Factors Influencing Local Variation of Bald Eagle Density in North-central Saskatchewan

by

Elston H. Dzus

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ABSTRACT

The influence of nesting habitat, prey resources and human activity on local variations of Bald Eagle (Haliaeetus leucocephalus) density was examined in 1986 and 1987 on Besnard and Nemeiben Lakes in north-central Saskatchewan. Eagle density and the number of active breeding areas on Besnard Lake was two to three times greater than on Nemeiben Lake. Differences in water area or area of forest within 200 m of shore accounts for a factor of 1.14 of the variation in eagle numbers, leaving the majority of the density differences to be explained by other factors.

Bald Eagles preferred to nest in large trees close to shore in mixed-wood stands dominated by coniferous trees. Treed rock, muskeg and even-aged coniferous stands were avoided. Trembling aspen (Populus tremuloides) was the preferred species for nesting on the mainland, while white spruce (Picea glauca) was preferred on islands. Percent of suitable forest habitat within the zone in which most eagles nest (200m from shore) was almost identical on Besnard (35%) and Nemeiben (36%) lakes and thus forest nesting habitat was not likely a factor limiting eagle numbers.

I investigated food resource levels by netting fish in both lakes, and examining records on commercial/sports-fisheries, and biological surveys. Cisco (Coregonus artedii), an important prey species for eagles, were more numerous and larger on Besnard Lake. Other indices of aquatic fauna and fish populations portray Besnard Lake as much more productive. Differences in the prey base was the most likely factor limiting eagle density on Nemeiben Lake.

I compared eaglet growth and hatching order of the sexes on Nemeiben Lake to that on Besnard Lake. Inflection points in growth curves and feather emergence were earlier in males than females. Second-hatched females, in mixed-sex broods, on Nemeiben Lake gained weight slower than males on both lakes, and had inflection points which were much later than those of females on Besnard Lake. Mixed-sex broods, with females hatching second, were rare on Besnard Lake, but common on Nemeiben Lake; the production of such broods may be an adaptive response to lower food levels.

I investigated human activity on the lakes through questionnaires distributed to cottage owners and analysis of campground occupancy. Human activity has been more intense on Nemeiben Lake for a longer period than on Besnard Lake. Human activity may have influenced the eagle populations, but did not account for all of the variation.

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General Introduction and Population Status of Bald Eagles on Besnard and Nemeiben lakes

1.1. Introduction

Two fundamental observations of animal populations are: (1) abundance varies from place to place, and (2) no population increases without limit (Krebs 1985). In many bird species, territoriality plays an important role in controlling population density, but ultimately the upper limit of density is set by some limiting resource (Newton 1979, Krebs 1985). Limiting resources for avian species include the availability of nest sites and food, whichever is in short supply; food is thought to be the most important factor in the majority of cases (e.g., Lack 1954, Giesel 1974, Newton 1979, Perrins and Birkhead 1983). Human intervention with the natural world is an additional factor influencing animal density, be it through direct persecution, or indirectly through aspects such as habitat alteration or pesticide use (Newton 1979). Comparisons of the quantity and quality of potential limiting resources can provide insights into which factors are most important in limiting density in one area relative to another.

With continuing development of access roads, tourist facilities and private cabins in northern Saskatchewan, it is important to evaluate the effects of human-induced changes on wildlife populations. Interpretation of such effects depends on an understanding of the natural basis for variablility in such populations. Bald Eagles (*Haliaeetus leucocephalus* Linnaeus) nest along the shores of many of the lakes and rivers in north-central Saskatchewan (Whitfield *et al.* 1974). Even on superficially similar lakes, there may be considerable differences in eagle density. Besnard Lake, on the southern boundary of the Precambrian Shield, has a well-studied population of Bald Eagles, which has been relatively stable from 1968 - 1988 (Gerrard et al. 1983, Gerrard, Bortolotti and Dzus, unpub. data). Nemeiben Lake, 40 km south-east of Besnard Lake, was superficially similar in size, surrounding forest stands and in fish populations (Koshinsky 1964, Chen 1974). However, eagle density in terms of breeding pairs and non-breeding individuals was much greater on Besnard Lake (Dzus and Gerrard, in review). The purpose of this study was to examine potential limiting factors (food, nest sites, and human factors) to gain an understanding of interlake variability in eagle density. Such knowledge should be important for future management considerations.

1.2. Study Area

Besnard Lake (lat. 55 20'N, long. 106 00'W) and Nemeiben Lake (lat. 55 20'N, long. 105 25'W) are relatively large lakes having approximate total shoreline lengths of 400 km and 416 km respectively. Nemeiben Lake is 27 km northwest of La Ronge and has had road access since 1958; Besnard Lake is about 65 km northwest of La Ronge and has been accessible by a gravel road since 1973. Besnard Lake has approximately 65 private and commercial cottage sites while Nemeiben lake has 80. As part of the leasing criteria for cottages, a 1.6 km buffer zone must be maintained between cottages, active trapper's cabins, and any highway or road. Further details of the study area are presented in subsequent chapters and have been discussed previously (Gerrard and Gerrard 1985; Whitfield et al. 1974).

1.3. Objectives

In the remainder of Chapter 1, I present data on population size and numbers of breeding areas on both lakes. This information serves as a basis for the examination of factors which may influence existing differences between lakes.

In Chapter 2, I examine nest-site selection by comparing forest stand characteristics at nest sites and random sites, and using utilization/availability data. Information on selectivity/avoidance of forest stand types was used to quantify the area of suitable and unsuitable forest habitat around each lake, to determine the role nest-site availability may play in limiting eagle density.

In Chapter 3, I investigate whether food influences differences in densities of Bald Eagles on Besnard and Nemeiben lakes. I compared fish populations between lakes using catch per unit effort data gathered in 1987. Saskatchewan Parks, Recreation and Culture (Fisheries Branch) information was also used for interlake comparisons and as references of past density.

In Chapter 4, I examine eaglet growth on Nemeiben Lake. This information was compared to growth parameters calculated for eaglets on Besnard Lake by Bortolotti (1984a,b, pers. comm.). Eaglet growth is discussed as an indication of the effect food may exert to produce interlake differences in eagle populations.

In Chapter 5, I compare differences in the sex ratio of eaglets between Besnard and Nemeiben lakes, primarily with respect to hatching order of the sexes. The adaptive significance of manipulation of sex ratio at hatching and the influence hatching order may have on eaglet growth and survival are examined in relation to food resources.

In Chapter 6, I examine human activities on the lakes and discuss interlake differences as they may affect eagle density on the lakes.

1.4. Methods

Methodology follows similar censuses designed for Besnard Lake (Gerrard et al. in review; Gerrard and Gerrard 1985). Using forestry inventory maps and a map wheel, we divided the shorelines of the lakes into 8-km sections, which were numbered consecutively. Each census of the lake consisted of two surveys, odd-numbered sections and a separate survey of even-numbered sections. Censusing half the lake required less time than a full survey, reduced the probability of counting birds twice because of the bird flying ahead of the boat into the next section, and produced precise estimates of adults, immatures and nests (Gerrard et al. in review). I used a motor boat or motorized canoe, travelling 8 - 16 km/h about 100 m from shore during daylight hours. Reduced visibility caused by moderate to heavy rain, high winds (> 32 km/h), thick fog or smoke, resulted in temporary cessation of the survey. Two sets of surveys were in 1984 and 1986. The first set of surveys were conducted in late May or early June, with the second set performed in July or August. These correspond to the activity and productivity flights conducted in most studies utilizing aerial surveys (Fraser et al. 1983). A boat survey was not conducted in May/June, 1987.

During each survey the following data were recorded: (1) location, age (adult, immature, young of the year) and behaviour (e.g., flying, perched, vocalizing) of each eagle seen, and (2) location of each nest. A breeding area is defined as one or more nests within the range of a mated pair. Breeding areas were recorded as empty, occupied, active and/or successful (see Gerrard et al. 1983 for definitions). Careful searches were conducted when an adult's behaviour suggested the presence of a nest or when adults were repeatedly seen in an area. On the July/August surveys, enough time was spent observing successful nests to confidently record the number of young. Confirmation of eaglets seen was established when many of the young were banded. Population estimates for each lake were calculated using a stratified sampling approach (Gerrard and Gerrard 1985). Proc GLM (SAS version 5) was used to compare eagle density on Besnard and Nemeiben lakes and on each lake separately (to detect changes from the activity to productivity surveys). Aerial surveys were flown on Besnard and Nemeiben lakes on 29 and 30 April 1986 and 1 May 1987 to determine the status of the breeding areas before the breakup of the ice and before leaf-out. Spotting nests in 1986 was difficult as it had snowed the night before our flights. A Cessna 185 with the same pilot, navigator and two observers were used on all flights.

1.5. Results

In 1984 at least 23 pairs attempted to nest on Besnard Lake; 18 pairs successfully fledged a total of 31 young. This compares to 14 successful pairs in 21-23 attempts producing 21 young in 1986. Nemeiben Lake had 3 of 3-6 pairs successfully fledged 3+ young in 1984, and 6 of 10 pairs produced a total of 9+ young in 1986 (Table 1.1).

Nest success on Besnard Lake in 1984 (72-75%) and 1987 (70%) was almost identical to the 14-year average ($\overline{X}$ = 73, 2S.D. = 12) reported by Gerrard et al. (1983), while that in 1986 was somewhat lower (50 - 58%)

Table 1.1. Numbers of Bald Eagle nests, breeding areas and young fledged on Besnard and Nemeiben lakes, Saskatchewan.

Lake	Total[1] nests	Total breeding areas[2]	Status of Breeding Areas: Empty	Occupied	Active	Successful (SBA/OBA %)[3]	Young fledged (YNG/OBA)[4]
Besnard							
1984[5]	34	25-26	1-2	24-25	23	18 (72-75)	31 (1.24-1.29)
1986	36	31-36	10-15	24-28	21-23[6]	14 (50-58)	21 (0.75-0.875)
1987	37	29	2	27	25	19 (70)	30+++[7] (1.11)
Nemeiben							
1984	7	7	1-3	3-6	3-6	3 (50-100)	3+ (0.5-1.0)
1986	11	10	0	10	10	6 (60)	9++ (0.9)
1987	11	10	0	10	9	7 (70)	9++ (0.9)

1 Total breeding areas fewer than total nests as some breeding areas have more than one nest.
2 Range of values given as I could not determine the status of some nests.
3 Nesting success: percentage of successful breeding areas (SBA) per occupied breeding area (OBA).
4 Number of young fledged (YNG) per OBA.
5 1984 data, Dzus and Gerrard, in review.
6 Two nests not seen on aerial survey, may have been active at that time.
7 Unable to determine accurately the number of young at + (1), ++ (2), or +++ (6) nests.

(Table 1.1). Nesting success (50-100%) on Nemeiben Lake was imprecisely determined in 1984; more reliable data were obtained in 1986 (60%) and 1987 (70%). Young fledged per occupied breeding area, a ratio used by Sprunt et al. (1973) to predict the stability of an eagle population, was 0.5 to 1.29 in 1984, 0.9 on Nemeiben Lake (1986 and 1987) and 0.75-0.88 and 1.11 on Besnard Lake in 1986 and 1987 (Table 1.1).

Eagle density increased on each lake from the activity to the productivity surveys and differed between lakes (Table 1.2). The number of adults and the total population on Besnard Lake increased by 50 % from May/June to July/August in 1984 and 1986 ($P < .01$). Increases in the number of immatures on Besnard Lake from May/June to July/August were not significant ($P > .05$). However, the increase was significant ($P < .001$) when data from 1976 - 1978 were included (Gerrard, Bortolotti and Whitfield unpub. data). The eagle population on Nemeiben Lake more than doubled from May/June to July/August in 1984 but remained essentially static in 1986 (Table 1.2). The coefficient of variation for all surveys on Besnard Lake was 11.3% and on Nemeiben Lake was 21.4%.

1.6. Discussion

The numbers of Bald Eagles differed on Besnard and Nemeiben lakes. Whitfield et al. (1974) found an area with high numbers of adults not associated with nests; therefore, density of adults is not necessarily commensurate with density of breeding areas. The number of active breeding areas on Besnard Lake was 2.6 times greater than on Nemeiben Lake, and Besnard Lake supports an eagle population (adults and immatures) which was about 3.3 times greater than on Nemeiben Lake. Home ranges of eagles nesting along the shores of Besnard Lake lie

Table 1.2. Estimates of the numbers of Bald Eagles on Besnard and Nemeiben lakes.

Lake		Survey[2]	Odd/even[3]	Estimated No. of Eagles/lake			Estimated No. of Eagles/1000ha water area[1]		
				Adults	Immatures	Ads&Imms	Adults	Immatures	Ads&Imms
Besnard***[4]	1984	1**	O	45.7	15.3	61.0	2.58	0.86	3.44
	1984	1	E	49.1	21.6	70.7	2.77	1.22	3.99
	1986	1	O	55.2	13.9	69.1	3.12	0.78	3.90
	1986	1	E	43.1	14.0	57.1	2.43	0.79	3.22
	1984	2	O	70.7	20.1	90.8	3.99	1.13	5.12
	1984	2	E	69.8	33.0	102.8	3.94	1.86	5.80
	1986	2	O	58.4	16.0	74.4	3.30	0.90	4.20
	1986	2	E	80.6	20.0	100.6	4.54	1.13	5.68
	1987	2	O	56.4	26.5	82.9	3.18	1.50	4.68
	1987	2	E	75.9	31.8	107.7	4.28	1.79	6.08
Nemeiben	1984	1	O	9.5	0	9.5	0.61	0	0.61
	1984	1	E	11.8	3.8	15.6	0.76	0.24	1.01
	1986	1	O	18.2	3.7	21.9	1.18	0.24	1.41
	1986	1	E	25.5	4.4	29.9	1.65	0.28	1.93
	1984	2	O	18.6	4.1	22.7	1.20	0.26	1.47
	1984	2	E	27.0	3.9	30.9	1.74	0.25	2.00
	1986	2	O	24.1	1.8	25.9	1.56	0.12	1.67
	1986	2	E	25.6	2.2	27.8	1.65	0.14	1.79
	1987	2	O	33.3	7.8	41.1	2.15	0.50	2.65
	1987	2	E	19.5	2.0	21.5	1.25	0.13	1.39

1 Water area on Besnard Lake = 17718 ha; Nemeiben Lake = 15488 ha.
2 Survey 1 conducted in May/June; survey 2 conducted in July/August.
3 Each lake is divided into survey units (odd and even), see methods in text.
4 Asterisks indicate differences in means: *** - population estimates for each age class a significantly different ($P < 0.001$) between Besnard and Nemeiben lakes for surveys 1 and ** - Besnard Lake population estimates for adults and ads&imms were significantly differ ($P < 0.01$) between surveys 1 and 2.

primarily on and adjacent to the lake (Gerrard and Bortolotti 1988), thus interlake comparisons of potential limiting factors can be restricted to these lakes. If eagle density is proportional to water area, the greater water area on Besnard Lake would account for a factor of 1.14 in eagle density (Koshinsky 1964, Chen 1974). This leaves the vast majority of the density differences to be explained. With these lakes being 40 km apart it is unlikely that climatic or major geographical differences could account for the differences. In this study I will address potential factors limiting or reducing eagle use on Nemeiben Lake relative to Besnard Lake including availability of suitable nesting sites, availability of a sufficient prey (fish) base, and human activities and development on the lakes.

2. Chapter 2

Nesting Habitat: Selection and Availability

2.1. Introduction

The availability of suitable nest-sites may be important in limiting the breeding density of birds (Newton 1979). To classify nesting habitat based on its suitability, it is necessary to show that one component of the habitat is being chosen disproportionately in relation to its availability (Mosher et al. 1987). To determine whether availability of suitable nesting habitat influenced differences in the breeding density of Bald Eagles on Besnard and Nemeiben Lakes I investigated nest-site selection on both lakes and used the information to classify forest stand types as suitable or unsuitable. I then compared the total area in each category to determine whether availability of suitable nesting habitat was a limiting factor.

2.2. Methods

2.2.1. Nest-site Selection

2.2.1.1. Habitat Analysis

Characteristics of overstory vegetation at nest-sites on Besnard and Nemeiben lakes were compared to random points on each lake. I could then identify features that may be important in nest-site selection and determine possible interlake differences in nesting habitat. Sampling of the nesting habitat was restricted to a 200 m zone from shore, as 90 % of nests in north-central Saskatchewan were found there (Whitfield et al. 1974). Trees were sampled using the plotless, point-centered quarter method (Cottam and Curtis 1956), and sampling design approximated that of Steenhof (1976).

At each nest-site or random shoreline point, a 200-m transect was established perpendicular to shore. The first sampling point was located five meters in from shore. Four additional main points were located at 50 m intervals along the transect line. An additional sampling location was located 10-30 m perpendicular to each side of the main points. To reduce bias in the selection of side point locations, I used randomly generated numbers to indicate the number of meters to be paced perpendicular to the main transect line and then left or right from the end of the perpendicular line. The main point and its accompanying two side points will be referred to as a stratum; thus there were five strata at each nest and random shoreline location.

I will only summarize the sampling procedures for the point-centered quarter as they are well documented elsewhere (Cottam and Curtis 1956, Mueller-Dombois and Ellenburg 1974). A stake driven into the ground served as the central location for each samplng point. The compass bearing of the transect was bisected at a 90 degree angle, forming the four quarters. The nearest tree in each quarter was selected for sampling. Measurements in each quarter included: distance (cm) to the nearest tree, tree species, diameter at breast height (DBH, measured with a calibrated diameter tape 1.4 m above the ground), height (using a Sunto altimeter), and a qualitative evaluation of tree height relative to the canopy level (below, within, slightly above, or well above). Additional measurements taken at nest-sites included: nest-tree species, DBH and height of nest tree, height to top of nest, distance to shore (m). Absolute density, relative species density and basal area were calculated as outlined by Mueller-Dombois and Ellenburg

(1974).

