from tapes to coding sheets and keypunched into an IBM mainframe computer. Indicated pairs of waterfowl were calculated for each survey as the sum of (observed pairs + males in all-male groups of 5 or less). Groups were divided into the appropriate number of pairs and excess males. All summaries and analyses were performed using SAS procedures (SAS Institute Inc. 1985a,b). Prior to regression and correlation analyses, data were log-transformed using log(x+1) to reduce skewness. Regression analysis was performed with PROC STEPWISE using the maximum r^2 method and significance level for entry into the model = .05. Correlation matrices were obtained using the PRINCOMP procedure. Total population and density estimates were generated using procedures for a stratified random sample; i.e. separate estimates were generated for each stratum, then combined for an overall estimate.

RESULTS AND DISCUSSION

Habitat Conditions

During the first full survey on 6 June, the highest elevation plots (Plots 91, 93, 112, 222; elevation 1,460-1,510 m) were still 70-90 percent snow covered with the larger ponds and lakes still frozen. The lowest plots were almost totally snow and ice free. Some of the waterbodies in the vicinity of Blackfly Lake had about 5 percent ice cover. Meltwater was abundant on all plots. Streams were extremely high, and many lakes were above their normal levels.

On 13 June the highest plots still had 10 to 20 percent snow cover and some of the lakes on them had partial ice cover. Water levels had receded somewhat on most plots, especially at lower elevations.

On 31 July all plots were substantially drier than during early June. Most of the shallow ponds and peatlands were markedly drier, and many of the peatlands completely lacked standing water.

Figures 2 and 3 show some of the typical wetlands over a range of elevations in the 20 plots which were surveyed. These photographs were taken on 31 July 1990.

Waterfowl Populations

The actual plot by plot counts of waterfowl and loons on the 6 and 13 June and 31 July surveys are shown in Appendices I and II, and sightings of other birds and miscellaneous wildlife are contained in Appendix III. On 6 June 497 waterfowl were counted including 261 indicated pairs, while on 13 June 476 individuals were counted including 197 indicated pairs (Table 1). This resulted in estimates of 6,406±41%(SE) waterfowl and 3,505±40% pairs on 6 June and 5,220±50% waterfowl and 1,959±45% pairs on 13 June (Tables 2, 3). Overall densities of waterfowl were 4.88 individuals and 2.67 pairs per km^2 on 6 June and 3.98 individuals and 1.49 pairs per km^2 on 13 June (Table 4).

On 31 July 208 birds and 26 broods were counted (App. II), resulting in a total

population estimate of 3,009±59%(SE) birds including 314±59% broods (Table 5). Overall densities were 2.3 birds and 0.24 broods per km^2 (Table 6). Sizes and ages of broods are given in Table 7. Brood numbers were very low compared to breeding pairs (314 broods vs. 2,000-3,500 breeding pairs), about 1 brood for every 6-11 breeding pairs. Several factors are possibly responsible for this: Broods are less visible than breeding pairs, and fairly windy weather at the time of the brood survey (in contrast to ideal conditions during the breeding pair surveys) likely exaggerated this difference in visibility. It is also possible that because of a late spring melt combined with a dry summer, many pairs either did not nest, suffered low nest success, or nested so late that hatching occurred after the 31 July survey.

Species Composition

On both breeding pair surveys the most abundant species observed and estimated were Scaup (presumably Lesser Scaup), Northern Pintails, and American Green-winged Teal. Oldsquaw, Mallard, and American Wigeon were present in much smaller numbers.

On the brood survey Northern Pintail, American Green-winged Teal, and Scaup were again the most common species (App. II). No broods of the less common species were seen, probably because of the small numbers of broods seen in total. The composition of broods observed (App. II) and estimated (Table 6) differs markedly from the composition of broods observed in mid-July 1989 in a small part of the study area (Majiski et al. 1990). In 1989 26 broods were counted (46% Scaup, 14% Wigeon, 11% Pintail, 11% Green-winged Teal, 6% Mallards, 2% Oldsquaw). Scaup broods were more predominant in 1989 (46%) than in 1990 (23%). Wigeon and Mallard and Oldsquaw broods were present in 1989 (14%, 6%, and 6% respectively) but were absent in 1990. Northern Pintail broods were much less predominant in 1989 (11%) than 1990 (35%), as were Green-winged Teal (11% vs. 30%). Oldsquaw broods were seen in 1989 but not in 1990. It seems that the Kawdy Plateau experienced a late spring but an extremely dry June and July compared to normal years, which may have resulted in some of these differences.

The species composition (measured by total birds, breeding pairs, or broods) was remarkably different from that which appears to be typical of lower elevation wetlands in adjacent parts of northern B.C. (Table 8). Notable at high elevation is the complete absence of cavity nesters such as Barrow's Goldeneye and Bufflehead, which together constitute approximately 20% of the population at low elevations. Mallards and American Wigeon are greatly reduced at high elevations. Northern Pintails, however, are a substantial part (38-48%) of the waterfowl community at high elevation, whereas they are insignificant at lower elevations. Oldsquaws, Harlequin Ducks, and Red-throated Loons are present in low densities at high elevation. This was more or less expected for Harlequins, but the Oldsquaws and Red-throated Loons were not expected. Scaup dominate the community at both high and low elevations.

Compared to waterbird (waterfowl, grebes, and loons) populations in the parklands of central British Columbia (Boyd et al. 1989), this study indicated the Kawdy Plateau has fewer species present (14 vs. 30) and breeding (approx. 8 vs. 23). Extensive ground surveys in the Kawdy Plateau would reduce this discrepancy somewhat. Again, the striking characteristic of the Kawdy Plateau in 1990 was the dominance of Scaup, Northern Pintail, and American Green-winged Teal, and the scarcity of almost everything else.

The waterfowl community found on the Kawdy Plateau may be indicative of the community found on other ecologically similar landscapes in northern B.C., for example the Spatsizi and Level Mountain areas. It appears that the high elevation areas of northern B.C. may be more significant than low elevation areas for Northern Pintails, while the reverse is definitely true for most other species common at lower elevations (Barrow's Goldeneye, Mallard, American Wigeon, Bufflehead.)

Figure 2. Photographs of the Kawdy Plateau study area. a. Plot 88. Elevation 1,260 m.

b. Plot 231. Elevation 1,280 m. Red-throated loons were found nesting in this plot.

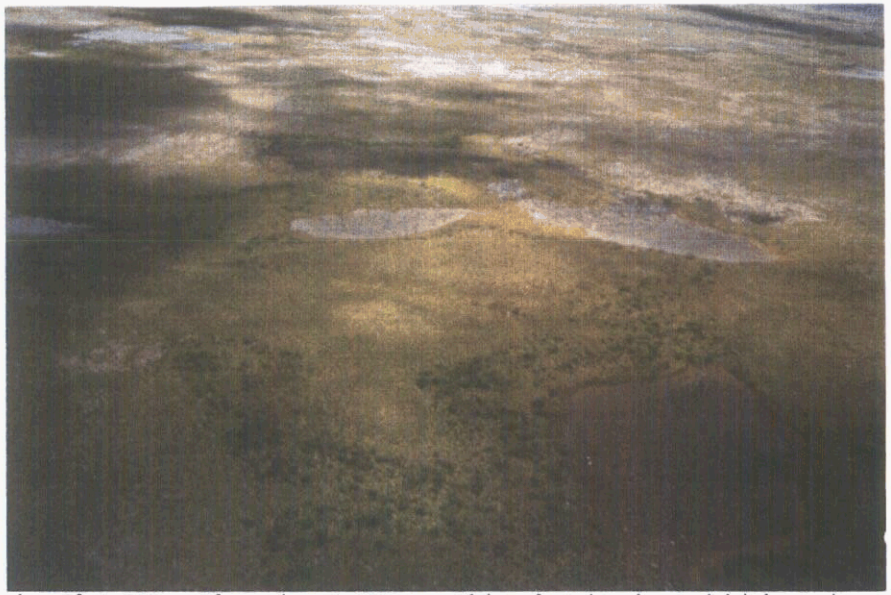
c. Plot 305. Elevation 1,260 m.

d. A flock of moulting Canada Geese was on this wetland between Plots 305 and 322 during the 31 July 1990 aerial survey. Elevation approx. 1,260 m.

Figure 3. Photographs of the Kawdy Plateau study area. a. Plot 105. Elevation 1,310 m. This plot just above treeline is rich in shrubs and small fens. It had lots of moose on the 6 June survey.

b. Plot 199. Elevation 1,250 m. This plot has abundant peatlands. The one pictured here near the southern edge of the plot is the most diverse and had the most birdlife.

c. Plot 91. Elevation 1,510 m. This plot is at the highest elevation of all the surveyed plots.



d. Plot 222. Elevation 1,460 m. This plot is the 2nd highest in elevation but the soils and vegetation are much poorer than in plot 91 (left). The wetlands here have stony bottoms and very few birds.

Table 1. Number of indicated pairs and total waterbirds observed in high and low density strata on aerial surveys in the Kawdy Plateau study area of northern B.C., 1990.

Species	6 June						13 June					
	High Density		Low Density		Total		High Density		Low Density		Total	
	Pairs	Total Birds	Pairs	Total Birds	Pairs	Total Birds	Pairs	Total Birds	Pairs	Total Birds	Pairs	Total Birds
Mallard	3	5	8	10	11	15	3	6	3	7	6	13
Northern Pintail	35	52	45	61	80	113	27	99	21	64	48	163
American Wigeon	4	7	-	-	4	7	2	2	-	-	2	2
Green-Winged Teal	26	34	20	28	46	62	24	38	18	32	42	70
Blue- Winged Teal	-	-	-	-	-	-	-	1	3	5	3	6
Northern Shoveler	1	2	4	6	5	8	4	4	-	-	4	4
Scaup sp.	45	121	53	120	98	241	62	111	18	71	80	182
Ring-necked Duck	1	2	-	-	1	2	-	-	-	-	-	-
Diver sp.	-	2	-	-	-	2	-	1	-	-	-	1
Common Merganser	-	1	-	-	-	1	1	2	-	-	1	2
Oldsquaw	5	9	6	11	11	20	4	7	3	6	7	13
Surf Scoter	-	-	-	-	-	-	2	5	-	-	2	5
Harlequin Duck	1	2	4	7	5	9	-	-	2	5	2	5
Duck sp.	-	-	-	6	-	6	-	-	-	-	-	-
Canada Goose	-	7	-	2	-	9	-	9	-	-	-	9
Loon sp.	-	1	-	-	-	1	-	-	-	-	-	-
Red-throated Loon	-	-	-	1	-	1	-	-	-	1	-	1
TOTAL	121	245	140	252	261	497	129	285	68	191	197	476

Table 2. Estimated numbers and species composition of indicated pairs and total waterbirds in the Kawdy Plateau study area (1,312 km^2) of northern B.C., 1990.

Species	6 June						13 June					
	Pairs			Total Birds			Pairs			Total Birds		
	EP[1]	SE[2]	%	EP	SE	%	EP	SE	%	EP	SE	%
Mallard	185	±54%	5.3	237	±46%	3.7	76	±70%	3.9	175	±81%	3.4
Northern Pintail	1112	±32%	31.7	1524	±33%	23.8	558	±36%	28.5	1762	±44%	33.8
American Wigeon	15	±62%	0.4	26	±62%	0.4	7	±53%	0.4	7	±53%	0.1
Green-Winged Teal	532	±35%	15.2	737	±35%	11.5	481	±41%	24.5	839	±41%	16.1
Blue- Winged Teal	-		-	-		-	66	±100%	3.4	113	±100%	2.2
Northern Shoveler	91	±78%	2.6	139	±73%	2.2	15	±62%	0.8	15	±62%	0.3
Scaup sp.	1323	±42%	37.8	3067	±38%	47.9	621	±41%	31.7	1959	±50%	37.5
Ring-necked Duck	4	±86%	0.1	7	±86%	0.1	-		-	-		-
Diver sp.	-		-	7	±86%	0.1	-		-	4	±86%	0.1
Common Merganser	-		-	4	±86%	0.05	4	±86%	0.2	7	±86%	0.1
Oldsquaw	150	±39%	4.3	273	±40%	4.3	80	±67%	4.1	157	±55%	3.0
Surf Scoter	-		-	-		-	7	±85%	0.4	18	±85%	0.3
Harlequin Duck	91	±78%	2.6	160	±75%	2.5	44	±68%	2.2	109	±70%	2.1
Duck sp.	-		-	-		2.0	-		-	-		-
Canada Goose	-		-	69	±81%	1.1	-		-	33	±58%	0.6
Loon sp.	-		-	4	±100%	0.05	-		-	-		-
Red-throated Loon	-		-	22	±100%	0.3	-		-	22	±100%	0.4
TOTAL	3504	±40%	100	6406	±41%	100	1959	±45%	100	5220	±50%	100

[1] Estimated Population

[2] Standard Error of the estimate. Determined as follows: Standard Error = Standard Deviation/(square root of n) x square root(1-n/N). 95% Confidence limits can be calculated from this by multiplying by $t_{.05,n-1}$. For the high density stratum n=6, N=22 and t = 2.571. For the low density stratum n=14, N=302 and t=2.16.

Table 3. Estimated numbers of indicated pairs and total waterbirds in high and low density strata on aerial surveys in the Kawdy Plateau study area of northern B.C., 1990.

Species	6 June												13 June											
	High Density				Low Density				Total				High Density				Low Density				Total			
	Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds	
	EP[1]	SE[2]	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE
Mallard	11	±58%	18	±55%	175	±54%	218	±50%	185	±54%	237	±46%	11	±58%	22	±44%	66	±72%	153	±86%	76	±70%	175	±81%
Northern Pintail	128	±24%	191	±37%	984	±33%	1333	±32%	1112	±32%	1524	±33%	99	±28%	363	±22%	459	±38%	1399	±50%	558	±36%	1762	±44%
American Wigeon	15	±62%	26	±62%	·		·		15	±62%	26	±62%	7	±53%	7	±53%					7	±53%	7	±53%
Green-Winged Teal	95	±15%	125	±15	437	±39%	612	±39%	532	±35%	737	±35%	88	±17%	139	±12%	393	±46%	699	±47%	481	41%	839	±41%
Blue- Winged Teal	·		·		·		·				·		·		4	±86%	66	±100%	109	±100%	66	±100%	113	±100%
Northern Shoveler	4	±86%	7	±86%	87	±77%	131	±72%	91	±78%	139	±73%	15	±62%	15	±62%	·				15	±62%	15	±62%
Scaup sp.	165	±31%	444	±35%	1158	±44%	2623	±39%	1323	±42%	3067	±38%	227	±24%	407	±27%	393	±51%	1552	±56%	621	±41%	1959	±50%
Ring-necked Duck	4	±86%	7	±86%	·		·		4	±86%	7	±86%	·		·		·				·			
Diver sp.	·		7	±86%	·		·		·		7	±86%	·		4	±86%	·				·		4	±86%
Common Merganser	·		4	±86%	·		·		·		4	±86%	4	±86%	7	±86%	·				4	±86%	7	±86%
Oldsquaw	18	±29%	33	±35%	131	±40%	240	±40%	150	±39%	273	±40%	15	±42%	26	±39%	66	±72%	131	±58%	80	±67%	157	±55%
Surf Scoter	·		·		·		·		·		·		7	±85%	18	±85%			·		7	±85%	18	±85%
Harlequin Duck	4	±86%	7	±85%	87	±77%	153	±75%	91	±78%	160	±75%					44	±68%	109	±70%	44	±68%	109	±70%
Duck sp.	·		·		·		131	±72%	·		·		·		·		·				·			
Canada Goose	·		26	±47%	·		44	±100%			69	±81%			33	±58%	·						33	±58%
Loon sp.	·		4	±100%	·		·		·		4	±100%			·									
Red-throated Loon	·		·		·		22	±100%	·		22	±100%	·		·		·		22	±100%			22	±100%
TOTAL	444	±29%	898	±36%	3060	±42%	5508	±41%	3504	±40%	6406	±41%	473	±28%	1045	±28%	1486	±50%	4175	±55%	1959	±45%	5220	±50%

[1] Estimated Population

[2] Standard Error of the estimate. Determined as follows: Standard Error = Standard Deviation/(sqare root of n) x square root(1-n/N). 95% Confidence limits can be calculated from this by multiplying by $t_{.05,n-1}$. For the high density stratum n=6, N=22 and t = 2.571. For the low density stratum n=14, N=302 and t=2.16.

Table 4. Estimated densities of indicated pairs and total waterbirds per 100 km² in high and low density strata on aerial surveys in the Kawdy Plateau study area of northern B.C., 1990.