2.2.1.2. Habitat Utilization-availability

Nest-site selection can also be examined in terms of utilization of available habitat (Mathisen 1983, Titus and Mosher 1987). Saskatchewan Parks, Recreation and Culture (SPRC, Forestry Branch) staff outlined a 200 m zone on 1:12,500 Forest Inventory (FI) maps and provided an areal summary (ha) within this zone (islands and mainland) according to stand classification (species association and height class); this was the total amount of nesting habitat available to eagles within the zone primarily used for nesting. I plotted Bald Eagle nests on the FI maps and recorded the stand classification. Using a Chi-square goodness-of-fit test I was able to test the hypothesis that stand types were being used in proportion to their availability, and Bonferroni confidence intervals allowed me to ascertain which stand types were being selected or avoided (Neu et al. 1974, Byers et al. 1984).

I also compared stand classification on FI maps to species frequencies found on nest-site transects as a method of ground-truthing. However, because not all stand types were checked in this manner and some transects crossed more than one stand type, the Chi-square analysis, Bonferroni intervals and the following suitability analysis were based on SPRC FI map classifications.

2.2.2. Suitable Nesting Habitat

Using characteristics of nest trees, their associated stands and the results of the nest-site selection analysis, I grouped the FI categories into classes of suitable and unsuitable nesting habitat. These suitability classes are not absolute, rather they are qualitative categories with the "unsuitable" classes having a lower probability of being selected for nest placement than "suitable" categories. More specific methodology is found in section 2.3.2 as methodology depends upon the results of the nest-site selection data.

2.3. Results

2.3.1. Nest-site Selection

2.3.1.1. Habitat Analysis

Tree height and basal area of at nest-sites were greater at nest-sites, with the largest differences in Strata 1, 2 and 3. These variables were greatest on Nemeiben Lake nest transects (e.g., trembling aspen (Populus tremuloides, Michx.), Figures 2.1 and 2.2). Similar trends existed in height and basal area for balsam fir (Abies balsamea, (L.) Mill), black spruce (Picea mariana, (Mill.) B.S.P.), and to a lesser extent white spruce (P. glauca, (Moench) Voss) (Appendix 1). The density of black spruce and white birch (Betula papyrifera, Marsh.) were much greater at random points than nest-sites, with the density of black spruce increasing from stratum 2 to 5 for both transect types on Besnard Lake and on nest transects on Nemeiben Lake (Appendix 2). Relative density of trembling aspen and white spruce were similar on both lakes, however the density of white spruce on nest transects on Nemeiben Lake was lower than the rest in stratum 2 and 3 (Appendix 2). The density of balsam fir tended to be greater at nest-sites than random sites (Appendix 2). Absolute tree density at Nemeiben Lake nest-sites was much lower than at random sites; no such differences were evident on Besnard Lake (Appendix 2).

Nest trees on Nemeiben Lake averaged 2.6 m taller and 40 mm more in

Figure 2.1. Mean height of trembling aspen at nest and random point transects on Besnard and Nemeiben lakes.

- Besnard Lake, random point transects
- Nemeiben Lake, random point transects
- Besnard Lake, nest transects
- Nemeiben Lake, nest transects

Vertical line is standard error. Sample size is presented above standard error.

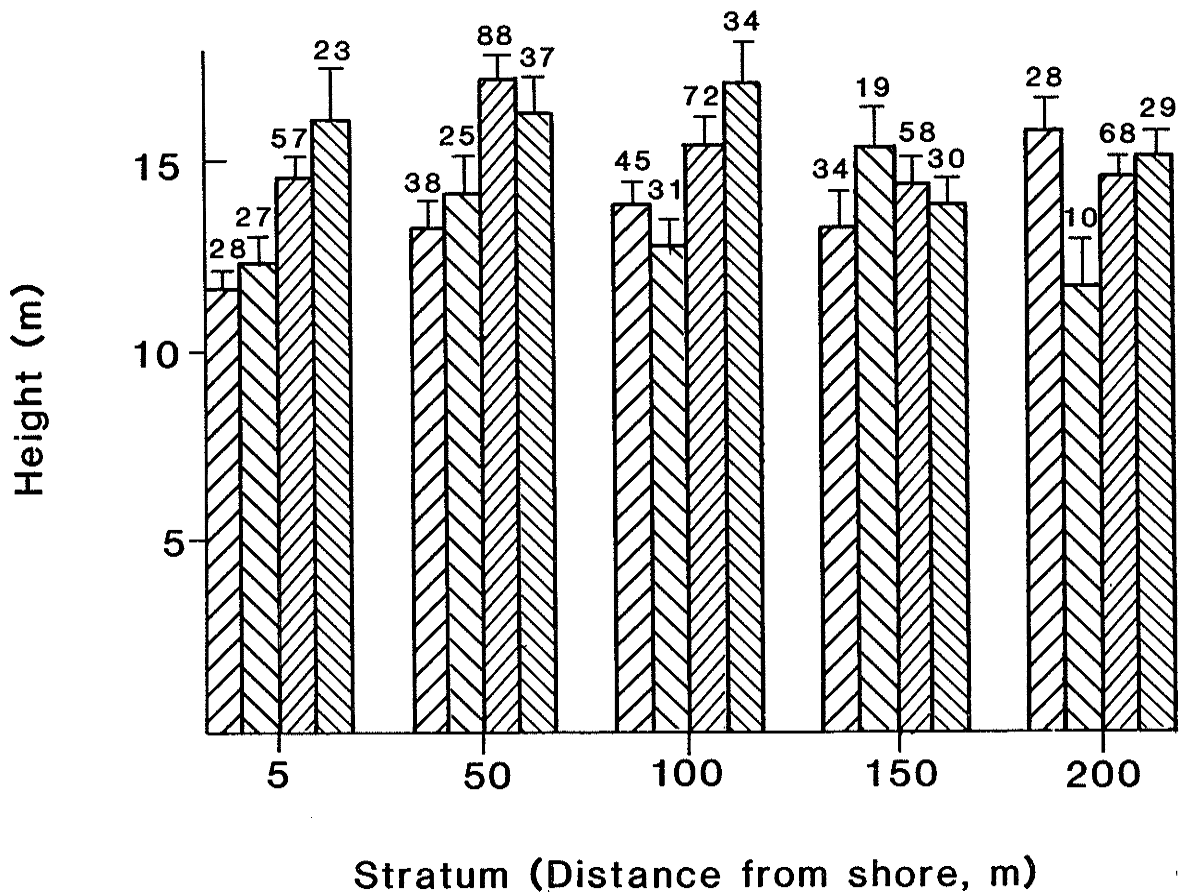

Height (m)
15
10
5
28
27
57
23
38
25
88
37
45
31
72
34
34
19
58
30
28
10
68
29
5
50
100
150
200
Stratum (Distance from shore, m)

Figure 2.2. Mean basal area of trembling aspen at nest and random point transects on Besnard and Nemeiben lakes.

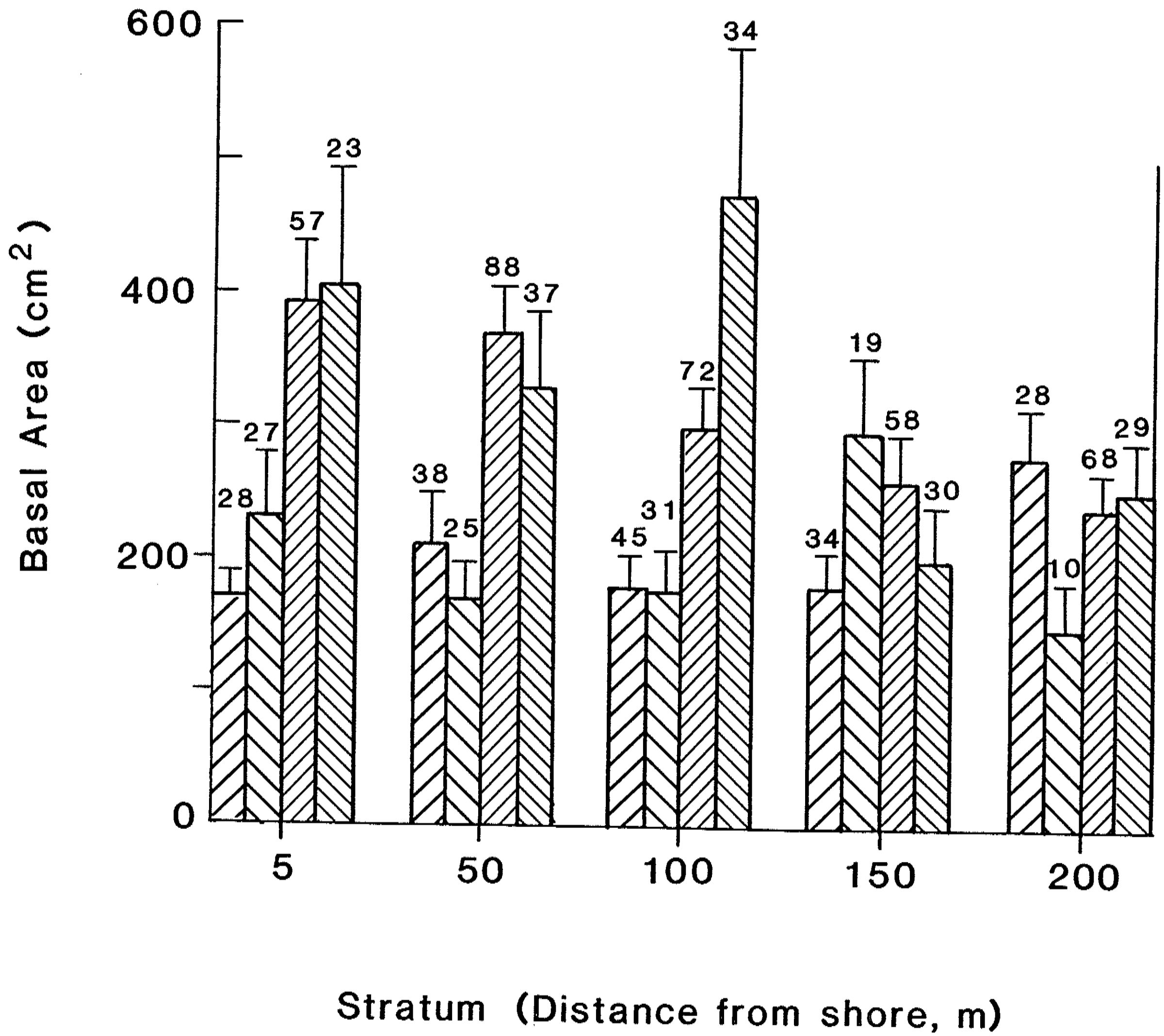
- Besnard Lake, random point transects

- Nemeiben Lake, random point transects

- Besnard Lake, nest transects

- Nemeiben Lake, nest transects

Vertical line is standard error. Sample size is presented above standard error.


Basal Area (cm2)
600
400
200
0
28
27
57
23
38
25
88
37
45
31
72
34
34
19
58
30
28
10
68
29
5
50
100
150
200
Stratum (Distance from shore, m)

DBH than nest trees on Besnard Lake (Table 2.1). The distance from nest tree to shore on Nemeiben Lake averaged 29.2 m more than on Besnard Lake, however the difference was not significant (Kruskal-Wallis test, $\chi^2 = 1.67$, DF = 1, Pr > $\chi^2 = 0.20$). All 61 nests were in trees. Of the 49 nests on Besnard Lake, 33 (67%) were in trembling aspen, 11 (22%) in white spruce, four (8%) in balsam poplar (P. balsamifera, L.), and one (2%) in jackpine (Pinus banksiana, Lamb.). Nine of 12 nests on Nemeiben Lake were in trembling aspen, one was in a white spruce, and two in jackpine. Nine of 16 (56%) nests on islands in Besnard Lake were in white spruce and 30 of 33 (91%) were in trembling aspen on the mainland. Only two nests on Nemeiben Lake were on islands and both were in trembling aspen.

2.3.1.2. Habitat Utilization-availability

See Appendix 3 for a complete summary of habitat available on Besnard and Nemeiben lakes in the 200-m zone surrounding each lake.

As a result of similarities of stand classification of nests on islands and mainland (Table 2.2), nests were combined for the following tests. Eagles were not nesting in the stand types according to their availability on Besnard Lake ($\chi^2 = 55.3$), Nemeiben Lake ($\chi^2 = 19.7$) or both lakes combined ($\chi^2 = 60.1$)(χ^2 7df,α.05 = 14.1, Table 2.3; note: as both lakes show similar trends in nesting with regard to stand classification, the results of both lakes combined are presented to confirm trends with an increase in sample size).

Pure softwood stands (S-) and "non-productive" areas were utilized less than expected by chance, while softwood dominated mixed-wood stands (SH- sP tA) were used more than expected by chance (95% family confid-

Table 2.1. Nest tree and nest height, diameter at breast height (1.4m, DBH) of nest tree and distance from nest tree to shore on Besnard and Nemeiben lakes.

Variables	Besnard Lake (n = 31) $\bar{X} \pm$ S.E.	Nemeiben Lake (n = 10) $\bar{X} \pm$ S.E.
Height of nest tree (m)	20.2[1] ± 0.74	22.8 ± 1.24
Height to top of nest (m)	16.0 ± 0.67	17.6 ± 1.53
DBH (mm)	409.7 ± 14.55	449.2 ± 50.64
Nest tree to shore (m)	22.8 ± 3.21	51.9 ± 18.70

1 Kruskal-Wallis test, $\chi^2 = 0.6$, DF = 1, Pr. $>\chi^2 = 0.098$.

Table 2.2. Bald Eagle nests relative to species associations of forest stands on Forestry Inventory maps on Besnard and Nemeiben lakes, Saskatchewan.

	Number of Nests			
	Besnard Lake		Nembeiben Lake	
Species Association[1]	Island	Mainland	Island	Mainland
S - wS	1			
S - bS				
S - jP				
S - lT				
SH - sP tA	11	12	1	2
SH - jP tA		3		1
HS - tA sP	2	9	1	5
HS - tA jP		4		
H - tA	1	4		2
H - wB				
non-productive	1	1		
Subtotal	16	33	2	10
Total per Lake	49		12	

[1]. S - softwood, SH - softwood dominated mixed-wood forest, HS - hardwood dominated mixed-wood forest, H - hardwood forest. wS - white spruce, bS - black spruce, jP - jackpine, lT - larch, sP - spruce spp., tA - trembling aspen (includes wB in HS and SH categories), wB - white birch, non-productive - treed rock and muskeg.

Table 2.3. Utilization-availability data for forest stand types on Besnard and Nemeiben lakes.

Besnard Lake Species association	Total Area (ha)	Relative area (ha)	Observed number of nests	Expected number of nests[1]
S-	1519.9	0.203	1	9.97
SH-sptA	1114.1	0.149	23	7.31
SH-jPtA	428.5	0.057	3	2.81
HS-tAsp	921.5	0.123	11	6.04
HS-tAjP	636.4	0.085	4	4.17
H-tA	877.2	0.117	5	5.75
H-wB	288.5	0.039	0	1.89
non-productive	1685.6	0.226	2	11.05
Total	7471.7	1.000	49	49.00

$\chi^2 = 55.27$, χ^2 df=7, α=0.05 = 14.1.

Nemeiben Lake Species association	Total Area (ha)	Relative area (ha)	Observed number of nests	Expected number of nests[2]
S-	2292.1	0.357	0	4.28
SH-sptA	1178.9	0.183	3	2.20
SH-jPtA	357.9	0.056	1	0.67
HS-tAsp	927	0.144	6	1.73
HS-tAjP	168.3	0.026	0	0.31
H-tA	401.1	0.062	2	0.75
H-wB	141	0.022	0	0.26
non-productive	960.1	0.149	0	1.79
Total	6426.4	1.000	12	12.00

$\chi^2 = 19.72$, χ^2 df=7, α=0.05 = 14.1.

Besnard and Nemeiben lakes combined. Species association	Total Area (ha)	Relative area (ha)	Observed number of nests	Expected number of nests[3]
S-	3812	0.274	1	16.73
SH-sptA	2293	0.165	26	10.06
SH-jPtA	786.4	0.057	4	3.45
HS-tAsp	1848.5	0.133	17	8.11
HS-tAjP	804.7	0.058	4	3.53
H-tA	1278.3	0.092	7	5.61
H-wB	429.5	0.031	0	1.89
Non-productive	2645.7	0.190	2	11.61
Total	13898.1	1.000	61	61.00

$\chi^2 = 60.09$, χ^2 df=7, α=0.05 = 14.1.

ence coefficient) on Besnard Lake and both lakes combined (Table 2.4).

Thirty-one of 42 (74%) nests were located in softwood dominated mixed-wood stands based on species frequencies from the habitat analysis, compared to 26 of 61 (43%) based on FI classification (Table 2.2). Sample sizes differ because habitat analysis was not conducted at one nest on Nemeiben Lake and 18 nests on Besnard Lake.

2.3.2. Suitable Nesting Habitat

SH-sP tA was the only habitat type that was "selected". However, based on the number of nests found in several other categories, I have classified the following species associations in height classes of 15, 20, and 25 m as suitable: SH-sP tA, SH-jP tA, HS-tA sP, HS-tA jP (mainland only) and H - tA (mainland only) (see abbreviation definition in Table 2.2). All softwood-dominated stands and "non-productive" areas were classified as unsuitable because of significant avoidance of such areas. The remaining stand types were not selected or avoided based on the Bonferroni confidence intervals. However, given the low expected and observed number of nests in these categories and/or that no nests were located in height classes 5 or 10 m, I have classified all remaining species association/height classes as unsuitable.

Besnard Lake has 336 more hectares of suitable habitat than Nemeiben Lake, but the percentage of suitable habitat on Besnard Lake (35.4%) was very similar to that on Nemeiben Lake (36.0%) (Table 2.5). The amount of unsuitable habitat on islands is the only class with a marked difference. Besnard Lake has approximately twice as much unsuitable island habitat as Nemeiben Lake.

Table 2.4. Simultaneous confidence intervals using the Bonferroni approach for utilizaion of forest species associations.

Besnard Lake

Species association	Expected proportion of usage	Actual proportion of usage P_i	Bonferroni intervals for P_i
S-	0.203	0.020	$0.000 < P_1 < 0.151^*$
SH-sptA	0.149	0.469	$0.277 < P_2 < 0.662^*$
SH-jPtA	0.057	0.061	$0.000 < P_3 < 0.154$
HS-tAsp	0.123	0.224	$0.064 < P_4 < 0.385$
HS-tAjP	0.085	0.082	$0.000 < P_5 < 0.187$
H-tA	0.117	0.102	$0.000 < P_6 < 0.219$
H-wB	0.039	0.000	$0.000 < P_7 < 0.111$
non-productive	0.226	0.041	$0.000 < P_8 < 0.151^*$

Nemeiben Lake

Species association	Expected proportion of usage	Actual proportion of usage P_i	Bonferroni intervals for P_i
S-	0.357	0.000	$0.000 < P_1 < 0.382$
SH-sptA	0.183	0.250	$0.000 < P_2 < 0.588$
SH-jPtA	0.056	0.083	$0.000 < P_3 < 0.500$
HS-tAsp	0.144	0.500	$0.110 < P_4 < 0.890$
HS-tAjP	0.026	0.000	$0.000 < P_5 < 0.382$
H-tA	0.062	0.167	$0.000 < P_6 < 0.457$
H-wB	0.022	0.000	$0.000 < P_7 < 0.382$
non-productive	0.149	0.000	$0.000 < P_8 < 0.382$

Besnard and Nemeiben lakes combined.

Species association	Expected proportion of usage	Actual proportion of usage P_i	Bonferroni intervals for P_i
S-	0.274	0.016	$0.000 < P_1 < 0.123^*$
SH-sptA	0.165	0.426	$0.255 < P_2 < 0.597^*$
SH-jPtA	0.057	0.066	$0.000 < P_3 < 0.151$
HS-tAsp	0.133	0.279	$0.124 < P_4 < 0.434$
HS-tAjP	0.058	0.066	$0.000 < P_5 < 0.151$
H-tA	0.092	0.115	$0.005 < P_6 < 0.225$
H-wB	0.031	0.000	$0.000 < P_7 < 0.090$
non-productive	0.19	0.033	$0.000 < P_8 < 0.123^*$

Table 2.5. Areal summary of suitable and unsuitable nesting habitat for Bald Eagles on Besnard and Nemeiben lakes, Saskatchewan.

	Available Habitat (ha)			
	Besnard Lake		Nemeiben Lake	
	Island	Mainland	Island	Mainland
Suitable	452.7	2194.6	502.7	1809.1
Unsuitable	1364.9	3459.5	676.5	3438.1

2.4. Discussion

Characteristics of Bald Eagle nests on Besnard and Nemeiben lakes are similar to previous findings in north-central Saskatchewan and elsewhere. Eagles nested close to shore in large, dominant or codominant trees which provided good support (Corr 1974, Whitfield et al. 1974, Gerrard et al. 1975, McEwan and Hirth 1979, Grubb 1976). The predominance of trembling aspen as eagle nest trees in Saskatchewan was also found by Barber et al. (1985) and Gerrard et al. (1975). The lower proportion of trembling aspen in Gerrard's study was partly due to sampling in more northerly parts of the province where jackpine is more abundant and makes a greater contribution as nest trees. The preference for large trees was reflected in their selection of predominantly white spruce on islands where protection from fire allows spruce to surpass aspen in stature as a result of succession (Barber et al. 1985, Gerrard and Bortolotti 1988). The size of Bald Eagle nest trees in my sample was similar to those sampled previously on Besnard Lake. Trembling aspen nest-trees were predominantly greater than 70 years (ages based on growth ring counts) and more than 100 years for white spruce (Whitfield and Leighton, unpub. data). Old growth forests are an important common denominator in most areas where Bald Eagles nest in trees (Stalmaster 1987).

Bald Eagles strongly prefer heterogenous stands, but avoid forest stands having a dense complement of trees of similar age and height (e.g. Juenemann 1973, Grubb 1976, Stalmaster 1987, cf. Lehman 1979). Such avoidance was found in various areas on both lakes. Parts of Besnard and Nemeiben lakes lie on the Precambrian shield. Much of this terrain consists of exposed rock and shallow soils which are sparsely populated with short, primarily coniferous trees. These areas are called "treed rock" on FI maps and provide very few trees suitable for nesting Bald Eagles. Treed and untreed muskeg are another common component adjacent to lakes in north-central Saskatchewan, and are also unsuitable for nesting. From a forestry perspective, treed rock and muskeg are combined to form the FI category, "non-productive". Such terminology is also applicable to these areas as sources of suitable nest trees for eagles. Classification of forest stands as "suitable or unsuitable" is somewhat arbitrary, but provides a useful procedure for quantifying available habitat.

The distribution of Bald Eagle nests by species association on Besnard Lake may have changed since research began on the lake in 1968. Gerrard et al. (1975) reported 37% of nests on Besnard Lake were in softwood stands and 18.6% in pure hardwood stands. Comparable data for my sample (1973 - 1987) were 2% and 10.2% (n = 49) respectively. It is unlikely that there has been a shift in selection criteria by the eagles, although the possibility of this cannot be ruled out. I used FI maps based on aerial photos taken in 1980, while Gerrard et al. (1975) used maps based on 1967 photos. Air photo interpretation is somewhat subjective and discrepancies based on judgement may have played a role in some of the differences in the quantities of each stand type. Methodology in calculating the amounts of each species association differed. I used a digitized 200 m zone around the entire lake, while the previous analysis was based on map-wheel estimates along the shoreline. The distribution of stand types on the shore may not be the same as it is 50, 100 or 200 m, etc. from shore. Based on habitat analysis, black spruce and jackpine density increase from shore inland. Therefore, I would expect my estimates of softwood to be higher than previous estimates. However, softwood stands comprised 20.3% of my sample and 26.8% of Gerrard et al. (1975). Previous estimates of the hardwood component (28.9%) exceed present data (15.6%), while mixed-wood forests in the present study (41.2%) make a 10 % greater contribution than in the past. Whitfield and Leighton (unpub. data) found that aspen nest trees were older than 70 years and occur primarily in stands with a high proportion of spruce because pure stands of aspen are converted to softwood at about 80 years. It is possible that there has been a seral shift to a greater mixed-wood component thus explaining the preponderance of eagle nests in mixed-wood stands in the present study (83.6%) compared to 44.2% in Gerrard et al. (1975).

Nest-site availability as a factor limiting the breeding density of birds has been considered by numerous authors. Lack of suitable nesting sites has been implicated in some raptor populations, usually in concert with some aspect of territorial behaviour (Newton et al. 1977, Village 1983). There are many brief descriptions of nest-site characteristics with conclusions, based on qualitative, or no evidence, that availabiity of suitable nest-sites was not limiting breeding density (e.g. Brown and Watson 1964, Tjernberg 1985, Hansen and Hodges 1985). Available habitat is occasionally quantified in an effort to determine if a shortage of nest-sites is limiting the breeding population (e.g. Gauthier and Smith 1987). By using nest-site selection criteria to classify available habitat into categories of suitability and having an accurate estimate of the amount of suitable habitat, I am confident the availability of suitable nest-sites in not likely a factor limiting the breeding density of Bald Eagles on Nemeiben or Besnard lakes.

Van Horne (1983) showed that a positive correlation between habitat quality and density may not always exist. The nest tree and associated stand represent one component of nesting habitat and suitability may be influenced by other factors such as food supply (Mackenzie et al. 1982, Village 1983). Clearly, factors other than nest-sites influenced the suitability of nesting habitat and breeding density of Bald Eagles on Nemeiben Lake.

2.5. Summary

Bald Eagles on Besnard and Nemeiben lakes nest primarily on trembling aspen in softwood-dominated, mixed-wood stands on the mainland and show a slight preference for white spruce on the islands. There may have been a shift from nesting in stands classified as hardwood only and softwood only stands to those with a mixture of soft- and hardwoods. Forest stands dominated by one species, all stands with a height classification of 10 m or less, muskeg, and treed rock are avoided by Bald Eagles on Besnard and Nemeiben lakes. There is no evidence for nest-site availability acting as a factor influencing interlake density differences.

3. Chapter 3

Fish Populations

3.1. Introduction

Food supply has long been recognized as an important factor limiting aspects of the breeding ecology of birds (Lack 1954, review by Newton 1980). Timing of laying, clutch size, breeding success, and fledging rate have been shown to be affected by food supply (e.g. Southern 1970, Smith et al. 1981, Janes 1984). Varying degrees of functional and numerical responses (Solomon 1949) have been observed for numerous birds of prey, often in response to cyclic prey (e.g. McInvaille and Keith 1974, Linden and Wikman 1983, Steenhof and Kochert 1988). Geographic variation in avian breeding density has been correlated with indices of food supply (measured directly and indirectly, reviewed by Newton 1979, 1980); but experimental evidence is limited and equivocal (e.g. Yom-Tov 1974, Watson et al. 1984). Unequivocal evidence for food as a limiting factor may not be attainable because food supply may act in concert with other factors. Thus the quality of the evidence is important (Newton 1980).

Food availability can influence the movements and density of non-breeding Bald Eagles, as well as the breeding chronology, density and breeding success of territorial breeding pairs (Fraser et al. 1985a, Hansen 1987, Gerrard and Bortolotti 1988). Fish comprise 99% of the eagle's diet on Besnard Lake, with white sucker (*Catostomus commersoni*) and cisco (*Coregonus artedii*) as the most important species in their diet (Table 3.1, excerpt from Gerrard and Bortolotti 1988). Reliable estimates of prey composition of nesting eagles on Nemeiben Lake are not

Table 3.1. Proportion of prey species delivered to Bald Eagle nests on Besnard Lake.[1]

	Delivered to nests[2]	
Species	% occurence	% by weight
Cisco	46.7	27.9
White sucker	30.9	39.0
Northern pike	10.0	12.6
Burbot	8.6	15.8
Walleye	2.4	3.2
Yellow perch	0.3	0.1
Whitefish	0	0
Duck spp.	1.0	1.3

1 Excerpt from Appendix 3a in Gerrard and Bortolotti (1988).
2 Based on observations of 291 prey items brought to nine nest on Besnard Lake from May to August, 1980 to 1982 (Bortolotti unpublished).

available; however, fish were the most common prey remains found in nests when visited for eaglet growth analysis. Much of the food acquisition and territorial defense by breeding eagles occurs near the nest site (Ofelt 1975, Gerrard et al. 1975, Haywood and Ohmart 1986); combining this with the influence food availability has on non-breeding eagles makes it valid to examine fish populations in Besnard and Nemeiben lakes as possible factor influencing known density differences of Bald Eagles.

Evidence from previous biological surveys showed dramatic differences in fish productivity and stocks (especially cisco) of Besnard and Nemeiben lakes (Koshinsky 1964, Chen 1974). Changes in cisco and white sucker populations may have occurred, but more recent government records do not include information on these two species as they are of little importance to commercial or sports fisheries. To update information on cisco and white sucker populations in Besnard and Nemeiben lakes I conducted test netting in 1987.

3.2. Materials and Methods

Catch per unit effort (CPUE) is a commonly used index of abundance used in fisheries biology (Nielson and Johnson 1983); similar methodology has been applied to terrestrial systems in indices of abundance of small mammal populations (e.g., Steenhof and Kochert 1988). Theoretically CPUE should be directly proportional to abundance, however numerous variables affect CPUE (Ricker 1975, Nielsen and Johnson 1983). A rigid sampling design identifying the season, time, location, gear and duration of sets can reduce much of the variability among gill-net samples (Nielson and Johnson 1983). Application of identical methodology and equipment on Besnard and Nemeiben lakes allowed CPUE to be used as an index of fish abundance. Sampling was conducted in June, July and August, 1987; seven nets were set on each lake per time period. The ecology of the target species, cisco and white sucker, are quite different and a separate stratified sampling design was desirable for each species. However, sample points were selected at random because of logistical constraints. I do not think this imposed a serious bias as locations were well distributed and the lakes have similar morphological characteristics. All nets were set on the bottom (bottom sets).

I used nylon, multifilament gill nets (survey type (B), bottom nets, from Lundgrens Fiiskredskaps-Fabrik, Stockholm, Sweden) that were 58m on the topline and 70m on the bottomline. Each net consisted of six panels. Each panel was 9.5m long and was made of one of the following stretched mesh sizes (in mm): 38.1, 50.8, 60.3, 63.5, 76.2, and 88.9, (in inches: 1.5, 2, 2.3, 2.5, 3, 3.5). The use of several mesh sizes reduced the effects of size selectivity (Nielsen and Johnson 1983). Nets were set in the evening and pulled twelve hours later. Gill nets are most effective during this period (Nielsen and Johnson 1983) and human interference with the nets was minimized.

Number, length, weight and species of fish were recorded according to the mesh size in which they were caught. Fork length (length of the fish from the most anterior point to the caudal end of the median rays of the tail) was recorded (to the nearest mm). Accu-weigh spring scales were used for weights; models T-2 (1kg x 10g), T-4 (2kg x 20g), and T-10 (5kg x 50g) were used where appropriate. Fish were identified with reference to Scott and Crossman (1973); coregonids were identified by mouth morphology. Fish were released alive when possible, otherwise game fish were turned over to the local conservation officer or distributed to local native families or senior citizens. Rough fish (ciscoes and suckers, Catostomus species) and small game fish were disposed of in accordance with guidelines set out by Fisheries staff.

Proc GLM (SAS version 5) was used to compare the mean number, weight and length of each species caught per net set. Mensural data was log transformed prior to analysis.

3.3. Results

Significantly more ciscoes ($F = 6.23$, $P > F = 0.017$) and yellow perch (Perca flavescens) ($F = 17.21$, $P > F = 0.0002$) were caught per set in Besnard Lake (Table 3.2). Lake trout (Salvelinus namaycush, $N = 3$) and longnose sucker (Catostomus catostomus, $N = 6$) were only caught in Nemeiben Lake, while one trout-perch (Percopsis omiscomaycus) was caught in Besnard Lake.

Averaged over the three sampling periods, ciscoes caught in Besnard Lake were 154 g heavier ($P < 0.01$) and 5.2 cm longer ($P < 0.05$) than those from Nemeiben Lake (Table 3.2). By sampling period, ciscoes in Besnard Lake were longer and heavier in June ($P < 0.01$) and July (Figure 3.1, weight only); no cisco were caught in Nemeiben Lake in August. Although white suckers averaged 25 g heavier on Besnard Lake, differences in weight and length were not significant in June (Figure 3.2, weight only), nor for all sampling periods combined (Table 3.3). In July, white suckers were 100 g heavier ($P < 0.01$) and 3.3 cm longer ($P < 0.001$) in Nemiben Lake; in August, white suckers in Besnard Lake averaged 144.6 g heavier and 2.6 cm longer than in Nemeiben Lake (Figure

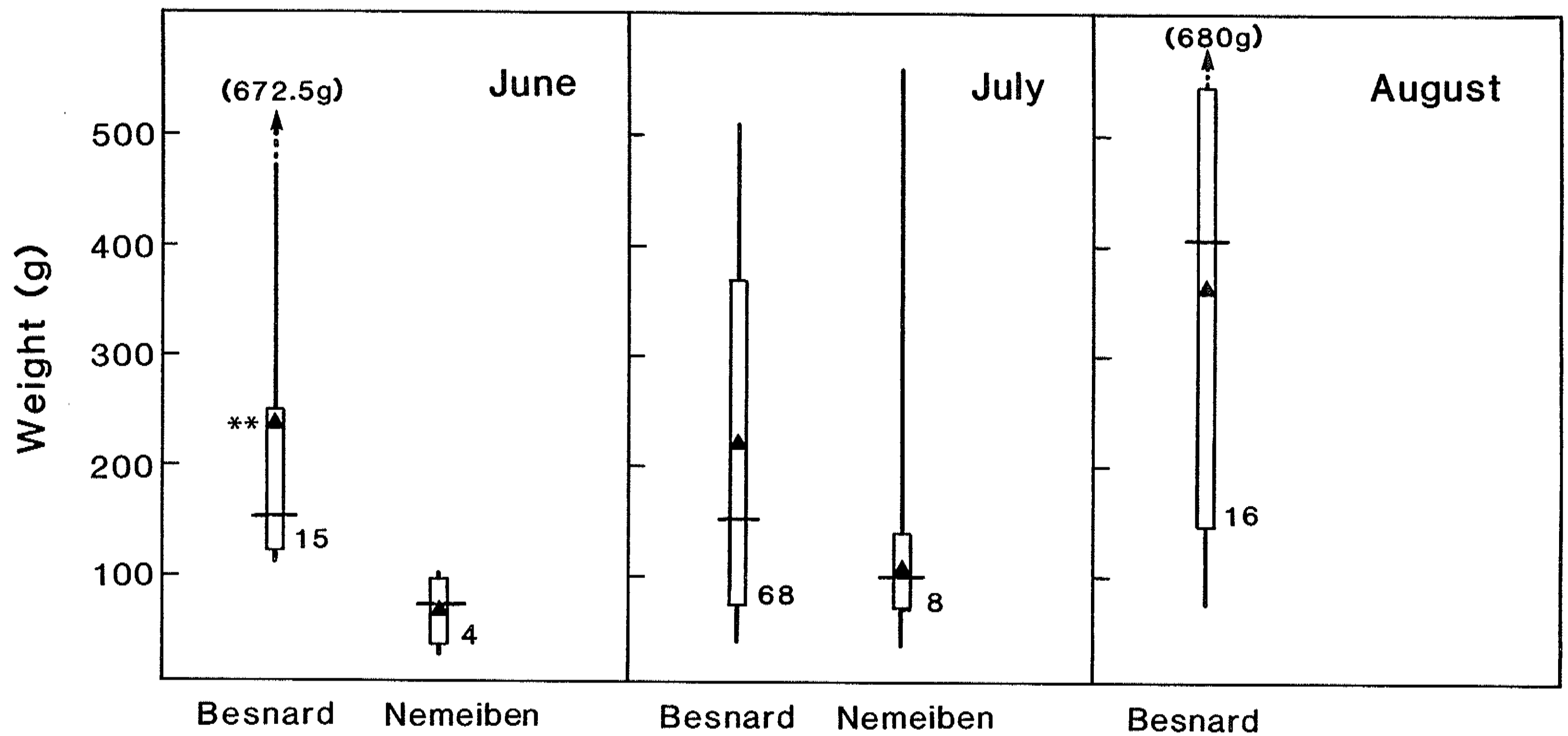
Table 3.2. Catch-per-net set on Besnard and Nemeiben lakes, 1987.