Species	6 June												13 June											
	High Density				Low Density				Total				High Density				Low Density				Total			
	Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds		Pairs		Total Birds	
	ED[1]	SE[2]	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE
Mallard	13	±58%	21	±55%	14	±54%	18	±50%	14	±54%	18	±46%	13	±58%	25	±44%	5	±72%	13	±86%	6	±70%	13	±81%
Northern Pintail	146	±24%	217	±37%	80	±33%	109	±32%	85	±32%	116	±33%	113	±28%	413	±22%	38	±38%	114	±50%	42	±36%	134	±44%
American Wigeon	17	±62%	29	±62%	-		-		1	±62%	2	±62%	8	±53%	8	±53%	-		-		0.5	±53%	0.5	±53%
Green-Winged Teal	108	±15%	142	±15	36	±39%	50	±39%	8	±35%	56	±35%	100	±17%	158	±12%	32	±46%	57	±47%	37	41%	64	±41%
Blue- Winged Teal	-		-		-		-		-		-		-		4	±86%	5	±100%	9	±100%	5	±100%	9	±100%
Northern Shoveler	4	±86%	8	±86%	7	±77%	11	±72%	7	±78%	11	±73%	17	±62%	17	±62%	-		-		1.1	±62%	1.1	±62%
Scaup sp.	188	±31%	504	±35%	95	±44%	214	±39%	101	±42%	234	±38%	258	±24%	463	±27%	32	±51%	127	±56%	47	±41%	149	±50%
Ring-necked Duck	4	±86%	8	±86%	-		-		0.3	±86%	0.5	±86%	-		-		-		-		-		-	
Diver sp.	-		8	±86%	-		-		-		0.5	±86%	-		4	±86%	-		-		-		0.3	±86%
Common Merganser	-		4	±86%	-		-		-		0.3	±86%	4	±86%	8	±86%	-		-		0.3	±86%	0.5	±86%
Oldsquaw	21	±29%	38	±35%	11	±40%	20	±40%	11	±39%	21	±40%	17	±42%	29	±39%	5	±72%	11	±58%	6	±67%	12	±55%
Surf Scoter	-		-		-		-		-		-		8	±85%	21	±85	-		-		0.5	±85%	1.4	±85%
Harlequin Duck	4	±86%	8	±85%	7	±77%	13	±75%	7	±78%	12	±75%	-		-		4	±68%	9	±70%	3	±68%	8	±70%
Duck sp.	-		-		-		11	±72%	-		-		-		-		-		-		-		-	
Canada Goose	-		29	±47%	-		4	±100%	-		5	±81%	-		38	±58%	-		-		-		2.5	±58%
Loon sp.	-		4	±100%	-		-		-		0.3	±100%	-		-		-		-		-		-	
Red-throated Loon	-		-		-		2	±100%	-		1.7	±100%	-		-		-		2	±100%	-		1.7	±100%
TOTAL	444	±29%	898	±36%	250	±42%	450	±41%	267	±40%	488	±41%	473	±28%	1045	±28%	121	±50%	341	±55%	149	±45%	398	±50%

[1] Estimated Density per 100 square kilometres.

[2] Standard Error of the estimate. Determined as follows: Standard Error = [Standard Deviation/(sqare root of n)] x square root(1-n/N). 95% Confidence limits can be calculated from this by multiplying by $t_{.05,n-1}$. For the high density stratum n=6, N=22 and t = 2.571. For the low density stratum n=14, N=302 and t=2.16.

Table 5. Estimated numbers of broods, juveniles and total birds in high and low density strata in the Kawdy Plateau study area of northern B.C., July 31 1990.

Species	High density						Low Density						Total					
	Broods		Juveniles		Total Birds		Broods		Juveniles		Total Birds		Broods		Juveniles		Total Birds	
	EP[1]	SE[2]	EP[1]	SE[2]	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE	EP	SE
Mallard	-	-	-	-	-	-	-	-	-	-	131	±85%	-	-	-	-	131	±85%
Northern Pintail	15	±63%	48	±78%	147	±57%	109	±48%	481	±50%	787	±39%	124	±50%	529	±52%	934	±42%
Green-Winged Teal	22	±54%	110	±49%	209	±35%	44	±58%	175	±60%	459	±37%	66	±57%	285	±56%	668	±72%
Scaup sp.	15	±43%	81	±39%	121	±40%	44	±58%	153	±64%	219	±59%	58	±55%	234	±55%	340	±52%
Duck sp.	-		-		-		66	±85%	66	±85%	66	±85%	66	±85%	66	±85%	66	±85%
Red-throated Loon	-		-		7	±54%	-		-		-		-		-		7	±54%
TOTAL	51	±20%	238	±20%	605	±32%	262	±39%	874	±36%	2404	±27%	314	±59%	1113	±56%	3009	±59%

[1] Estimated Population

[2] Standard Error of the estimate expressed as a percentage of the estimated population. Determined as follows: Standard Error = Standard Deviation/(sqare root of n) x square root(1-n/N). 95% Confidence limits can be calculated from this by multiplying by $t_{.05,n-1}$. For the high density stratum n=6, N=22 and t = 2.571. For the low density stratum n=14, N=302 and t=2.16.

Table 6. Estimated density (per 100 km^2) of broods, juveniles and total birds in high and low density strata in the Kawdy Plateau study area of northern B.C., July 31 1990.

Species	High density						Low Density						Total					
	Broods		Juveniles		Total Birds		Broods		Juveniles		Total Birds		Broods		Juveniles		Total Birds	
	ED[1]	SE[2]	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE	ED	SE
Mallard	-		-		-		-		-		11	±85%	-		-		10	±85%
Northern Pintail	17	±63%	54	±78%	167	±57%	9	±48%	39	±50%	64	±39%	9	±50%	40	±52%	71	±42%
Green-Winged Teal	25	±54%	125	±49%	238	±35%	4	±58%	14	±60%	38	±37%	5	±57%	22	±56%	51	±72%
Scaup sp.	17	±43%	92	±39%	138	±40%	4	±58%	13	±64%	18	±59%	4	±55%	18	±55%	26	±52%
Duck sp.	-		-		-		5	±85%	5	±85%	5	±85%	5	±85%	5	±85%	5	±85%
Red-throated Loon	-		-		8	±54%	-		-		-		-		-		0.5	±54%
TOTAL	58	±20%	271	±20%	688	±32%	21	±39%	71	±36%	196	±27%	24	±59%	85	±56%	230	±59%

[1] Estimated Density

[2] Standard Error of the estimate expressed as a percentage of the estimated density. Determined as follows: Standard Error = Standard Deviation/(sqare root of n) x square root(1-n/N). 95% Confidence limits can be calculated from this by multiplying by $t_{.05,n-1}$. For the high density stratum n=6, N=22 and t = 2.571. For the low density stratum n=14, N=302 and t=2.16.

Table 7. Size and age class of waterfowl broods observed on the Kawdy Plateau study area, 31 July 1990.

Species	Size X Age Class
Northern Pintail	4 x Ib-c 6 x IIa 4 x IIc 5 x ? 8 x IIb 3 x ? 1 x ? 3 x ? 1 x II
Green-winged Teal	5 x Ib 3 x III 6 x Ic 5 x Ib-c 1 x IIb 6 x IIb 7 x IIa 5 x ?
Scaup sp.	5 x Ib 2 x Ib 7 x Ib-c 6 x Ia-b 9 x Ib[1]
Duck sp.	1 x Ic 1 x Ib 1 x Ib

[1] 2 females in attendance; probably amalgamation of 2 broods.

Relationships Among Species

Generally the 3 most common species of ducks were significantly correlated with each other, i.e. plots which had one of the 3 common species tended to have the other two as well (Table 9). The strongest associations were between Green-winged teal and Pintails on the first survey and between Green-winged Teal and Scaup on both surveys. The weakest associations were between Scaup and Pintails in both surveys and between Green-winged teal and Pintails on the second survey.

Relationships Between Waterfowl and Habitat

The distribution of wetland types (as determined from the topographic maps) varied widely among the sampled plots (Table 10). Bivariate correlation analyses of five habitat variables and numbers of indicated pairs and total numbers of American Green-winged Teal, Northern Pintail, and Scaup on each of the 20 plots (all log-transformed except elevation) show that numbers of pairs were positively correlated to the amount and number of wetlands, and negatively correlated with elevation. Pairs of Green-winged Teal and Pintails were most correlated with elevation (negatively) followed by the total area of marsh on the first survey, and by the area of marsh on the second survey (Table 11, Fig. 4). Pairs of Scaup were best correlated with elevation, followed by the total area of lakes and ponds on both surveys (Table 11, Fig. 5).