	Fish caught per set					
	Besnard			Nemeiben		
Species	$\overline{X}$	SD	(Range)	$\overline{X}$	SD	(Range)
White Sucker	23.00	8.438	(7 - 35)	22.57	10.722	(8 - 44)
Cisco	4.76*[1]	7.589	(0 - 32)	0.57	1.248	(0 - 4)
Lake Whitefish	1.29[2]	7.589	(0 - 6)	3.2	4.110	(0 - 12)
Northern Pike	4.05	2.906	(0 - 10)	2.86	2.007	(0 - 6)
Walleye	10.62	7.83	(0 - 33)	10.90	8.330	(0 - 26)
Yellow Perch	4.29***	3.333	(0 - 15)	0.95	1.564	(0 - 5)
Burbot	0.10	0.301	(0 - 1)	0.19	0.402	(0 - 1)

[1] Asterisks indicate that mean at Besnard differs significantly from mean at Nemeiben Lake. * = $P < 0.05$, *** = $P < 0.001$).

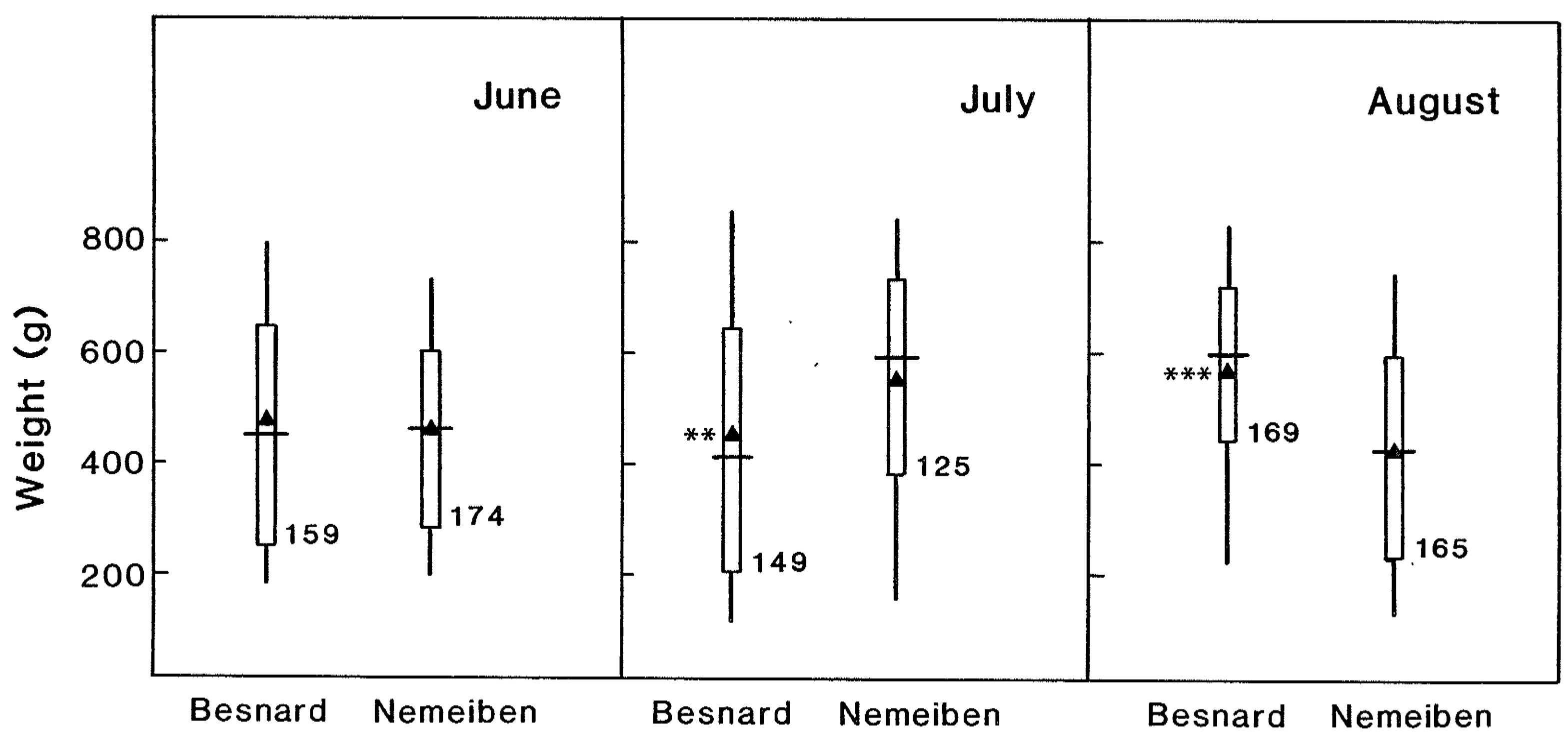
[2] Differences in the mean number of fish per set approach significance ($0.1 < P < 0.05$).

Figure 3.1. Mean weight of ciscoes caught in nets set in Besnard and Nemeiben lakes in June, July and August, 1987. Horizontal line is median, ▲ is mean, box is 25 and 75 percentiles, vertical lines are 10 and 90 percentiles. Sample size is given beside the box. (**) indicates mean weight of cisco in Besnard Lake differed significantly ($P < 0.01$) from the mean on Nemeiben Lake. Note: no ciscoes were caught in Nemeiben Lake in August.



Weight (g)
500
400
300
200
100
(672.5g)
June
**
15
4
Besnard
Nemeiben
July
68
8
Besnard
Nemeiben
(680g)
August
16
Besnard

Figure 3.2. Mean weight of white suckers caught in nets set in Besnard and Nemeiben lakes in June, July and August, 1987. Horizontal line is median, ▲ is mean, box is 25 and 75 percentiles, vertical lines are 10 and 90 percentiles. Sample size is given beside the box. Asterisks indicate means of Besnard Lake differed significantly from means of Nemeiben Lake: ** $P < 0.01$; *** $P < 0.001$.



June
July
August
Weight (g)
800
600
400
200
159
174
**
149
125
***
169
165
Besnard
Nemeiben
Besnard
Nemeiben
Besnard
Nemeiben

Table 3.3. Comparison of length and weight of fish caught in Besnard and Nemeiben lakes, sampling periods combined, 1987.

Species	Lake[1]	N[2]	Weight (g) X	SE	N	Length (cm) X	SE
			(Range)			(Range)	
White Sucker	B	477	496.9	11.56	476	31.6	0.30
			(35-1120)			(14.0-48.2)	
	N	464	471.8	11.09	459	31.8	0.28
			(35-1275)			(15.0-46.4)	
Cisco	B	99	247.1**	19.80	100	24.7*	0.71
			(28-885)			(12.8-45.8)	
	N	12	93.8	14.73	12	19.5	1.04
			(25-205)			(13.7-26.5)	
Lake Whitefish	B	27	589.6	59.43	27	35.0#	1.32
			(70.1110)			(18.9-45.3)	
	N	67	517.8	42.06	67	32.3	0.87
			(75-1350)			(18.8-46.3)	
Northern Pike	B	84	954.9	71.05	85	49.4*	1.20
			(60-3075)			(21.3-76.2)	
	N	59	1133.2	101.21	60	53.3	1.41
			(150-4950)			(28.0-88.0)	
Walleye	B	217	759.1**	20.39	221	39.9#	0.44
			(55-1600)			(10.3-51.6)	
	N	227	650.6	19.71	224	38.5	0.39
			(60-1990)			(19.6-54.4)	
Yellow Perch	B	65	57.8*	5.67	88	15.2	0.32
			(15-285)			(10.5-28.4)	
	N	18	37.5	19.2	19	14.9	0.45
			(20-85)			(12.4-19.1)	

1 B = Besnard Lake; N = Nemeiben Lake.
2 Number (N) for lengths and weights per species may differ as both variables were not measured on each fish.
** Difference significant at $P < 0.01$.
* Difference significant at $P < 0.05$.
# Difference approaches significance $0.1 < P < 0.05$.

3.2, weight only). Northern pike (Esox lucius) in Nemeiben Lake were on average, 3.9 cm longer ($P < 0.05$) and 178 g heavier (difference not significant). Walleye (Stizostedion vitreum) averaged 100 g heavier in Besnard Lake ($P < 0.01$) and Yellow Perch were also heavier ($P < 0.05$) in Besnard Lake (Table 3.3).

3.4. Discussion

Food supply is a major factor affecting the dispersion and density of many bird species, including some raptors and owls (Village 1982, review by Newton 1980). Prey (fish) availability was the most important factor influencing Osprey (Pandion haliaetus) productivity in one Idaho study area (Van Daele and Van Daele 1982). Hansen (1987) increased Bald Eagle nesting and fledging success by providing additional food. Sparrowhawk (Accipiter nisus) density correlated with land productivity (an index of food supply) (Newton et al. 1977) and prey (bird) density (Newton et al. 1986). Variation in the density of nesting pairs of various raptors and owls is correlated with the density of their cyclic prey (McInvaile and Keith 1974, Smith et al. 1981, Village 1982, Korpimaki 1987). Breeding of Wedge-tailed Eagles (Aquila audax) was dependent on the occurrence of a minimum level of available prey (Ridpath and Brooker 1986). Differences in food supply may contribute to differences in the density of Bald Eagles in north-central Saskatchewan.

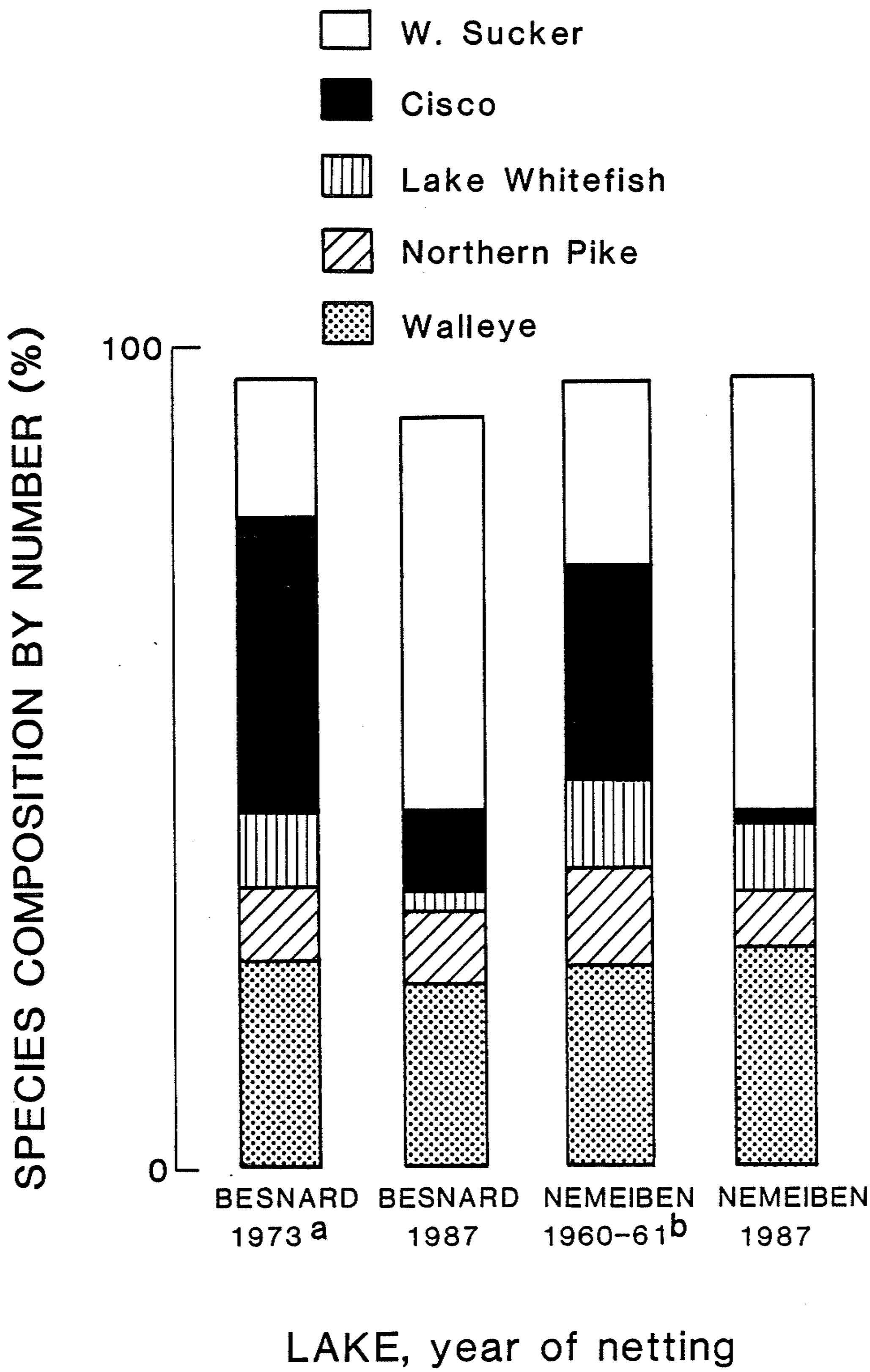
Plankton and benthic fauna form the basis of aquatic food chains and are useful indicators of the trophic or nutritive status of lakes (Koshinsky 1964). Standing crops of plankton and benthic fauna on Besnard Lake were more than twice that reported for Nemeiben Lake, and the mineral content on Besnard Lake was higher than Nemeiben Lake (Table 3.4)(Koshinsky 1964, Chen 1974). Differences in productivity at the lower end of the food web should continue through the higher trophic levels.

Past and current data from test-netting support the contention that fishes in Besnard Lake are larger and more numerous. Although absolute values were greater on Besnard Lake, walleye, northern pike, lake whitefish (Coregonus clupeaformis) and white sucker contribute similar proportions to previous gillnet samples on Besnard Lake (Chen 1974) and Nemeiben Lake (Koshinsky 1964) (Fig 3.3). White suckers make up a much larger proportion in my samples, and coregonids contribute much less than in previous studies (Fig. 3.3). The mean depth of nets (m) in my samples (Besnard Lake $\overline{X} \pm$ S.D., 4.8 $\pm$ 11.27, n = 19; Nemeiben Lake 5.5 $\pm$ 10.93, n = 21) are much less than in past studies (Besnard Lake 10.3 $\pm$ 3.37, n = 17 (Chen 1974); Nemeiben Lake 11.3 $\pm$ 8.19, n = 23 (Koshinsky 1964)). White suckers are a shallow water species, generally inhabiting the top 10 m and frequently move into shallower water at dawn and dusk to feed (Scott and Crossman 1973). Chen (1974) caught lake whitefish and cisco more often in open, deep water than near shore or in shallow water. Differences in the proportions of white sucker, lake whitefish and cisco between my study and earlier ones is most likely due to net placement, rather than changes in fish populations. The average catch per standard gang gillnet nest on Besnard Lake was N = 135.7 (79.9 kg) with cisco contributing 35.8 % to the catch by number and 23.4 % by weight. The average catch in Nemeiben Lake was N = 90.1 (49.2 kg) with cisco contributing 26.0 % to the catch by number and 5.8 % by weight.

Table 3.4. Summary of morphometry, standing crops of plankton and benthic fauna, and gill-net sets of Besnard and Nemeiben Lakes (Koshinsky 1964, Chen 1974).

	BESNARD		NEMEIBEN	
Water Area (ha)	17,718		15,488	
No. of islands	255		257	
Mean depth, meters	7.9		6.7	
Maximum depth, meters	26.8		39.3	
Water volume, m^3	1.4021×10^9		1.0321×10^9	
Shoreline, km (not including islands)	303.2		326.45	
Depth (m)	Water area		Water area	
	ha	%	ha	%
0-5	7484	42.23	)	
5-10	4619	26.09	13010)	84
10-20	5265	19.74	)	
20-26.8(Bes.) (39.3,Nem.)	350	1.98	2478)	16
Standing Crop - Plankton (kg/ha)	63.82		30.5	
- Bottom fauna (kg/ha)	9.4		4.0	
Mineral content (ppm)	60		45	
Mean number of fish caught per standard gang net	135.7		90.1	
Mean weight of fish caught per standard gang net, kg	79.9		49.2	

Figure 3.3. Species composition of gill-net samples in Besnard and Nemeiben lakes. [a] (Chen 1974), [b] (Koshinsky 1964).


W. Sucker
Cisco
Lake Whitefish
Northern Pike
Walleye
SPECIES COMPOSITION BY NUMBER (%)
100
0
BESNARD 1973 a
BESNARD 1987
NEMEIBEN 1960-61 b
NEMEIBEN 1987
LAKE, year of netting

Dramatic differences in CPUE and size of ciscoes found in earlier surveys (Koshinsky 1964, Chen 1974) continue to exist.

Sports and commercial fisheries data provide additional avenues of information on fish populations. A positive correlation exists between commercial fish catch and Bald eagle density in central Saskatchewan (Whitfield and Gerrard 1985). Commercial fisheries catch per license on Besnard Lake (2628 kg) over a forty year period was much greater than the Nemeiben Lake counterpart (1699 kg) (S.P.R.C. unpublished reports); however, this information is of limited value as no reliable measure of effort is available and does not provide specific data on cisco or suckers, as they were of little commercial value. Estimated sports fishing harvests support the contention that Besnard Lake has a more substantial fish population. In 1978 total sports fishing harvests on Besnard Lake were 40,600 kg (44.6 % northern pike, 55.4 % walleye) compared to 21,800 kg (52 % northern pike, 44.1 % walleye, 3.9 % lake trout) on Nemeiben Lake (A.McCutcheon, pers. comm.); this is despite 64 % more angling effort on Nemeiben lake (see Ch. 6.). Regardless of the long term effects angling may have caused on Nemeiben Lake, sports- and commercial fishing information provides additional support for the existence of large differences in the size of fish populations on Besnard and Nemeiben lakes. Continuing this trend up the food chain, it follows that eagle density should be (and is) greater on Besnard Lake and therefore food availabiliy is probably an important factor influencing differences in Bald Eagle density.

Fish harvested by anglers are not available to eagles, but fish which are injured by angling and released are susceptible to predation by eagles. Discard rates (the difference between catch and harvest rates) decreased from 1975 to 1978 on Nemeiben Lake for walleye (23 % to 18 %) and northern pike (47 % to 42 %); on Besnard Lake (1975 - 1979) discard rates for walleye increased from 6 % to 28 % and from 31 % to 51 % for northern pike (A. McCutcheon, pers. comm.). Walleye harvests peaked on Nemeiben Lake in 1967 and decreased to 1978; decreasing harvests are associated with decreasing discard rates as anglers become less selective in what they keep. Walleye harvests on Besnard Lake peaked in 1978, and although data are not available, it is probable that discard rates of walleye would have decreased since 1978. Increasing discard rates on Besnard Lake from 1975 - 1979 may have influenced the increase in the number of active breeding areas close to tourist access points (Gerrard et al. 1985). It is possible the Bald Eagle population on Nemeiben Lake benefitted from such a resource in the mid-1960's, but no data were available to confirm this. Nemeiben Lake had road access 15 years prior to the opening of the Besnard Lake road. Angling may be contributing to existing differences in Bald Eagle density on Nemeiben Lake relative to Besnard Lake because of reduced fish populations, declining discard rates and increasing human disturbance.

Additional support that the Nemeiben Lake Bald Eagle population is food limited comes from the non-breeding contingent. Non-breeding adults and immatures do not have to defend a nesting territory and thus are able to wander extensively, probably in response to food availability (Hodges et al. 1987, Gerrard and Bortolotti 1988). Besnard Lake experiences an influx of non-breeding eagles in July and August while nearby smaller lakes witness a decrease in this contingent of the population (Dzus and Gerrard in review, Gerrard et al. in review; Ch. 1.); there are similar patterns in a Minnesota population (Fraser et al. 1985a). These movements likely are the result of a decrease in food availability on the smaller lakes and an increase in food availability on the large lakes. A seasonal increase in the number of dead, floating fish occurs on Besnard Lake (Gerrard et al. in review). Comparable data on dead fish were not available for Nemeiben Lake. If such an increase in food availability occured or if the food supply on Nemeiben Lake was high, it should be reflected in the density of non-breeding eagles. Nemeiben Lake hosts very few immatures or non-breeding adults and evidence is equivocal about a mid-summer influx of non-breeding eagles (Dzus and Gerrard, in review, Ch. 1.). The lack of a substantial contingent of eagles that are known to exploit areas of food abundance adds support for the hypothesis that food is limiting the Nemeiben Lake Bald Eagle population.

Prey availability does not necessarily equate with abundance. Fish must be very close to the surface to be available for capture by Bald Eagles. My nets were set on the bottom and may not be representative of the number of fish available to eagles. I do not feel this seriously biases my study as the fishes most susceptible to bottom-set nets, i.e. benthic-feeding fish (e.g. white suckers), are very important prey throughout the eagle's range (Haywood and Ohmart 1986, Stalmaster 1987, Gerrard and Bortolotti 1988). Pelagic prey species (e.g. cisco) show diurnal and seasonal movements through the water column (Engel and Magnuson 1976), making them susceptible to both bottom-set nets and eagles. Species abundance in net catches and selectivity by avian predators differ (Van Daele and Van Daele 1982, this study); e.g. walleye were much more common in nets, while burbot (Lota lota) were more common in the eagles diet (Gerrard and Bortolotti 1988). These differences reflect: (1) species ecology - walleye avoid high light levels and are largely unavailable to eagles during much of the day, and (2) selectivity of nets - walleye have numerous, spiny projections that make them susceptible to nets, while burbot have virtually nothing to be caught in nets by. Although net catches do not reflect the true availability of fish to eagles, they are still valuable references for inter-lake comparisons based on CPUE.

3.5. Summary

Interlake differences in the food supply of Bald Eagles was investigated directly, with information on fish populations, and indirectly, through related information provided in biological surveys of Besnard and Nemeiben lakes. Indicators of lake productivity such as mineral content, and standing crop of benthic fauna and plankton were greater on Besnard Lake. Cisco, a key prey species for eagles, were much more common and significantly larger than in Nemeiben Lake. Data from past biological surveys, commercial and sports fisheries support the view that Besnard Lake has more and larger fish than Nemeiben Lake. Non-breeding Bald Eagles are known to respond to local variation in food availability and are much more common on Besnard Lake. Although food shortages have seldom been suggested as factors limiting Bald Eagles (Hansen 1987), prey availability was likely a very important factor contributing to density differences of Bald Eagles between Besnard and Nemeiben lakes.

4. Chapter 4

Growth of Nestling Bald Eagles

4.1. Introduction

Intraspecific growth rates vary seasonally, geographically and among individuals (Ricklefs 1968); phenotypic variation in growth is likely due, in some way, to nutrition. Factors influencing growth include environmental variability (e.g., Bryant 1975, Moss 1979, Werschkul 1979, Briskie 1985), differences in parental foraging ability (e.g., Coulson and Porter 1985, Groves 1984, Picozzi 1980), sibling competition (e.g., Hebert and Barclay 1986, Evans and McMahon 1987, Mock 1985), genetic differences (e.g., Bortolotti 1984b) or some combination of the above factors. The overall growth rate is limited by the amount of energy available after maintenance costs have been met (O'Connor 1978); therefore, growth rate may be a sensitive measure of the amount of food received by the growing chick (Coulson and Porter 1985, Bortolotti 1988).

Food abundance/availability has been correlated with growth in several species (e.g., Moss 1979, Ricklefs and Peters 1979, Ross 1980, Poole 1982, Gaston et al. 1983). Differences in feeding rate and diet composition can affect growth rate (Bird and Clark 1983, Serafin 1982, Boag 1987). Since reduced food abundance/availability can be manifested in reduced rates of growth, intraspecific variation in growth rates may provide an indication of prey availability (Bechard 1983, Ricklefs et al. 1984).

Growth rate should increase in proportion to energy consumption up to some physiological maximum. Below this maximum, growth may be strongly influenced by availability of prey and/or the parental ability in provisioning (Bortolotti 1988). Eaglet growth in ecologically distinct regions of Besnard Lake varies in relation to predicted fish (prey) productivity and mass of prey delivered to the nest (Bortolotti 1988). White Sucker and Cisco were the primary prey of Bald Eagles on Besnard Lake (Gerrard and Bortolotti 1988). Previous evidence suggested fish, especially Ciscos, were less abundant in Nemeiben Lake than nearby Besnard Lake (Koshinsky 1964, Chen 1974); this was substantiated by netting conducted in 1987 (Chapter 3). Prey abundance may play an important role in determining nestling growth rates of Bald Eagles. A comparison of eaglet growth on Nemeiben Lake to a similar study conducted on Besnard Lake (Bortolotti 1984a,b) may give further insights into the influences of the prey base on the Bald Eagle population of Nemeiben Lake.

4.2. Methods

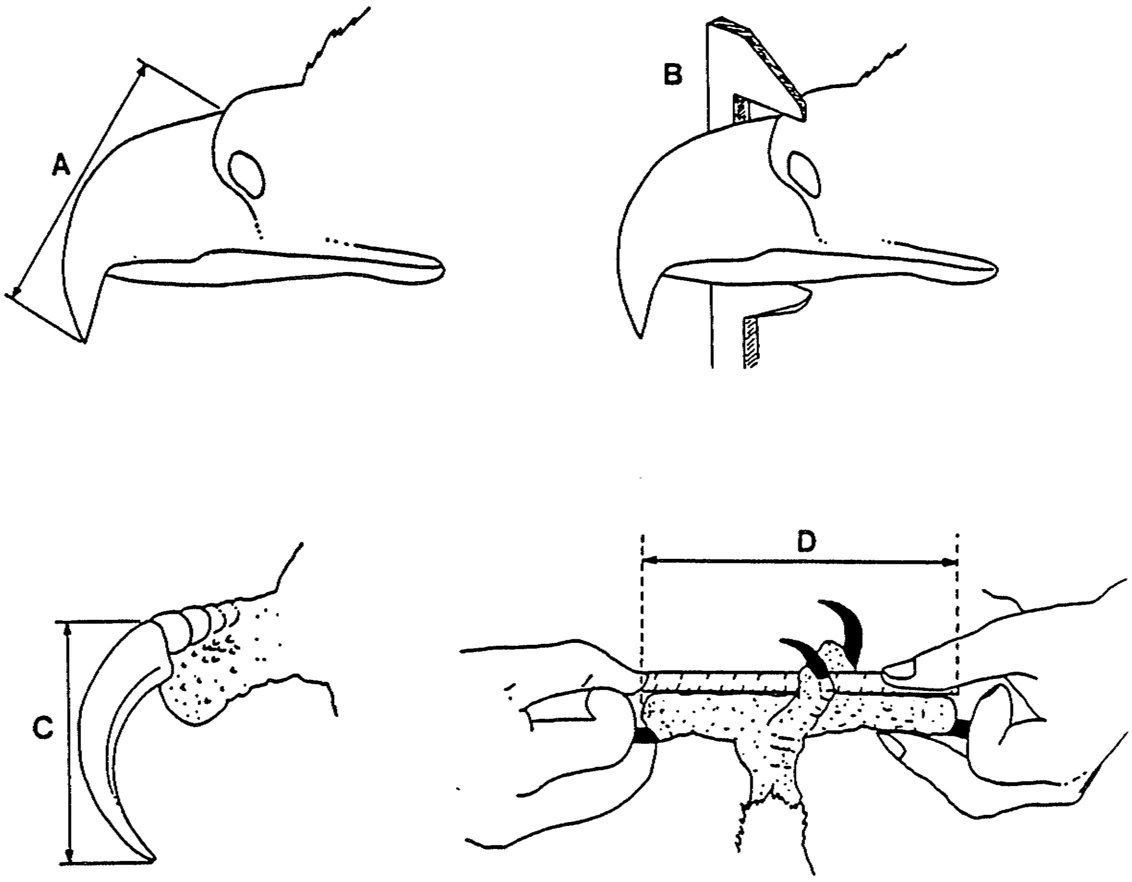
Techniques used in this study follow recommendations of Bortolotti et al. (1985) and utilized by Bortolotti (1984a,b) while studying growth of Bald Eagles on Besnard Lake. As soon as the lake ice thawed (13 May, 1987) I began monitoring the behaviour of incubating adults at nests on Nemeiben Lake to enable me to synchronize the timing of my first climb with the hatching of the first egg (Hatch = Day 0) (Bortolotti et al. 1985). Observations were made with a 15 - 60 X spotting scope from a concealed location a few hundred meters from the nest. Nestlings were marked on the tarsus and toes with a waterproof marker; marks were renewed as needed. I thus knew the hatching order and was able to identify the nestlings. Note: the modal clutch size of Bald Eagles in north-central Saskatchewan was two (Gerrard and Bortolotti 1988).

Efforts were made to minimize disturbance at the nest sites, especially during the incubation and early nestling stages. Nest trees were spiked with 25 cm spikes in February, 1986, before the arrival of the adults, to facilitate fast and safe tree climbing. To minimize disturbance during the first two weeks post hatch, time at the nest site was limited to less than 20 minutes, and measurements were taken in the nest. After this my assistant climbed to the nest and lowered the young to the ground for measuring. Measurements at a nest ended when the oldest chick was about 60 days old because of the risk of the eaglets jumping prematurely from the nest.

Only three measurements were taken in the first two weeks post-hatch: length of the mid toe excluding claw, chord of the culmen (see Figure 4.1), and weight. Linear measurements were made with a vernier caliper to the nearest 0.1 mm. An Accu-weigh spring scale (1 kg x 10 g, estimated to nearest 5 g) was used to measure weight; as the birds grew, Accu-Weigh scales of 2 kg x 20 g (estimated to the nearest 10 g) and 5 kg x 50 g (estimated to the nearest 25 g) were used. Crop contents were estimated as empty, 1/4, 1/2, 3/4 or full. In feeding experiments of eaglets, with an estimated mean age 30 days, a full crop represented about twelve percent of the birds weight. Nestling weight was determined by subtracting estimated weight of crop contents from measured weight.

After the youngest chick in a nest had reached day 14, five additional measurements were taken: bill depth (at the leading edge of the cere perpendicular to the long axis of the skull and flush to the

Figure 4.1. Diagrams of measurements useful in determining the age and/or sex of Bald Eagles: (A) culmen length, (B) bill depth, (C) hallux claw length, (D) foot pad length (from Bortolotti 1984a).


A
B
C
D

underside of the gonys), foot pad (maximum expanse of the stretched foot with a ruler pressed flat against the mid toe and hallux, talons excluded), hallux claw, eighth primary (ruler inserted to the skin between remiges eight and nine, recorded to the nearest mm) with feather pressed flat against the ruler, and central rectrix (ruler inserted to the skin between the central rectrices). Nestlings were handled on average every 5.6 days (range 4 - 8 days).

I found the Gompertz growth equation gave the best fit to weight and culmen length. Bortolotti (1984a,b) used Ricklef's (1967) graphical technique to fit individual Gompertz equations to weight and culmen length. I determined k values from least squares regressions fit to data that were transformed into values from Ricklefs (1967). Parameters of the Gompertz equation are:

K - a constant proportional to the overall growth rate,

t - age at the inflection point of the curve (days),

a - asymptotic size

To examine development further Bortolotti (1984a,b) used linear regressions of age and length of the eighth primary and central rectrix, where the slope of the line represents the feather's rate of growth and the intercept is the age of emmergence. For comparison, I followed Bortolotti's procedures.

There are sex-specific growth characteristics in numerous species of raptors (e.g. Bortolotti 1984a,b, 1986a; Collopy 1986), and as such it is important to classify nestlings according to sex whenever possible. The degree of sexual dimorphism remains constant in foot pad and bill depth measurements after 40 to 45 days (Bortolotti 1984c).

Nestlings in my study were sexed according to these measurements.

G.R. Bortolotti kindly provided Gompertz growth parameters (K,t,a) and eighth primary growth rate and age of emergence values of individual chicks from his study. This simplified statistical testing of interlake comparisons. Intersexual and interlake comparisons of Gompertz growth parameters for weight and culmen for Nemeiben Lake eaglets were assessed using a Kruskal-Wallis test in Proc NPAR1WAY on S.A.S. (Version V, year). Intersexual analysis of feather development was analysed using Proc GLM, with sex as a 'dummy' variable (Neter and Wasserman 1974). I used a Kruskal-Wallis test for interlake comparisons of eighth primary growth. Individuals on Nemeiben Lake were compared to Besnard Lake mean values using a t-test to compare a single observation to a mean of a sample as outlined by Sokal and Rohlf (1981, Box 9.7, page 231). Significance was set at alpha = 0.05.

4.3. Results

I climbed to nests on the day of hatch for three young, within a day for two more, and I estimated the age of two young by comparing them to the others and through discussions with G.R. Bortolotti. Hatching spread for the population was five days (i.e., difference between the earliest hatched young, 26 May, and the latest, 31 May). Hatch interval within broods varied from one to four days. See Table 4.1 for hatching dates, intervals, and hatching order by sex.