Regression analysis (Table 12) showed that on survey 1 elevation was the most important predictor of pairs of all species. Area of marsh was the next most useful predictor for Northern Pintail and Green-winged Teal, and the number of ponds was next best for Scaup. The best model was that for Scaup, which explained 72 percent of the variation in numbers of pairs. On the second survey area of marsh was most important in predicting pairs of Northern Pintail and Green-winged Teal, followed by area of ponds for Pintail and number of marshes for Green-winged Teal. These models could explain only 40-45 percent of the variation, however. For Scaup, elevation was extremely important, explaining 54 percent of the variation. Adding area of ponds to the model increased this to 78 percent.

It should be noted that although two or more habitat variables might be highly correlated with the numbers of a particular duck species (Table 11), those habitat variables are often highly correlated with each other as well (e.g. in this case the total area of ponds and total area of marshes). When that is the case, only one of the habitat variables might contribute substantially to a multiple regression analysis because the others explain virtually the same variation.

Overall, the correlation and regression analysis results reflect three things: The strong positive relationship between duck numbers and wetlands; The negative influence of increasing elevation; and the influence of a drying trend between surveys as meltwater receded from the "marsh" areas indicated on the map. The drying trend caused Pintails to move to more permanent water, which tended to be indicated as "ponds" on the map. Scaup were closely related to ponds on both surveys but because of the drying trend this became more pronounced on the second survey. As expected, diving ducks (i.e. Scaup) were associated with deeper water than dabblers (Pintail and Green-winged Teal). Elevation was only weakly correlated with the 4 variables representing the number and area of wetlands (e.g. Fig. 6), thus it had a relatively independent influence on the number of ducks present.

These analyses are somewhat crude due to the nature of the habitat data used. On the mapsheets some marsh areas included ponds, while others did not. There are great differences in the characteristics of wetlands from one plot to another which have not been quantified and therefore have not been considered in these analyses. For example some ponds are peatlands whereas others have gravel or

Table 8. Estimated species compositon[1] (percent) of waterfowl populations at high elevation wetlands (Kawdy Plateau) and low elevation wetlands (Teslin Plateau and Liard Plain) of northern B.C.

Species	Teslin Plateau 1989	Liard Plain 1989	Kawdy Plateau 1990
Mallard	11	18	3
Northern Pintail	1	1	24-34
American Wigeon	3	3	<1
Green-Winged Teal	2	6	11-16
Blue- Winged Teal	<1	1	0-2
Northern Shoveler	1	1	0-2
Scaup sp.	48	28	38-48
Ring-necked Duck	5	6	<1
Canvasback	<1	-	-
Common Merganser	<1	-	<1
Barrow's Goldeneye[2]	11	14	-
Bufflehead	8	5	-
Oldsquaw	<1	-	3-4
Scoter sp.	1	<1	-
Surf Scoter	4	4	<1
White-winged Scoter	<1	<1	-
Harlequin Duck	-	-	2
Canada Goose	-	-	1
Common Loon	1	7	-
Red-throated Loon	-	-	<1
Pacific Loon	<1	4	-
TOTAL	100	100	100

[1] For the Teslin and Liard areas, the figure is the mean of 4 replicate surveys. For the Kawdy area the figure is the range of two surveys.

[2] includes some Goldeneye sp.

Table 9. Correlations among 3 species of ducks on 2 surveys of 20 plots on the Kawdy Plateau study area, B. C., 1990. Correlation coefficients are given for log-transformed numbers of indicated pairs. Except where noted, correlations of log-transformed total birds of each species were similar to those for indicated pairs.

Species	American Green-winged Teal		Northern Pintail		Scaup	
	6 June	13 June	6 June	13 June	6 June	13 June
American Green-winged Teal	1.0	1.0	0.81**	0.51*	0.74[1]** (0.66)	0.71[2]** (0.84)
Northern Pintail	0.81**	0.51*	1.0	1.0	0.61**	0.59**
Scaup	0.74[1]** (0.66)	0.71[2]** (0.84)	0.61**	0.59**	1.0	1.0

[1] In survey 1 scaup pairs were distributed differently than total Scaup. The number in parentheses is the correlation between Green-winged Teal pairs and total Scaup.

[2] In survey 2 Green-winged teal pairs were distributed differently than total Green-winged Teal. The number in parentheses is the correlation between total Green-winged Teal and Scaup pairs.

* The critical value of the t statistic in this case for H_0: $r \leq 0$ and H_A: $r > 0$ where $n=20$ plots is 1.734 at the 95% probability level. This corresponds to values exceeding $r=0.38$ (*). At the 99% probability level $r=0.51$ is the critical value (**). In a table such as this 1 of every 20 values will be significant by chance alone at the 95% level and 1 of 100 will be significant by chance alone at the 99% level.

Table 10. Characteristics of 20 2x2 km plots surveyed on the Kawdy Plateau of northern B.C., June 1990.

Plot No.	Stratum (High or Low Density)	Elevation (m)	UTM Location (centre)		Amount and Type of Wetlands					Waterfowl Counted			
					Ponds and Lakes		Marshes, Bogs, and Fens		Creeks	6 June		13 June	
			Easting	Northing	No.	Area (ha)	No.	Area (ha.)	Length of Creek (km)	Indicated Pairs	Total Birds	Indicated Pairs	Total Birds
199	H	1,250	401	6552	10	7.6	5	74.2	6	24	48	29	48
302	H	1,260	393	6570	8	17.65	3	49.4	3	38	71	23	81
226	H	1,370	395	6556	11	14.75	1	48	2	13	39	8	9
105	H	1,310	365	6540	24	7.4	4	47.6	3.25	8	10	11	16
305	H	1,260	391	6572	15	12.05	2	24.45	8	29	55	27	47
322	H	1,220	393	6576	13	16.4	3	14.3	3.5	23	62	26	45
55	L	1,380	383	6532	1	0.2	4	19.2	6	8	12	12	17
231	L	1,280	405	6556	25	10.6	1	6.5	2.5	19	41	33	52
93	L	1,460	385	6538	16	9.75	1	3.2	3.5	5	30	2	17
91	L	1,510	389	6538	9	3.37	3	7.1	1.5	0	0	1	2
222	L	1,460	387	6556	16	7.4	0	0	1.0	0	0	2	3
112	L	1,460	383	6540	5	1.28	2	5.05	6.5	3	4	7	13
216	L	1,350	381	6554	6	5.39	0	0	3.5	21	71	37	68
104	L	1,290	363	6540	2	0.64	1	4.7	4	1	1	21	34
278	L	1,390	399	6564	5	2.35	0	0	1.0	0	0	0	0
264	L	1,350	401	6562	5	1.55	1	0.3	2.2	0	0	0	0
171	L	1,370	393	6548	5	1.4	0	0	4.5	0	1	5	5
88	L	1,260	391	6536	3	1.05	0	0	4	15	27	16	30
176	L	1,320	397	6550	0	0	0	0	8.25	3	4	7	11
87	L	1,380	393	6536	0	0	0	0	4	0	0	0	0

stone bottoms. Some are connected to creek systems and others are not. A more thorough analysis would consider these parameters and would be best done on a wetland by wetland basis.

Some studies have considered waterfowl populations on the basis of numbers of birds per area of wetland habitat rather than per total area as expressed above under Populations. This is usually done to allow comparisons of habitat "quality" among wetlands of varying size and in different regions. In the Kawdy Plateau study area, the 6 high density plots which were surveyed averaged 13.9% wetlands and the 14 low density plots averaged 1.6% wetlands. The density figures in Table 4 (which are based on total area) can be quickly converted to numbers of birds per km^2 of wetland by dividing by 13.9 for the high density stratum and by 1.6 for the low density stratum. This yields figures of 65 and 75 birds per km^2 of wetland in the high density stratum on the two breeding pair surveys and 213 and 281 birds per km^2 for the low density stratum. For the 20 plots considered together regardless of stratum the figures are 112 and 117 birds per km^2.

These figures are somewhat higher than the 39-82 birds per km^2 reported by Murphy et al. (1984) for taiga ponds in east-central Alaska. The explanation for this is probably complex, but may be primarily related to differences in the suite of wetland sizes examined in the two studies. Previous studies have shown a strong positive relationship between wetland size and total bird numbers (as suggested in most of the analyses above), but the density of birds tends to be lower on larger waterbodies. The exact nature of that relationship between bird numbers and wetland size depends on the range of wetland types (as defined by limnological characteristics) included in the analysis. The ponds in the plots which were surveyed in the Kawdy Plateau study area are very small on the average (<1 ha), much smaller than the ponds examined by Murphy et al. (1984) or Boyd et al. (1989); thus the bird densities tend to be very high. Closer examination of the sizes of fens, bogs, swamps and marshes in the Kawdy Plateau study area is not possible at this point because the actual wet habitat suitable for waterfowl was usually much smaller than the area indicated as fen, swamp, bog, or marsh on the topographic map. This factor probably contributed to lower overall densities of birds per area of wetland in the high density stratum (which was very rich in that type of wetland; Tables 10, 13).

In the Riske Creek study area of south-central British Columbia (Boyd et al. 1989), the "area of open water" in individual wetlands (a "size" variable relatively comparable to "area of ponds and lakes" above) proved to be the variable most correlated with numbers of adult ducks of almost all species, and "area of marsh" was actually strongly negatively correlated with numbers of Northern Pintails. Although our analysis was not nearly as rigorous, this difference in the results suggests that the wetlands examined in the Riske Creek area have a substantially different suite of ecological characteristics than those of the Kawdy Plateau.

Survey Cost, Design, and Efficiency

Each aerial survey in this study required 5.1 hours of flying time to complete. Slightly over 1 h of this was required to ferry from the base at Dease Lake to the study area and return. An average of 11-12 minutes was required to survey a plot and fly to the next one (Table 14). K. Ross (pers. comm.) also reported a figure of approx. 10-15 minutes to survey a plot of this size and fly to the next one in a similar study conducted in northern Ontario (Ross 1985, 1987).

An evaluation of the sampling design using optimal allocation procedures (Cochran 1977:98) indicated that the best allocation of effort between the high and low strata on survey 1 to achieve the minimum variance in numbers of total waterfowl would have been achieved by surveying 1 (4.5%) of the high density plots and 19

Table 11. Correlations between habitat variables and 3 species of ducks on 2 surveys of 20 plots on the Kawdy Plateau study area, B. C., 1990. Correlation coefficients are given for log-transformed numbers of indicated pairs vs log-transformed values of habitat variables (except elevation, which was not log-transformed). Except where noted, correlations of log-transformed total birds of each species were similar to those for indicated pairs.

Habitat Variable	American Green-winged Teal		Northern Pintail		Scaup	
	6 June	13 June	6 June	13 June	6 June	13 June
Total Number of Ponds	0.29	0.31	0.15	0.38	0.36	0.39*
Total Area of Ponds	0.41*	0.42*	0.30	0.58**	0.45*	0.65**
Total Number of Marshes	0.44*	0.31	0.46*	0.52*	0.22	0.37*
Total Area of Marshes	0.58**	0.53**	0.59**	0.60**	0.32	0.56*
Elevation	-0.77**	-0.46*	-0.61**	-0.34	-0.63**	-0.74**

* The critical value of the t statistic in this case for H_0: $r \leq 0$ and H_A: $r > 0$ where n=20 plots is 1.734 at the 95% probability level. This corresponds to values exceeding r=0.38 (*). At the 99% probability level r=0.51 is the critical value (**). In a table such as this 1 of every 20 values will be significant by chance alone at the 95% level and 1 of 100 will be significant by chance alone at the 99% level.

Table 12. Results of multiple stepwise regresssion analyses of five habitat variables as predictors of numbers of pairs of Northern Pintail, American Green-winged Teal, and Scaup on 20 plots on the Kawdy Plateau study area, northern B.C., 1990. Coefficients of Determination (r^2) are given for all models. All variables except elevation are log-transformed.

Habitat Variable	6 June				13 June			
	First Variable Entered	Amount of Variation Explained (r^2)	Second Variable Entered	Amount of Variation Explained (r^2)	Fist Variable Entered	Amount of Variation Explained (r^2)	Second Variable Entered	Amount of Variation Explained (r^2)
Northern Pintail pairs	Elevation	0.37	Area of Marsh	0.53	Area of Marsh	0.36	Area of Ponds	0.45
Green-winged Teal pairs	Elevation	0.60	Area of Marsh	0.72	Area of Marsh	0.28	Number of Marshes	0.40
Scaup sp. pairs	Elevation	0.40	Number of Ponds	0.50	Elevation	0.54	Area of Ponds	0.78

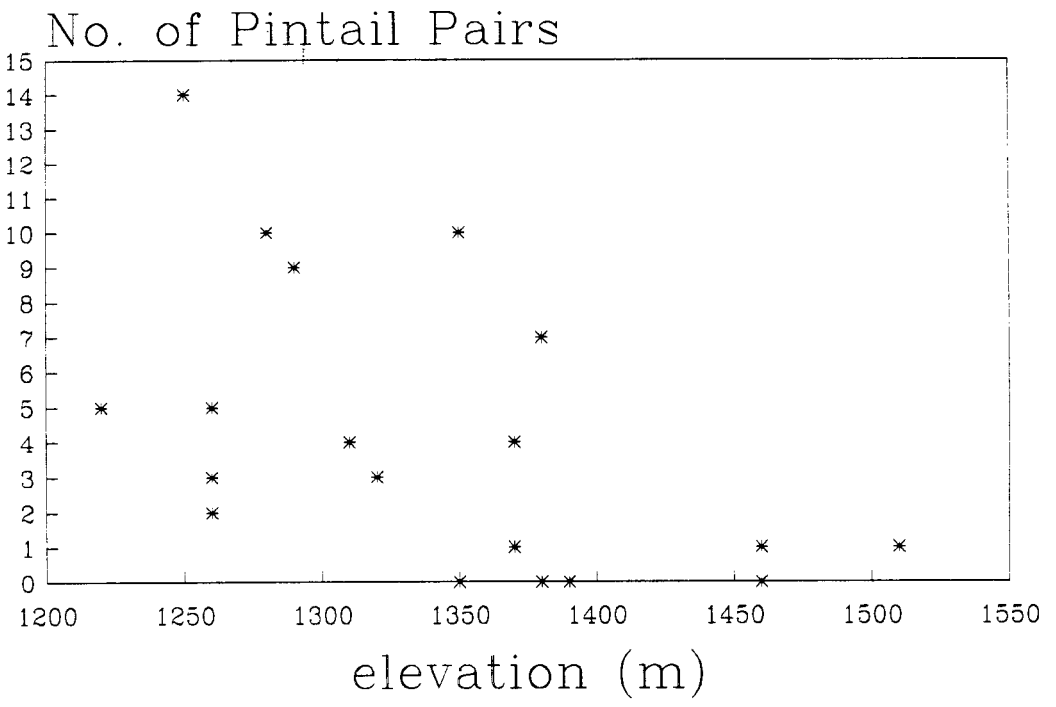


Figure 4a. Relationship between elevation and the number of pairs of Northern Pintails observed on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia on 6 June 1990.

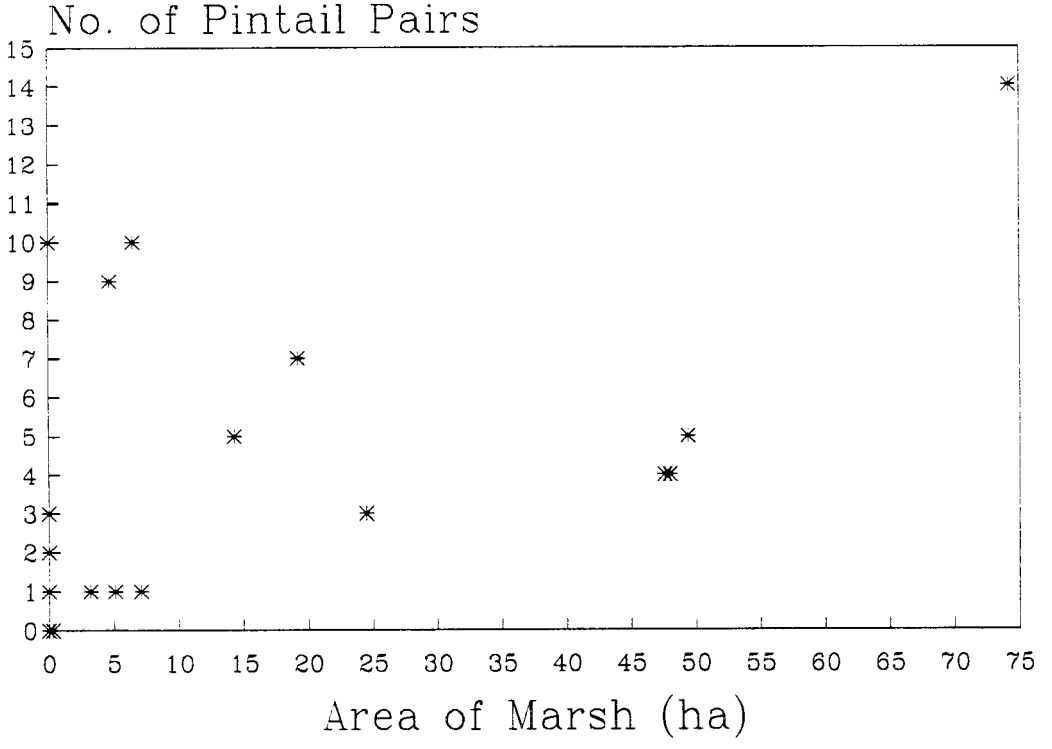


Figure 4b. Relationship between area of "marsh" and the number of pairs of Northern Pintails observed on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia on 6 June 1990.