4.3.1. Intersexual Comparisons for Nemeiben Lake Eaglets

For unknown reasons the first-hatched eaglet, F1 (note: "F" refers to the nest and "1" refers to the hatch order) at nest F fell out of the nest some time between my visits on Day 32 and 37. Aside from the

Table 4.1. Hatching date, intervals and order of sexes of nestling Bald Eagles on Nemeiben Lake, 1987.

Nest	Hatching date of first egg	Hatching interval (day(s))	Hatching order of the sexes
C	May 29	2	F/M
E	May 26	_[1]	M
F	May 26	4	M/F
I	May 27	1	M/F

[1] Second egg did not hatch.

lethargy imposed by a weight loss of 500 grams, F1 appeared uninjured. There was no previous evidence of poor health, so I fed it some fish and put it back in the nest. F1's weight on day 37 was well below expected; eight days later, F1 had gained 1,200 g (Figure 4.2). Ricklefs (1967, 1968) recommended that "abnormal" growth curves not be included in analyses. Since the weight growth curve appeared 'normal' without day 37 (Figure 4.2) and growth parameters for culmen were essentially unaffected (Figure 4.3), I have excluded F1's day 37 from the analyses. Note: in upcoming statistical tests, significance was not affected by the inclusion/exclusion of day 37.

Patterns of growth varied by sex and with respect to different parameters and mensural characters. Males were significantly smaller ($P < 0.05$) for culmen and weight, and trends of earlier inflection points (t) for the weight curve ($P = 0.077$) and culmen analysis ($P = 0.157$) were not signiicant (Table 4.2). There was no significant difference in growth rate (K) for culmen, though males gained weight at a significantly faster rate ($P = 0.034$) than females. There were no significant differences between the slopes (growth rate) for the eighth primary or the central rectrix. Central rectrices emerged 2.7 days earlier in males ($P = 0.022$), and there was a similar, but non-significant trend for the eighth primary (Table 4.3).

4.3.2. Interlake Comparisons

Bortolotti (1984b) reported males were smaller, had earlier inflection points, but showed no intersexual differences in growth rate (K) for weight or culmen (Table 4.4). Considering the differences I found in growth rate for weight, interlake comparisons were made by sex

Figure 4.2. Weight growth of male eaglet (F1) at Nest F on Nemeiben Lake, 1987. Arrow indicates day the eaglet was found on the ground below the nest. Broken line is the hypothetical ontogenic increase in weight which would have occurred if the chick had remained in the nest.

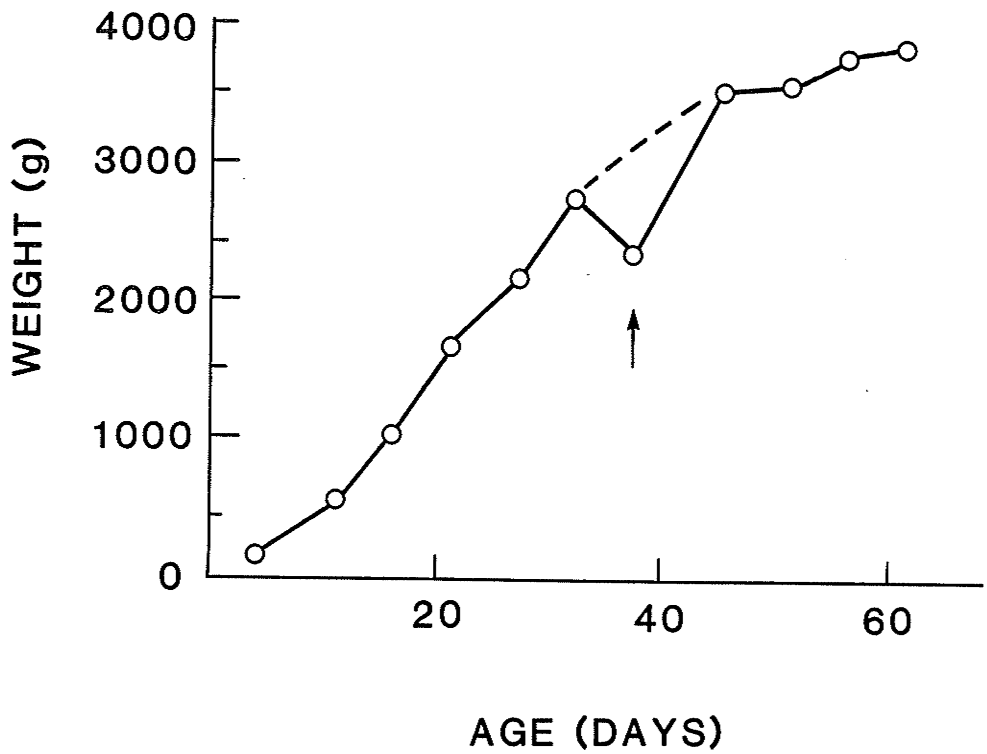

4000
3000
2000
1000
0
WEIGHT (g)
20
40
60
AGE (DAYS)

Figure 4.3. Weight and culmen length growth rate (K) comparisons for male eaglet F1, including and excluding Day 37 (eaglet found out of nest).

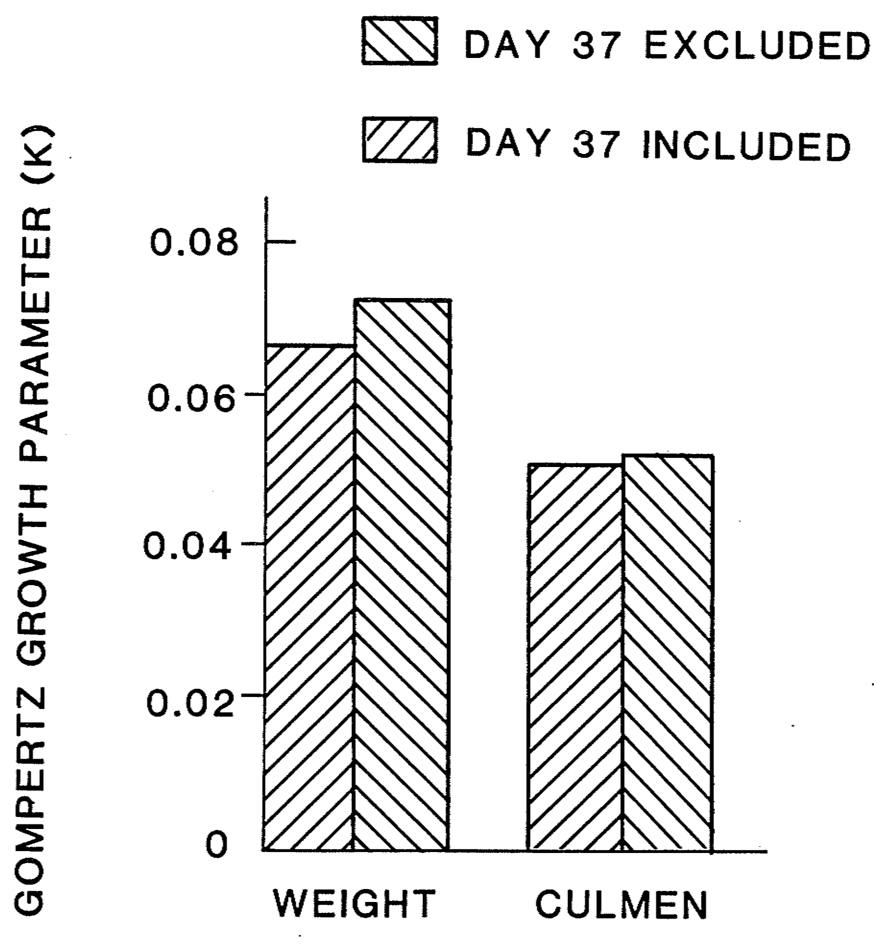

DAY 37 EXCLUDED
DAY 37 INCLUDED
GOMPERTZ GROWTH PARAMETER (K)
0.08
0.06
0.04
0.02
0
WEIGHT
CULMEN

Table 4.2. Parameters of Gompertz equations for weight and culmen growth of Bald Eagles on Nemeiben Lake, 1987.

			Growth parameter					
			K		t		a	
Variable	Sex	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
			(range)		(range)		(range)	
Weight	M	4	0.0705*[1]	0.00372	21.18[2]	0.946	3939*	115.4
			(0.067-0.075)		(20.1-22.4)		(3785-4065)	
	F	3	0.0594	0.00693	25.20	3.205	5175	298.4
			(0.052-0.065)		(22.1-28.5)		(4859-5452)	
Culmen	M	4	0.0576	0.00408	7.65	1.204	48.08*	1.846
			(0.051-0.061)		(6.1-8.7)		(46.5-51.2)	
	F	3	0.0494	0.00811	9.27	1.380	53.33	2.650
			(0.040-0.056)		(7.7-10.3)		(51.2-56.3)	

[1] Asterisk indicates that mean of males differs significantly from mean of females (Kruskal-Wallis, Chi square approximation, $P < 0.05$).

[2] Difference between males and females approached significance (Kruskal-Wallis, Chi square approximation, $0.1 < P < 0.05$).

Table 4.3. Growth parameters of feather development on Nemeiben Lake, 1987.

Variable	Sex	N	Growth rate[1] $\bar{X}$ SE (Range)	Age of emergence[2] $\bar{X}$ SE (Range)
Eighth Primary	M	4	0.146 0.0033 (0.139-0.151)	19.93 0.553 (17.88-21.47)
	F	3	0.148 0.0041 (0.145-0.153)	21.14 0.604 (20.10-22.24)
Central Rectrix	M	4	0.175 0.0059 (0.171-0.186)	24.59 0.752[3] (20.69-26.24)
	F	3	0.187 0.0083 (0.182-0.195)	27.33 0.881 (25.51-28.09)

1 Growth rate is represented by the slope of the regression between age and the length of the feather.

2 Age of emergence represents the intercept of the same regression.

3 Male's feathers emerged significantly earlier than female's ($P = 0.0223$).

Table 4.4. Parameters of Gompertz equations for weight and culmen length, and eighth primary growth of Bald Eagles on Besnard Lake, 1980-1982 (from Bortolotti 1984b, pers. comm.).

			Growth parameter		
Variable	Sex	N	K X SD (range)	t X SD (range)	a X SD (range)
Weight	M	26	0.0683 0.00330 (0.063-0.077)	20.85**[1] 1.153 (18.2-22.8)	4066*** 178.9 (3575-4500)
	F	21	0.0683 0.00403 (0.057-0.075)	22.80 1.297 (19.2-24.9)	5172 213.3 (4800-5600)
Culmen	M	26	0.0553 0.00414 (0.047-0.062)	6.97*** 0.972 (5.2-8.8)	49.14*** 1.315 (45.5-51.0)
	F	21	0.0538 0.00506 (0.045-0.062)	8.78 1.325 (5.6-12.1)	54.39 1.074 (52.0-56.5)
Eighth Primary[2]			Growth rate X SE (range)	Age of emmergence X SE (range)	
	M	26	0.1441 0.00106 (0.136-0.159)	19.052**** 0.2903 (15.77-22.13)	
	F	21	0.1418 0.00116 (0.135-0.155)	19.771 0.3686 (17.36-22.82)	

1 Asterisks indicate that mean of males differs significantly from the mean of females. ** = ANOVA P < 0.01, *** = ANOVA P < 0.001, **** = (F = 15.84, df = 1147, P < 0.0001, Bortolotti 1984b).

2 These data on eighth primary represent summary statistics calculated from growth rates and ages of emmergence of individual birds (Bortolotti pers. comm.).

for weight and culmen.

4.3.2.1. Culmen

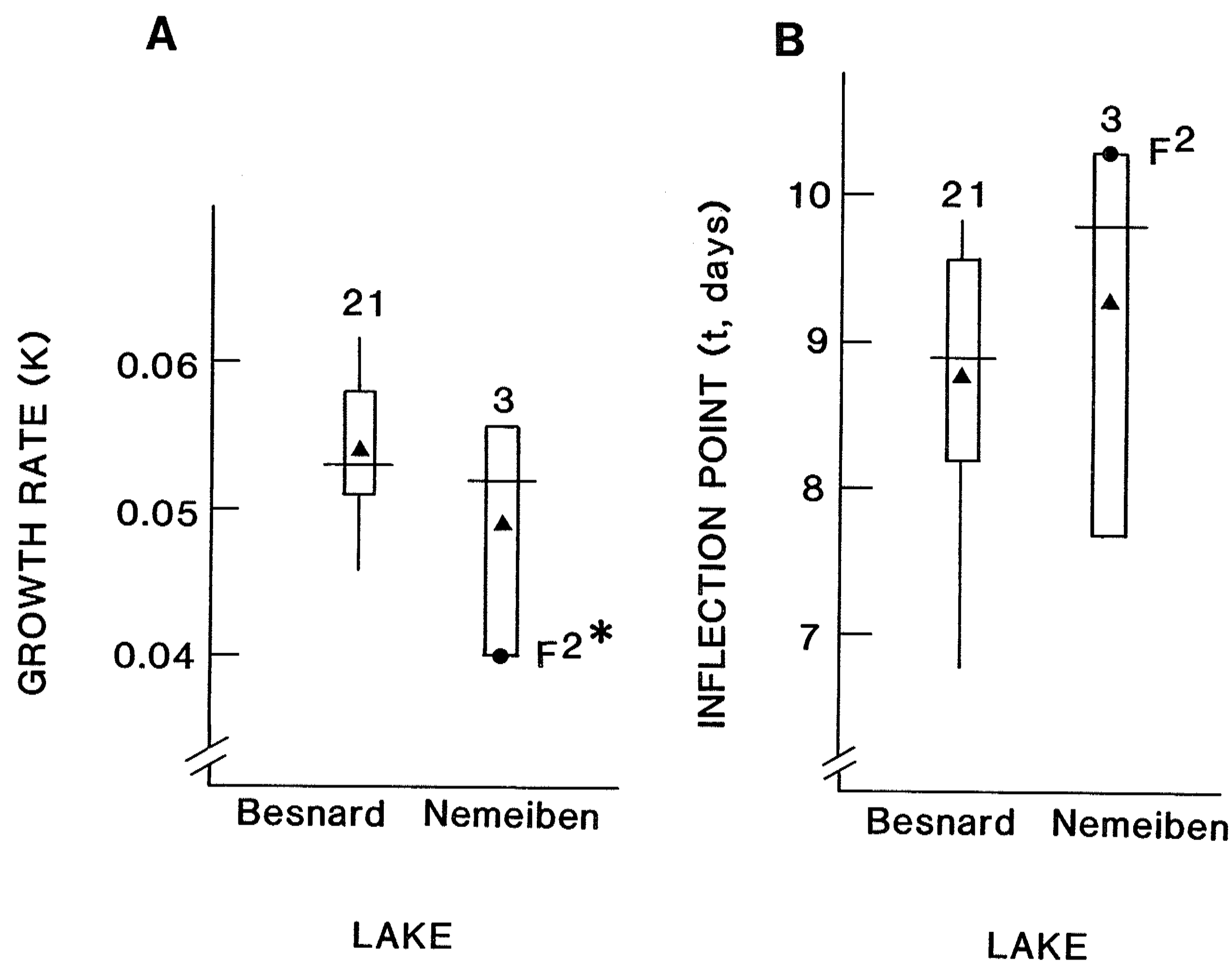
No significant interlake differences were found in mean K, t, or a values for culmen growth curves of male or female. Individual comparisons show that F2 grew significantly slower (K = 0.040; Student's t = -2.6, $P < 0.05$; Figure 4.4A) and had the latest inflection point (t = 10.33; Figure 4.4B) for Nemeiben Lake.

4.3.2.2. Weight

Nemeiben Lake female nestlings grew more slowly ($\chi^2 = 5.87$, P = 0.015; Figure 4.5A), and their average inflection point was 3.4 days later ($\chi^2 = 4.58$, P = 0.032; Figure 4.6) than Besnard Lake nestlings. Average values of K for males were not significantly different from Besnard Lake mean values (Figure 4.5B). There was no significant difference for mean inflection point values for males. Mean asymptotic values of Nemeiben Lake males and females did not differ significantly from corresponding Besnard means.

Comparisons of individual chicks from Nemeiben Lake provides further insights into interlake differences in growth. Female F2 grew significantly slower (K = 0.052, $P < 0.001$; Figure 4.5A) and had a later inflection point (t = 28.5, $P < 0.001$; Figure 4.6). Growth rate (K = 0.061; Figure 4.5A) and inflection point (t = 25.0; Figure 4.6) for female I2 approached significance ($0.1 < P < 0.05$) relative to Besnard Lake mean values.Growth parameters of Nemeiben Lake male eaglets fell within the range of Besnard Lake values. However, I1's rapid growth (K = 0.075) approached significance ($0.1 < P <0.05$, Figure 4.5B), and F1 also grew relatively rapidly (K = 0.072).

Figure 4.4. Interlake comparisons of (A) Gompertz growth rate (K) and (B) inflection point (t) for culmen length of female Bald Eagle nestlings. Horizontal line is median, ▲ is mean, box is 25 and 75 percentiles, vertical lines are 10 and 90 percentiles. Sample size is above 90^{th} percentile. Asterisk indicates nestling F2's growth rate is significantly different ($P < 0.05$) from the Besnard Lake mean.