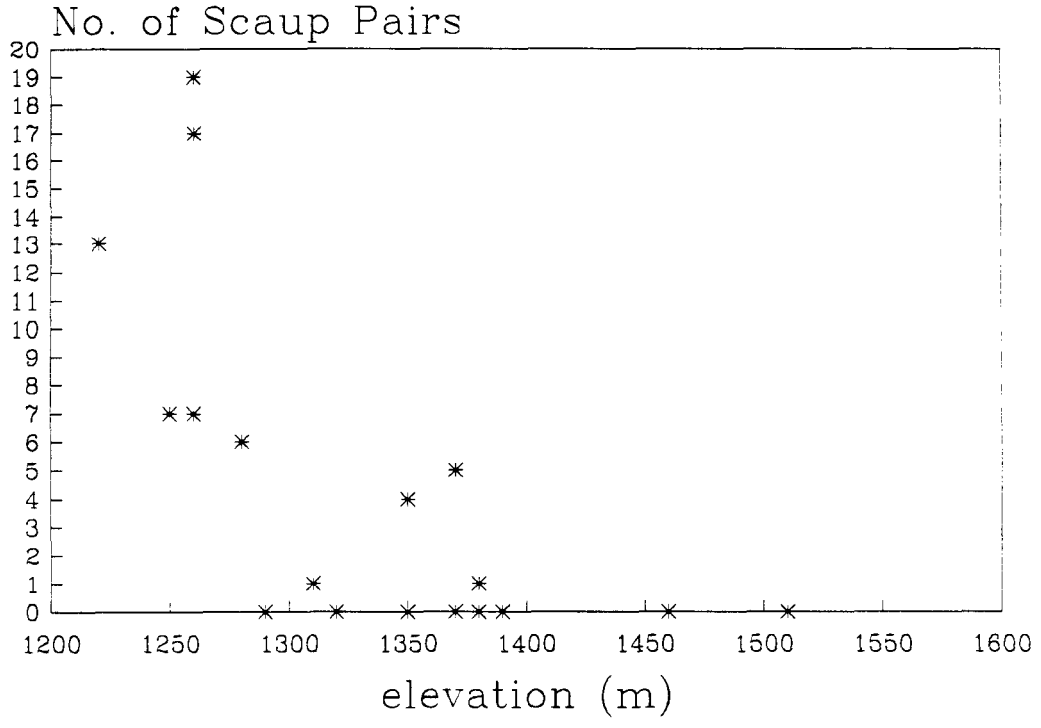


Figure 5a. Relationship between elevation and the number of pairs of Scaup observed on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia on 13 June 1990.

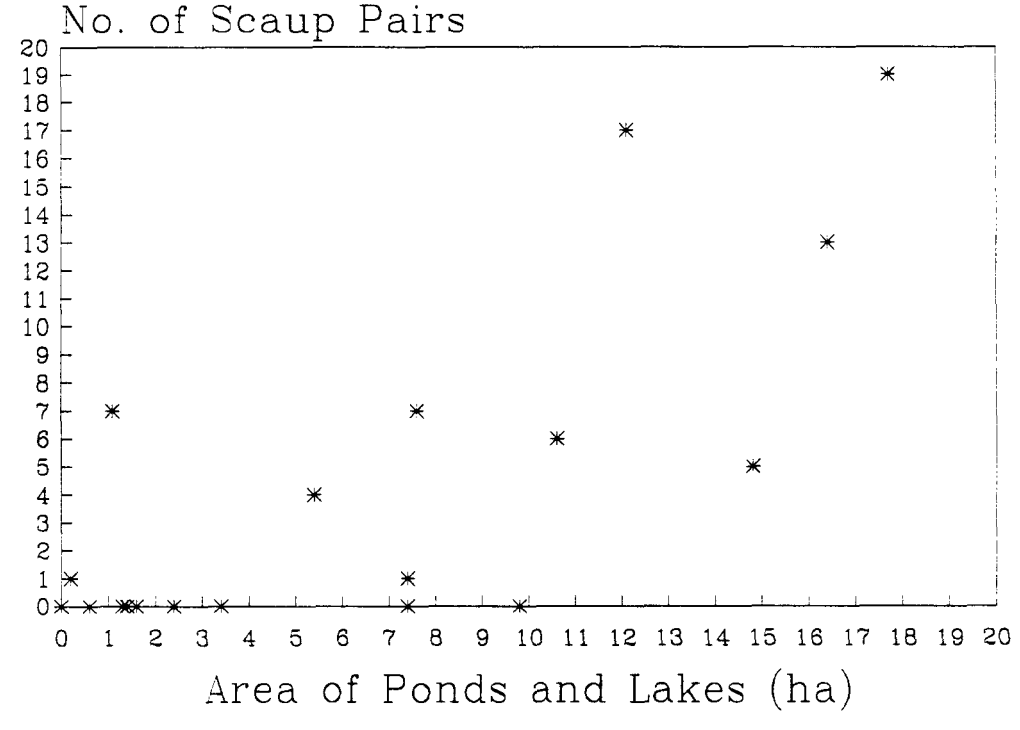


Figure 5b. Relationship between the area of lakes and ponds and number of pairs of Scaup observed on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia on 13 June 1990.

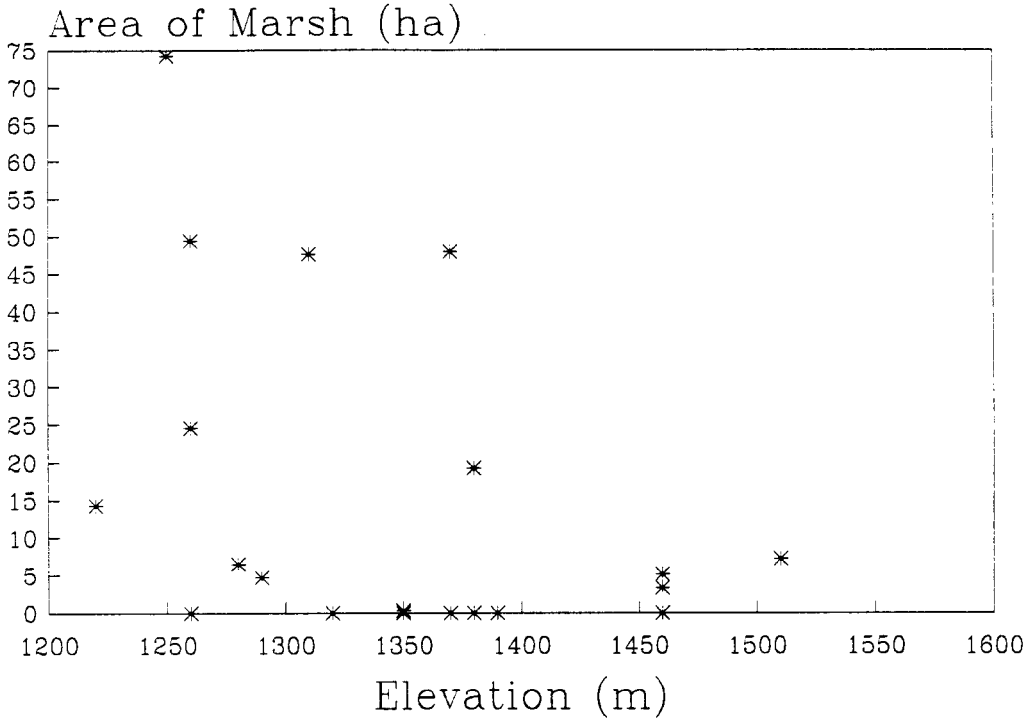


Figure 6a. Relationship between elevation and the area of "marsh" on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia.

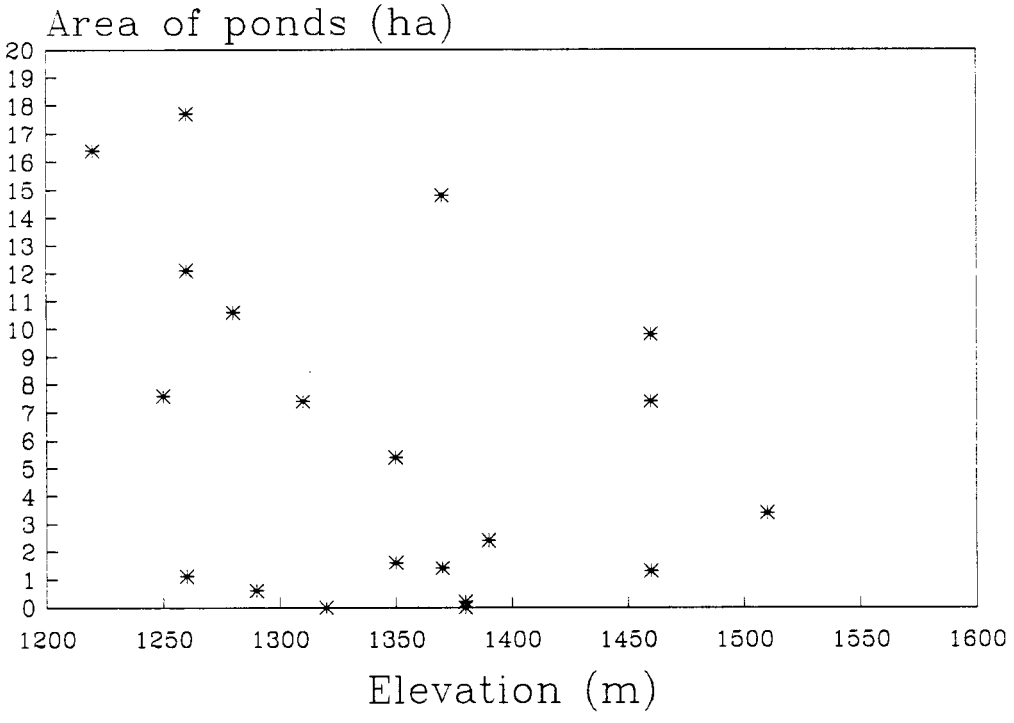


Figure 6b. Relationship between elevation and the area of lakes and ponds on 20 2x2 km plots on the Kawdy Plateau study area, northern British Columbia.

(6.2%) of the low density plots. For Northern Pintail alone the optimum allocation would have been the same as this, but for Scaup alone the best allocation would have been 4 highs and 16 lows. On the second survey the best allocation for all waterfowl pairs and Pintail pairs would have been 2 highs and 18 lows and for scaup the best would have been 3 highs and 17 lows. Thus in both surveys a more optimal sampling effort than the one which was employed would have been to simply sample the 2 strata in proportion to the number of plots in each (i.e. 1-2 highs and 18-19 lows), a procedure known as proportional allocation of sampling effort. In practice the sample of highs would have to be at least 2 plots in order to calculate a variance. The design which was employed (6 highs and 14 lows) was closest to the optimal allocation for scaup pairs and worst for total waterfowl pairs.

In this case, stratification has not been very effective in producing a more precise estimate than simple random sampling owing to the large size and high variation of the low density stratum. Another factor which is normally considered in an analysis such as this is the cost of surveying plots in one stratum vs another. Generally, plots in the low stratum can be surveyed slightly more quickly than those in the high stratum because they have less water. This consideration would also tend to favour surveying relatively more of the low density plots.

Examination of the data shows that the high variation in the low density stratum is due to the inclusion of 3 plots which had unexpectedly large numbers of birds on both surveys (plots 231, 216, and 88). Plot 231 was borderline for inclusion in the high density stratum because it had lots of ponds but little marsh. Plot 216 had several significant marsh areas which were not portrayed on the 1:50,000 topographic map. Plot 88 hosted high numbers of birds in spite of having relatively few ponds and no marshes. Its apparent productivity was likely due to low elevation and the hydrologic connection of many of the ponds. Thus of these 3 plots, 1 should have been included based on map information, 1 was incorrectly mapped, and 1 was a genuine anomaly.

This survey technique is expensive, but it offers advantages which may justify the expense in many circumstances. Some of these advantages were pointed out by Ross (1987): The method is more easily repeatable than are transect surveys; the UTM grid system provides a ready framework for the survey design and data base; problems of sightability which plague fixed-wing surveys and ground surveys are virtually eliminated; the helicopter can be flown at whatever speed is optimal, from 0 to over 160 km per hour; observers do not need to be as highly trained as those for fixed-wing surveys owing to the options of extremely low and slow flight and repeated passes to identify birds; only the wetland area is searched, eliminating unnecessary time, vigilance and observer fatigue which are associated with transect surveys, especially in areas where the potential habitat is fairly dispersed.

Above treeline the helicopter is truly a boon as it can safely manoeuvre at virtually any altitude. In heavily treed areas, especially those with tall trees, even helicopters will have difficulty in efficiently counting birds on small wetlands.

Aerial surveys using waterbodies as a sample unit have been employed extensively in the Yukon although it is still unclear when they are better than plot based surveys. A plot based design does not require any pre-judgement about what constitutes a "wetland" worthy of surveying, and it avoids problems caused by wetlands which were not indicated on maps or airphotos or which were indicated and do not actually exist at the time of the survey. Information on habitat use by various species can be obtained, since in theory the full range of waterfowl habitats is sampled. This does, however, require airphotos or maps sufficiently detailed to allow the location of birds to be recorded on a wetland by wetland basis. Ross (1985) recorded the locations of individual birds on 1:16,000 air photos, but the only photos available for the Kawdy Plateau survey were 1:60,000,

Table 13. Area (ha) of wetlands and plots surveyed in high and low density strata in the Kawdy Plateau Study area of northern B.C.

Parameter		High Density	Low Density
Plots: Number Surveyed/No. in Stratum		6/22	14/306
Total Area (ha) of surveyed plots		2,400	5,600
Marshes, Bogs, and Fens in surveyed plots:	Area	257.95	46
	Percent	10.7	0.8
Ponds and Lakes in surveyed plots :	Area	75.85	44.98
	Percent	3.2	0.8
Total Wetlands in surveyed plots:	Area	333.8	90.98
	Percent	13.9	1.6

Table 14. Details of flying time (minutes) required to survey 20 study plots on the Kawdy Plateau, northern B.C. on 6 and 13 June 1990.

Parameter	6 June	13 June	31 July
Total Elapsed Time	315	322	329
Ferry to Study Area	29	29	33
Ferry Study Area to Base	38	38	37
Refuel Break	16	17	26
Time Surveying Plots	232	238	233
Number of Plots	20	20	20
Mean Time per Plot	11.6	11.9	11.6

which where of insufficient detail to mark bird locations.

CONCLUSIONS AND RECOMMENDATIONS

Based on this small survey program, wetlands on the Kawdy Plateau appear to have waterfowl populations proportional to lower elevation wetlands, i.e. the quality of the habitat is similar. The species composition is much different, but that may be at least partly a reflection of the delayed spring experienced on the Kawdy Plateau in 1990. Pending further surveys of the Kawdy Plateau or similar high elevation wetlands, in total these areas should be viewed as having potentially significant populations of Scaup, Northern Pintail, and American Green-winged Teal. The estimates for the Kawdy Plateau alone represent three, three, and four percent, respectively, of the estimated total breeding populations of these species in British Columbia (British Columbia Waterfowl Technical Committee 1988).

To improve future surveys of this type, stratification could be based on the variables indicated by the regression and correlation analyses (i.e. elevation, area of "marsh", area of ponds), depending on the species of most interest. An extra observer, as used by Ross (1985, 1987) should be used whenever possible. Larger scale airphotos should be used to improve navigation and to allow recording the locations of individual birds for habitat studies.