A
GROWTH RATE (K)
0.06
0.05
0.04
21
3
F2*
Besnard
Nemeiben
LAKE
B
INFLECTION POINT (t, days)
10
9
8
7
21
3
F2
Besnard
Nemeiben
LAKE

Figure 4.5. Interlake comparisons of Gompertz growth rate (K) for weight of (A) female and (B) male Bald Eagle nestlings. Horizontal line is median, ▲ is mean, box is 25 and 75 percentiles, vertical lines are 10 and 90 percentiles. Sample size is above 90th percentile. I2, F2, I1 and F1 are individual nestlings whose growth rates are represented by (●). (*) indicates that mean of Besnard Lake differs significantly ($P < 0.05$) from the mean of Nemeiben Lake. (***) indicates growth rate for nestling F2 differs significantly ($P < 0.001$) from the mean value of Besnard Lake.

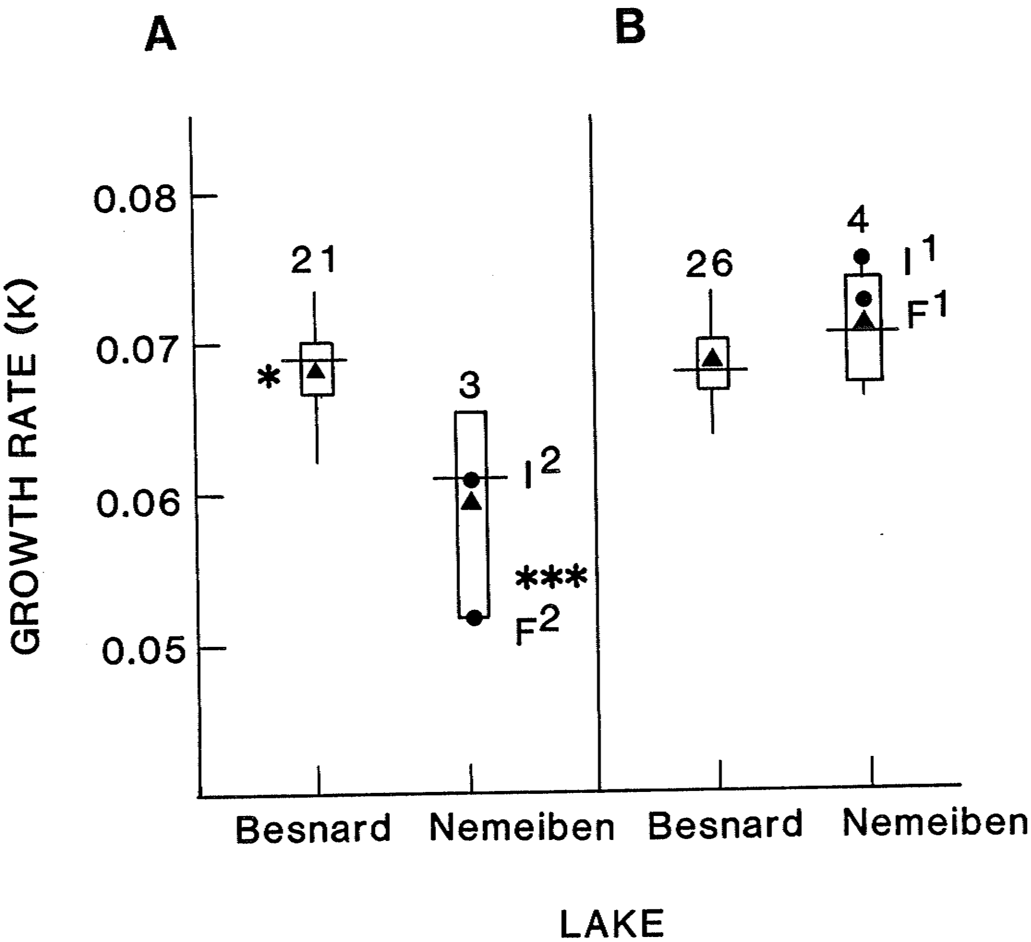
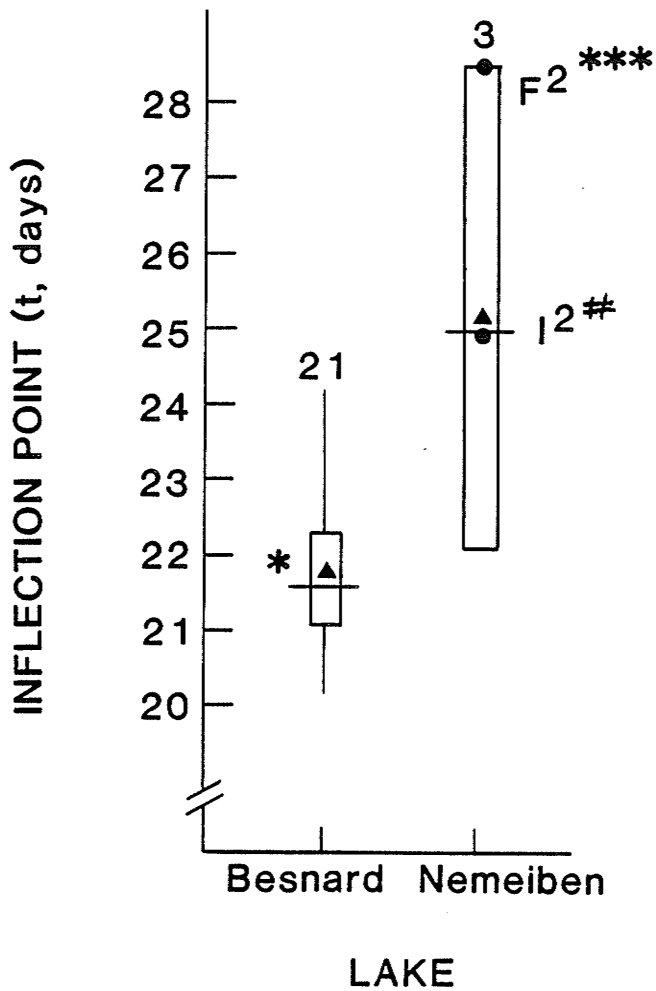

A
B
GROWTH RATE (K)
0.08
0.07
0.06
0.05
21
*
3
I2
***
F2
26
4
I1
F1
Besnard
Nemeiben
Besnard
Nemeiben
LAKE

Figure 4.6. Interlake comparisons of Gompertz inflection point (t) for female nestlings. Horizontal line is median, ▲ is mean, box is 25 and 75 percentiles, vertical lines are 10 and 90 percentiles. Sample size is above 90^{th} percentile. F2 and I2 are individual nestlings whose inflection points are represented by a (●). (*) indicates that the mean of Besnard differs significantly ($P < 0.05$) from mean of Nemeiben Lake. (***) indicates inflection point of nestling F2 differs significantly ($P < 0.001$) from mean of Besnard Lake. (#) indicates inflection point of nestling I2 approaches significance ($0.1 < P < 0.05$). relative to the mean of Besnard Lake.



INFLECTION POINT (t, days)
28
27
26
25
24
23
22
21
20
21
*
3
F2 ***
I2 #
Besnard
Nemeiben
LAKE

4.3.2.3. **Feather Development**

Since no significant intersexual differences in primary growth rate existed on Nemeiben Lake or Besnard Lake (Bortolotti 1984b), sexes were combined for interlake comparisons. No significant differences were found between Nemeiben Lake mean values of remix growth and those of Besnard Lake nestlings.

Bortolotti (1984b) found intersexual differences in the age of emergence of the eighth primary and central rectrix; males and females will be considered separately for interlake comparisons. Age of emergence of the eighth primary for the mean of the males and females was not significantly different from Besnard Lake values.

4.4. **Discussion**

Intersexual characteristics of eaglet growth on Nemeiben Lake largely support Bortolotti's (1984b) findings that the timing of developmental events are very important considerations in nestling growth. Changes in growth curve shape ("m" in the Richard's growth model) are more likely to occur following variability of environmental stressors than asymptote or k values. In models with a fixed shape constant (e.g. Gompertz, $m = 1$) responses will take the form of shifts in the age of inflection (Brisbin et al. 1987). Ricklefs (1968) previously suggested that inflection point was a useful index of variation in form of growth curves. Differences in K for weight growth were the only significant intersexual difference which deviated from eaglet growth on Besnard Lake. Wild, male Golden Eagle (Aquila chrysaetos) nestlings also grew faster than females (Collopy 1986); however, data on other sexually dimorphic species support Bortolotti's

(1984b) finding of equality of intersexual growth rates (Bancroft 1984, Newton and Moss 1986). While changes in the shape of growth curves (point of inflection) may provide an initial response to stresses (Brisbin et al. 1986), changes in other growth parameters (e.g. growth rate, K) may occur if stresses are more severe.

A morphological character whose growth parameters respond to changes in food intake would be most suited for evaluating intraspecific variation in growth. Anatomical characters such as bill, bone and feathers exhibit growth which parallels weight growth under favourable conditions, but are less susceptible to dietary influences, suggesting high developmental priorities (Dorward 1962, Ricklefs 1968, Moss 1979, Boag 1987). Ricklefs (1976) suggested retardation of feather elongation and other indices of development usually appeared only when nestlings were on the verge of starvation (cf. Lack and Lack 1951). The ability of F1 to regain a substantial weight loss while appearing to maintain normal culmen and feather development was remarkable, yet comparable to other species (Bryant 1978, Moss 1979). Growth parameters based on weight may be better indicators of nutritional limitations than growth parameters based on 'hard' tissues (Dorward 1962, cf. Scharf and Balfour 1971).

Differences in growth parameters between lakes were primarily due to slow growth of females on Nemeiben Lake. The two second-hatched females were responsible for the significant differences. Bortolotti (1984a, 1986a) found second-hatched chicks to grow slower and have later inflection points than first hatched chicks. The smaller sex of sexually dimorphic species characteristically acquire motor skills and behaviour patterns earlier than the larger sex, perhaps to allow them to compete successfully with the larger sex (Newton 1978, Moss 1979). Such growth and behavioural characteristics were important in Bortolotti's (1986b) prediction that a hatch order of male-female (MF) would have the highest probability of brood reduction. Combining sex specific growth characteristics, hatch sequence of the sexes and stresses associated with hatch order, would put second-hatched females at a disadvantage in a mixed-sex brood. Although brood reduction did not occur in this study, the developmental delays and decrease in growth rate of females in the MF broods suggest intense sibling competition may have been occurring.

Hatching asynchrony has been viewed as a mechanism by which parents can manipulate the probability of brood reduction in response to varying environmental conditions (Lack 1954, Ricklefs 1965). A longer laying interval, possibly produced by some form of energy limitation, would enhance advantages associated with age and size differences of first-hatched chicks, thus increasing the probability of brood reduction (Edwards and Collopy 1983, Astheimer 1985, Bortolotti 1986a,b). The hatching interval of four days at Nest F on Nemeiben Lake was greater than any found on Besnard Lake (Bortolotti pers. comm.). Although brood reduction did not occur, there was an enormous size difference (158%) on day 7. Thus, precursors of fratricide were established during the period when brood reduction was most likely to happen (Meyburg 1974, Edwards and Collopy 1983, Bortolotti 1986b). If second-hatched chicks are able to survive the initial period when brood reduction is most likely, they may obtain food more successfully and show better growth rates than they did previously (Evans and McMahon 1987). Edwards and Collopy (1983) suggested that below a threshold for fratricide, dominance resulting from size differences between siblings may have varied effects. Perhaps this threshold was not attained at Nest F or food availability may have increased for a period allowing F2 to receive sufficient food to survive. Longer hatch intervals and the associated greater probability of brood reduction on Nemeiben Lake are consistent with the idea that food may be limiting this population.

Bryant (1978) suggested that comparisons of growth parameters from a given area to those of a reasonably well studied population can be used to assess the quality of the breeding environment. Food abundance was the only observed difference between two areas in which growth and survival of Tree Swallows (*Tachycineta bicolor*) differed dramatically (Quinney *et al.* 1986). On Besnard Lake, growth rate of eaglets was positively correlated with the mass of prey delivered to the nest. Specifically, eaglets in the west end of Besnard Lake developed faster and attained the inflection points sooner than those on the east side of Besnard Lake (Bortolotti 1988). The faster growing chicks were raised in a region with higher indices of fish (prey) productivity (Chen 1974). Such variability in growth and prey deliveries on Besnard Lake may be the result of spatial variability in food resources. Spatial variation in food supplies is also important to nesting success and nestling growth in other birds of prey. Proximity to stable sources of prey influenced prey delivery and brood reduction in Ospreys (Poole 1982, Van Daele and Van Daele 1982, Hagan 1986) and Sparrowhawks (Moss 1979).

4.5. Summary

Prey availability may be an important factor contributing to differences in growth existing between eaglets on Nemeiben and Besnard lakes. Hatching intervals for two-chick nests were one, two and four day(s). Males were significantly smaller in weight and culmen length, with a trend to earlier inflection points for both variables. Growth rate did not differ between the sexes for culmen growth. Males gained weight significantly faster in contrast to Bortolotti (1984a,b). The eighth primary and central rectrix emerged earlier in males, but growth rate did not differ. No significant differences were found between male eaglets on Besnard and Nemeiben lakes for growth rate, inflection point and asymptotic size of culmen and weight. Feather growth rate and age of emergence did not differ between lakes for males or females. Female eaglets on Nemeiben Lake grew slower and had a later inflection point for weight and culmen growth. Although sex and hatching order influence growth, nutritional limitations may be more severe on Nemeiben Lake as females grew slower and reached developmental stages later than Besnard Lake nestlings.

5. Chapter 5

Sex Ratios of Nestling Bald Eagles in Relation to Hatching Order

5.1. Introduction

Much recent literature in avian biology has been devoted to various aspects of sex ratio theory (see review by Clutton-Brock 1986). In most large data sets, sex ratios at hatch are close to unity (Clutton-Brock 1986); however, sex ratio does vary with hatch date (e.g. Howe 1977, Patterson and Emlen 1980, Fiala 1981); order of clutch (Patterson et al. 1980); mothers age (Blank and Nolan 1983); laying sequence within a clutch (e.g. Ankney 1982, Ryder 1983); and hatching order (Bortolotti 1986b). Several recent contributions to sex ratio theory have dealt with sex ratio variation as possible adaptations to facilitate or avoid brood reduction thus maximizing reproductive success (Edwards and Collopy 1983, Bortolotti 1986b, Meathrel and Ryder 1987 cf. Weatherhead 1985).

Patterson and Emlen (1980) indicated that much of the available literature on sex ratio deals with information that has been combined from different years and areas. Meathrel and Ryder (1987) suggested such composite data sets are useful in relation to population phenomena whereas annual variability in sex ratio is of interest in terms of possible adaptive responses. Intraspecific sex ratio variation should also be manifested with respect to populations in localities experiencing different selective pressures. Available evidence on intraspecific geographic variability of sex ratio is limited.

In this chapter I compare data on sex ratios and hatching order of Bald Eagle nestlings on Besnard and Nemeiben lakes to similar data gathered on Besnard Lake (Bortolotti 1986b).

5.2. Methods

Sex of nestlings was determined on the basis of size; for bill depth and foot pad, "the distribution of birds was very strongly bimodal with a large area where no overlap occurred" (Bortolotti 1984c). In 1986 I determined age (and by inference hatching order) and sex of eaglets on Besnard and Nemeiben lakes during banding visits (see Bortolotti 1984c for method of aging). In 1987, hatching order and sex were determined while studying eaglet growth on Nemeiben Lake; data for Besnard Lake were gathered with the cooperation of G.R. Bortolotti.

5.3. Results

The most reliable data for hatching order and nestling sex are from years when growth studies were conducted because nestlings were seen at or near hatch (Bortolotti et al. 1985). In 1987 on Nemeiben Lake, females represented one of three first-hatched chicks and two of three second-hatched chicks (Table 5.1); this is an almost exact reciprocal of Bortolotti's (1986b) results for Besnard Lake (1980 - 1982) where 16/27 (59 %) of the first-hatched chicks and 8/27 (30 %) of the second hatched eaglets were female. Bortolotti (1986b) reported only one male-female (MF) brood of 27 in three years of his study. By combining data from all available years (Table 5.1), one of 47 (2.1%) of the two chick broods on Besnard Lake were MF. Three of five broods on Nemeiben Lake have been MF (Table 5.1).

Many researchers have demonstrated that size differences between siblings play an important role in brood reduction (e.g. Lack 1954, Newton 1979, Edwards and Collopy 1983). Edwards and Collopy (1983) and

Table 5.1. Number of Bald Eagle broods of different combinations of sex and hatching sequence.