ACKNOWLEDGEMENTS

Pilots Denny Denison of Coyote Air Service and Wade Robertson of Frontier Helicopters made the surveys both safe and enjoyable. Linda Wells assisted with the brood survey. Ducks Unlimited Canada kindly contributed logistical support for the helicopter surveys and encouraged the project from start to finish. Don Russell made helpful comments on earlier drafts of this report.

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Appendix I.

TOTAL PAIRS AND BIRDS IN SURVEYED AREA FOR SURVEY 1(JUNE 6) AND SURVEY 2(JUNE 13) 1990. P=pairs T=total birds

SURVEY 1

	PLOT																									
	55		87		88		91		93		104		105		112		171		176		199		216	
	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
SPECIES																								
AMERICAN GREEN-WINGED TEAL	3	4	0	0	6	8	0	0	0	0	3	4	4	6	0	0	0	0	0	0	7	9	4	7
AMERICAN WIGEON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0
BLUE-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAGO	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMMON MERGANSER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIVER SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUCK	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
HARLEQUIN DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0
LOON SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALLARD	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	4	4	0	0	0	0	1	1
NODU	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NORTHERN PINTAIL	7	8	0	0	2	3	1	2	1	2	9	15	4	4	1	1	1	1	3	5	14	27	10	12
NORTHERN SHOVELER	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4
OLDSQUAW	2	3	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1	1	2	4	1	2
RING-NECKED DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED THROATED LOON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCAUP SP	0	0	0	0	7	15	0	0	0	13	6	12	3	6	6	12	0	0	0	0	2	4	18	38
SURF SCOTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	12	17	0	0	16	30	1	2	2	17	20	34	11	16	7	13	5	5	7	11	27	48	37	68

(CONTINUED)

Appendix I. (cont.)

TOTAL PAIRS AND BIRDS IN SURVEYED
AREA FOR SURVEY 1(JUNE 6) AND SURVEY 2(JUNE 13) 1990

SURVEY 1

	PLOT																		TOTALS	
	222		226		231		264		278		302		305		322			
	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
SPECIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMERICAN GREEN-WINGED TEAL	0	0	2	2	4	5	0	0	0	0	3	6	6	7	4	4	46	62
AMERICAN WIGEON	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	4	7
BLUE-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAGO	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	1	0	9
COMMON MERGANSER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
DIVER SP	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
HARLEQUIN DUCK	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	0	5	9
LOON SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
MALLARD	0	0	0	0	1	2	0	0	0	0	2	3	0	0	1	2	11	15
NODU	.	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.	0	0
NORTHERN PINTAIL	0	0	4	4	10	12	0	0	0	0	5	6	3	5	5	6	80	113
NORTHERN SHOVELER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	8
OLDSQUAW	1	3	1	2	0	0	0	0	0	0	0	0	1	1	1	2	11	20
RING-NECKED DUCK	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
RED THROATED LOON	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
SCAUP SP	0	0	1	1	16	30	0	0	0	0	8	54	16	28	15	28	98	241
SURF SCOTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	1	3	8	9	32	52	0	0	0	0	23	80	26	47	26	45	261	497

Appendix I. (cont.)

TOTAL PAIRS AND BIRDS IN SURVEYED
AREA FOR SURVEY 1(JUNE 6) AND SURVEY 2(JUNE 13) 1990

SURVEY 2

	PLOT																									
	55		87		88		91		93		104		105		112		171		176		199		216	
	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
SPECIES																								
AMERICAN GREEN-WINGED TEAL	3	4	0	0	7	14	0	0	1	2	0	0	5	6	0	0	0	1	0	0	5	7	5	7
AMERICAN WIGEON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUE-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5
CAGO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
COMMON MERGANSER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIVER SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HARLEQUIN DUCK	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
LOON SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALLARD	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6
NODU	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NORTHERN PINTAIL	2	2	0	0	0	0	0	0	4	28	0	1	2	3	3	4	0	0	1	1	9	25	6	18
NORTHERN SHOVELER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0
OLDSQUAW	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
RING-NECKED DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED THROATED LOON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCAUP SP	1	2	0	0	7	12	0	0	0	0	0	0	1	1	0	0	0	0	0	0	7	10	4	34
SURF SCOTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	8	12	0	0	15	27	0	0	5	30	0	1	8	10	3	4	0	1	2	4	24	48	20	71

(CONTINUED)

Appendix I. (cont.)

TOTAL PAIRS AND BIRDS IN SURVEYED
AREA FOR SURVEY 1(JUNE 6) AND SURVEY 2(JUNE 13) 1990

SURVEY 2

	PLOT																TOTALS	
	222		226		231		264		278		302		305		322			
	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
SPECIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMERICAN GREEN-WINGED TEAL	0	0	5	5	2	4	0	0	0	0	4	9	5	8	0	3	42	70
AMERICAN WIGEON	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	2
BLUE-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6
CAGO	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	9
COMMON MERGANSER	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
DIVER SP	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HARLEQUIN DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5
LOON SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALLARD	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	6	13
NODU	0	0	.	.	.	.	0	0	0	0	.	.	.	.	.	.	0	0
NORTHERN PINTAIL	0	0	2	24	5	10	0	0	0	0	9	20	1	3	4	24	48	163
NORTHERN SHOVELER	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	4	4
OLDSQUAW	0	0	1	2	2	3	0	0	0	0	0	0	2	3	1	2	7	13
RING-NECKED DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RED THROATED LOON	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
SCAUP SP	0	0	5	8	6	23	0	0	0	0	19	38	17	30	13	24	80	182
SURF SCOTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	2	5
TOTALS	0	0	13	39	15	41	0	0	0	0	34	71	28	55	22	62	197	476

Appendix II. OBSERVED BROODS (B), JUVENILES (J), AND TOTAL BIRDS (T) ON EACH PLOT IN THE KAMDY PLATEAU STUDY AREA ON JULY 31 1990

	STRATUM																													
	HIGH DENSITY															LOW DENSITY														
	PLOT															PLOT														
	105			199			226			302			305			322			55			87			88			91			93		
SPECIES	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T
MALLARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NORTHERN PINTAIL	0	0	0	0	0	11	3	12	27	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	2	10	12	0	0	0
GREEN-WINGED TEAL	4	18	23	1	5	7	1	7	19	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	1	5	7	0	0	0	1	3	4
SCAUP SP	0	0	0	0	0	0	0	0	0	1	7	8	1	6	14	2	9	11	0	0	0	0	0	0	1	5	6	0	0	0	0	0	0
DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0
RED THROATED LOON	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4	18	23	1	5	19	4	19	46	1	7	17	2	7	16	2	9	11	0	0	0	0	0	0	5	13	16	2	10	12	1	3	4

	STRATUM																													
	LOW DENSITY																													
	PLOT																											TOTAL		
	104			112			171			176			216			222			231			264			278					
SPECIES	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T	B	J	T
MALLARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
NORTHERN PINTAIL	2	9	11	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	3	7	0	0	0	0	0	0	9	35	76
GREEN-WINGED TEAL	0	0	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	8	38	78
SCAUP SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	0	0	0	0	0	6	29	43
DUCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
RED THROATED LOON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
TOTAL	2	9	12	0	0	0	0	0	1	0	0	2	0	0	12	0	0	0	2	5	17	0	0	0	0	0	0	26	105	208

Appendix III. Sightings of Other Birds and Miscellaneous Wildlife.

A Red-throated Loon and its nest were seen on plot 231 on 13 June and adults were seen on plots 199 and 302 on 31 July. Four Canada Geese were seen near plot 302 and 12 near plot 231 on 6 June. On 31 July 25 Canada Geese including 5 young were seen on a lake between plots 105 and 216, and another group of 30 adults on a lake between plots 305 and 322. Flocks of Scaup were seen on some lakes between plots on 31 July. Mew and Bonaparte's Gulls and (Arctic?) Terns were observed commonly on the surveyed plots and nests of all 3 were seen from the air. Long-tailed Jaegers were observed on Plot 91 on 6 June and Plot 112 on 13 June. Lesser Yellowlegs and (presumably Red-necked) Phalaropes were also very common but no definite breeding evidence was seen. Moose and caribou were common. Four moose (3 cows, 1 cow+calf) were seen on plot 105 on 13 June. A black wolf was seen on plot 226 and a wolverine near plot 302 on 13 June. A grizzly bear was seen on plot 322 on 31 July.

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