		Brood type (C1/C2)[1]				
Lake	Year	M/M	M/F	F/M	F/F	
Besnard	1976-77	3	0	5	2	
	1980-82	10	1	9	7	
	1986	2	0	1	1	
	1987	2	0	3	1	
Total observed		17	1	18	11	= 47
Nemeiben	1986	1	1	0	0	
	1987	0	2	1	0	
Total observed		1	3	1	0	= 5

1 C1 indicates the first-hatched egg; C2, the second-hatched egg.

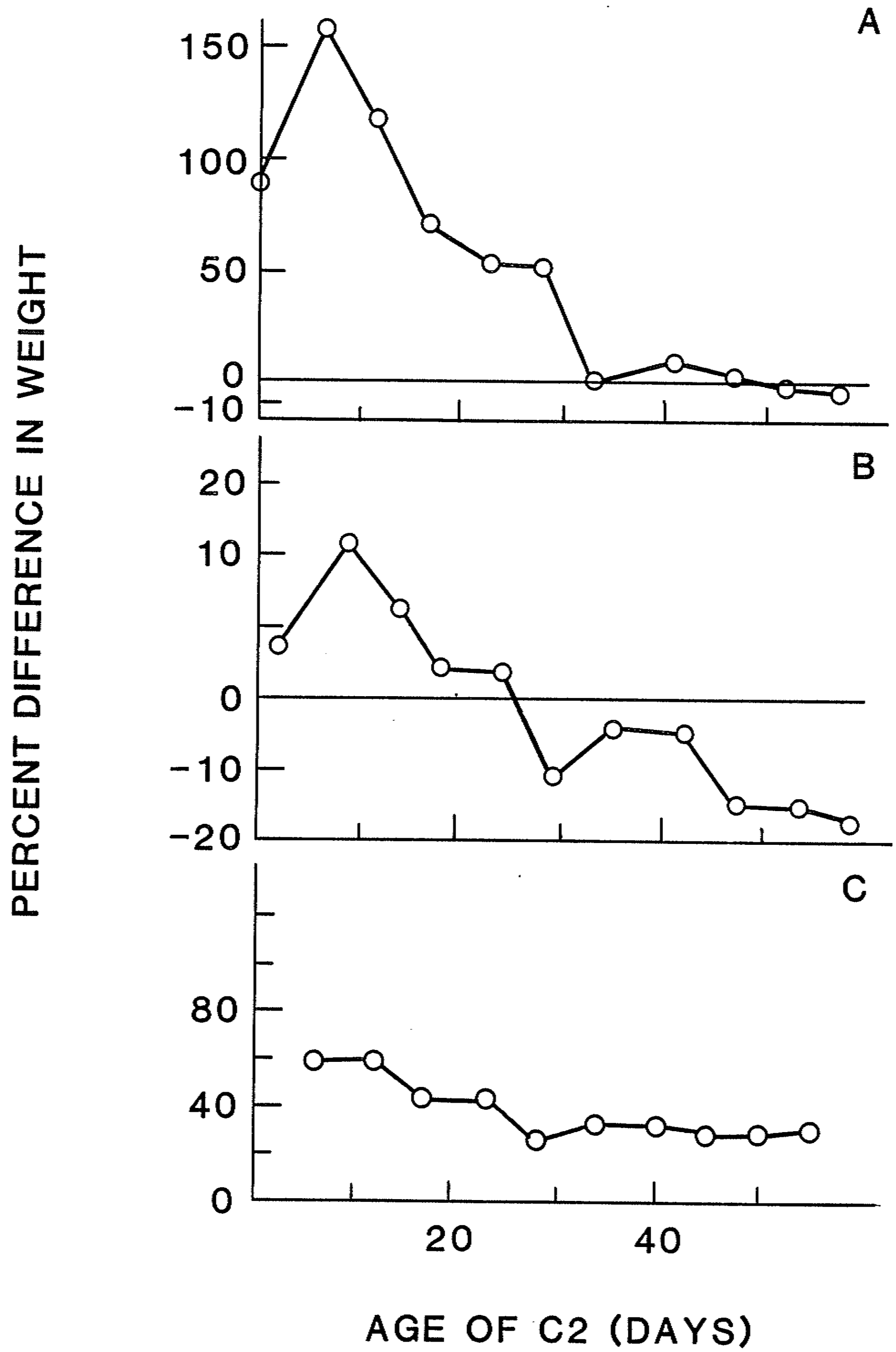
Bortolotti (1986a,b) used relative size differences to aid in understanding fratricide; this percent weight difference was calculated using the formula (weight of first hatched - weight of second hatched)/(weight of second hatched) x 100. I used actual weights to produce curves of relative weight difference for the three two-chick broods in my 1987 sample (Figure 5.1a,b,c). At nest F the hatching order MF, with a four day hatching interval, produced a very large weight difference (158% on day 7, Figure 5.1a). For a MF brood with a hatching interval of one day (nest I), the percent weight difference only reached 20 % (Figure 5.1b). Brood reduction was not found in the three two-chick studied in 1987.

5.4. Discussion

For facultative sex ratio variation to be adaptive, more young must survive to reproduce than if sex was allocated randomly. Selection for such variation should vary according to differing selective pressures. Sex ratio aberration may be associated with variation in female body condition in the pre-breeding season or with annual and geographic variation in environmental conditions that could affect the number and probability of raising young that will survive to reproduce.

Evidence of intraspecific sex ratio variation with respect to environmental conditions or body condition of adults is limited. Ankney (1982) suggested declining body condition of female Lesser Snow Geese (Chen caerulescens caerulescens) through the laying sequence may have caused a sex bias within clutches. A similar argument may apply to sexually dimorphic Red-winged Blackbirds (Agelaius phoeniceus) where more females were produced in the last egg (Fiala 1981). Ryder (1983) found a female bias (60.9 %) in three-egg clutches of a Ring-billed Gull

Figure 5.1. Sibling size differences in Bald Eagle nestlings for a (A) Male-Female (MF) brood (Nest F) with a four day hatching interval, (B) MF brood (Nest I) with a one day hatching interval, (C) Female-Male (FM) brood (Nest C) with a two day hatching interval.


A
150
100
50
0
-10
B
20
10
0
-10
-20
C
80
40
0
20
40
PERCENT DIFFERENCE IN WEIGHT
AGE OF C2 (DAYS)

(Larus delawarensis) population in 1979, a year with a late spring. However, neither female body condition nor food availability were quantified in these studies. Ring-billed Gulls had lower body condition indices and produced more females (67.4 % vrs. 52.7 %) in 1983 than 1984 (Meathrel and Ryder 1987); the authors suggested females maximized their reproductive success by producing a sex ratio skewed toward the "cheaper" sex. Other studies in which skewed sex ratios were reported in various years or areas (e.g. Newton and Marquiss 1979, Rosenfield et al. 1985) would have been more informative if data on female body condition or prey availability had been quantified. The assumption of differential reproductive potential (Trivers and Willard 1973) or intersexual cost differences in raising young (Fiala and Congdon 1983, Teather 1987; cf. Newton 1978, Collopy 1986) may not be the only factors potentially leading to facultative sex ratio manipulation.

Brood reduction has been viewed as a means of adjusting brood size to available food resources (Lack 1954, Ricklefs 1965) and may be central to facultative manipulation of hatching order of the sexes. Size differences are important in affecting sibling competition and the probability of brood reduction (e.g., Edwards and Collopy 1983, Bortolotti 1986a,b). Bortolotti used sex specific growth characteristics, hatch interval and hatching order of sexes to predict the probability of brood reduction in Bald and Golden eagles based on percent differences in weight between the siblings. As Bortolotti (1986b) predicted, a MF combination may be associated with very large weight differences between siblings. However, hatch interval can have an important effect in moderating sibling size differences. Fratricide in raptors primarily occurs early in the nestling period (Meyburg 1974, Newton 1979). Considering the timing of fratricide and the percent differences in weight found between MF siblings with hatch intervals greater than one day, Bortolotti (1986b) was probably correct that the probability for brood reduction is greatest in MF broods. Although fratricide did not occur in my study, the precursors were present.

Post-fledging survival may be affected by a host of factors associated with the nestling period. Coulson and Porter (1985) found high chick growth rates to be associated with increased post-fledging survival; this was also suggested by Plodger and Mock (1986). Weight at fledging is known to have little effect on survival (Ross 1980, Winterstein and Raitt 1983, Groves 1984, Newton and Moss 1986). Newton and Marquiss (1984) found that nestlings that fledged late in the season had poorer post-fledging survival than those that fledged earlier, and the latter were more likely to be recruited into the breeding population. In Bald Eagles, a FM brood combination may reduce the probability of brood reduction; however if the brood is food-stressed, the chances of survival could be lowered for both fledglings. A MF combination may increase the probability of brood reduction and consequently elevate the remaining young's chances of surviving to reproduce. In years of sufficient food supply, both young may be able to fledge in good condition.

Facultative sex ratio variation in Bald Eagles may relate to brood reduction and thus to environmental suitability. The selective pressure most likely to cause observed differences in proportions of MF broods between Besnard and Nemeiben Lakes is food availability. Bortolotti

(1986b) suggested that females on Besnard Lake may maximize their reproductive success by avoiding MF broods which have the highest probability of brood reduction. Prey availability seems to be lower on Nemeiben Lake; catch per unit effort of key prey species was smaller relative to Besnard Lake (see Ch. 3.) and various parameters of eaglet growth suggest poorer prey provisioning (see Ch. 4.). Lower food availability may make Bald Eagle MF broods the combination with the best chances of raising at least one young. The second egg may be laid to act as insurance against infertility of the first one laid (Meyburg 1974). Given the poorer prey base, I suggest Bald Eagles on Nemeiben Lake may be maximizing their reproductive success by manipulating the sex ratio within clutches to favor MF broods.

5.5. Summary

Three of five two-chick broods on Nemeiben Lake had a hatching order of MF. Percent difference in weight between siblings is thought to play an important role in fratricide. A difference of 158 % was found between two siblings, in a MF brood, that hatched four days apart. Weight differences in the other MF and a FM brood with hatching intervals of one and two days were not as great. Brood reduction did not occur at the three eagle nests studied on Nemeiben Lake in 1987. The production of MF broods on Nemeiben Lake may be an adaptive response to insufficient food resources.

6. Chapter 6

Human Activity

6.1 Introduction

Ecological impacts of human activities have caused the decline of Bald Eagle populations in much of the contiguous United States and may be a factor limiting eagle density in areas of north-central Saskatchewan (e.g., Fraser 1985, Stalmaster 1987). Some aspects of human intervention are direct and unequivocal, while the effects of other activities may be real but cause and effect relationships are difficult to confirm. Bald Eagles in north-central Saskatchewan have been directly affected by human activities such as illegal shooting, accidental trapping, and chopping down nest trees (Davis 1966, Gerrard and Bortolotti 1988, pers. obs.). In recent decades, increasing human activity in areas of Saskatchewan inhabited by eagles has resulted from recreational activities such as snowmobiling, fishing, boating and camping that has accompanied the expansion of road networks in this area. Outdoor enthusiasts cause direct and indirect interference to the birds and their habitat (Boyle and Samson 1985). However, classification of such activities as "disturbances" is difficult because this is a matter of variation from no observable response to abandonment of the breeding area (Forbis et al. 1977).

Human activities and their possible effects on the eagle populations of Besnard and Nemeiben lakes were investigated. Questionnaires were distributed to cottage owners to acquire information on cottage occupancy rates, and the owner's knowledge of and attitudes toward Bald Eagles. Campground occupancy was compared between lakes as a measure of human activity on the lakes. This investigation was a superficial examination of human activities on both lakes, looking for trends that may help explain existing differences in the density of Bald Eagles on Besnard and Nemeiben lakes and providing baseline data for future reference.

Primary resort development and the single campground on each lake are within a three-km length of shoreline accessible by one road. Nemeiben Lake has a small lodge located on an island approximately seven kms northwest of the road access point. These developments are point sources of human activity, as well as the source of additional disturbance caused by boating and fishing activity around the lake. There are approximately 65 cottages on Besnard Lake and 80 on Nemeiben Lake. Development of new lodges, expansion of existing lodges and campgrounds, and lease acqusition for cottages were curtailed in 1979. Nemeiben Lake is accessible via a 6-km dirt road which intersects the paved highway (# 2), 27 km north of La Ronge; road access was completed in 1958, with paving from Waskesieu through La Ronge completed in 1977. Besnard Lake has been accessible by road since 1973 when a 90 km gravel road connected the lake to highway # 2.

6.2. Methods

6.2.1. Campground occupancy

I used data on the occupancy rates of campgrounds as a measure of human activity on the lake, assuming campers spend similar amounts of time on each lake. This assumption was reasonable because the primary activity on both lakes is fishing. Data on campground occupancy were obtained from Saskatchewan Parks, Recreation, and Culture (S.P.R.C.) for

Besnard and Nemeiben lakes.

6.2.2. Nest-site Location

Nest-site selection by Bald Eagles may be influenced by cottage development and human activity on the lakes (Fraser et al. 1985b). I measured the distance from the nest tree to shore using a 30-m tape measure or a 50-m polychain. The minimum distance to shore was recorded to the nearest 0.5 m. Nest-to-shore distances were visually estimated at one nest on each of Besnard and Nemeiben lakes to the nearest 25 m because of unsafe footing on a muskeg. Nest, cabin and 100 random shoreline point locations were plotted on 1:12,500 forest inventory maps and straight-line distances from nests and random points to the nearest cabin were measured using dividers. Habitat analysis at nest sites was conducted after eaglets had fledged.

Kruskal-Wallis tests were used in the analysis of data based on linear measurements and campground occupancy data; significance was set at alpha = 0.05.

6.2.3. Questionnaire

I designed a questionnaire (see Appendix 4) to evaluate cabin occupancy rates and knowledge of Bald Eagles by owners of cottages on Besnard and Nemeiben lakes. Hypothetical situations were presented to gain some insight into the attitudes of cottage owners toward eagles. Questionnaires were mailed to cabin owners on 7 April, 1986. Reminder letters were sent to non-respondents one month after the initial mailing. A second reminder and a copy of the questionnaire were mailed on 30 January, 1987 to cabin owners who had not replied; this mailing was also followed by a reminder. I included a self-addressed, stamped envelope with each copy of the questionnaire. Frequency analysis was used on the responses. In the following discussion, "respondent" will be used synonymously with "cottage/cabin owner", i.e. non-respondents were not included in the bulk of the discussion. Questionnaire design and distribution followed the recommendations of Dillman et al. (1974), Heberlein and Baumgartner (1978), and Carpenter and Blackwood (1979).

6.2.4. Research-related disturbance

Research-related disturbance to Bald Eagles has received much attention, but most studies have found productivity and density were not adversely affected (Grier 1969, Fraser 1978, Bortolotti et al. 1985). I conducted aerial surveys of both lakes on 29 and 30 April, 1986 and 1 May, 1987 using a Cessna 185. The flight path was 100 - 200 m from shore and 50 to 200 m above the forest canopy. In 1986 single visits were made to nest-sites on both lakes to band the eaglets at six nests on Nemeiben Lake and 12 nests on Besnard Lake. In 1987 six nests on Nemeiben Lake were selected for analysis of eaglet growth; due to failure at two nests, repeated visits were only made to four nests. Single visits were made to an additional two nests on Nemeiben Lake and 14 nests on Besnard Lake to band the young in 1987. Visits of less than five minutes to check nest status were occasionally made from a boat at nests on both lakes. Breeding areas were checked for the presence of adults and/or young in August 1988.

6.3. Results

6.3.1. Campground occupancy

S.P.R.C. reports campground occupancy in terms of permit days and camper days (Table 6.1). Campground usage on Nemeiben Lake was more than twice that on Besnard Lake in terms of the number of camper days/year ($P < 0.05$) and permit days/year ($P < 0.05$). Occupancy varied by month with peak utilization in July on both lakes (Table 6.2).

Table 6.1. Annual campground occupancy on Besnard and Nemeiben lakes.

Year/lake	Permit Days[1] Besnard	Permit Days[1] Nemeiben	Camper Days[2] Besnard	Camper Days[2] Nemeiben
1976	339	3066	1557	10179
1977	1047	2538	4248	7941
1983	941	2334	3360	7874
1984	1587	2815	5230	8536
1985	1745	2455	5939	-[3]
1986	1391	3191	-	-
1987	-	3356	-	-
Mean	1175*[4]	2822	4067**	8633
Standard error	209.1	149.2	764.5	536.5

1 Permit days - Number of days the camping permit was issued for.
2 Camper days - Number of people X number of nights shown on each camping permit.
3 Data not available.
4 Asterisks indicate mean of Besnard Lake differs significantly from mean of Nemeiben Lake. * - Kruskal-Wallis test (Chi-square approximation) Chi-square = 6.00, DF = 1, Probability > Chi-square = 0.0143. ** Chi-square = 9.00, DF = 1, Probability > Chi-square = 0.0027.

Table 6.2. Seasonal distribution of campground occupancy on Besnard and Nemeiben lakes.

	Number of permit days/month			
Month	Besnard Lake[1] Mean ± S.E. (Range)		Nemeiben Lake[2] Mean ± S.E. (Range)	
May	59.0*[3]	31.0	211.2	30.05
	(0 - 105)		(153 - 345)	
June	348.3*	155.71	936.7	77.83
	(108 - 640)		(723 - 1228)	
July	375.7*	110.10	1042.0	49.91
	(159 - 518)		(841 - 1195)	
August	223.0*	128.18	682.3	76.31
	(0 - 444)		(450 - 990)	
September	37.7	21.65	31.3	12.03
	(0 - 75)		(1 - 75)	

1 Data from 1976, 1977 and 1985.
2 Data from 1976, 1977, 1984-1987.
3 Asterisk indicates mean of Besnard Lake differs significantly from mean of Nemeiben Lake, * - Kruskal-Wallis Test (Chi-square approximation). Prob. > Chi-square < 0.05.

Nemeiben Lake had more than twice the number of permit days ($P < 0.05$) for May through August; there were no significant differences in September. Occupancy in May and September were concentrated on the holiday weekends, usage in June, July and August was more constant with slight peaks in activity on the weekends (S.P.R.C. unpublished data).

6.3.2. Nest-site Location

The distance from the nest tree to the shore on Nemeiben Lake (51.9 $\pm$ 18.7, n = 10; mean $\pm$ 1 s.e.) was twice that on Besnard Lake (22.8 $\pm$ 3.21, n = 31), but the difference was not significant ($P > 0.05$). Distances from nests to the nearest cabin did not differ from comparable distances from random points ($P > 0.05$), nor did nest-to-cabin distances between lakes ($P > 0.05$) (Table 6.3).

6.3.3. Questionnaire responses

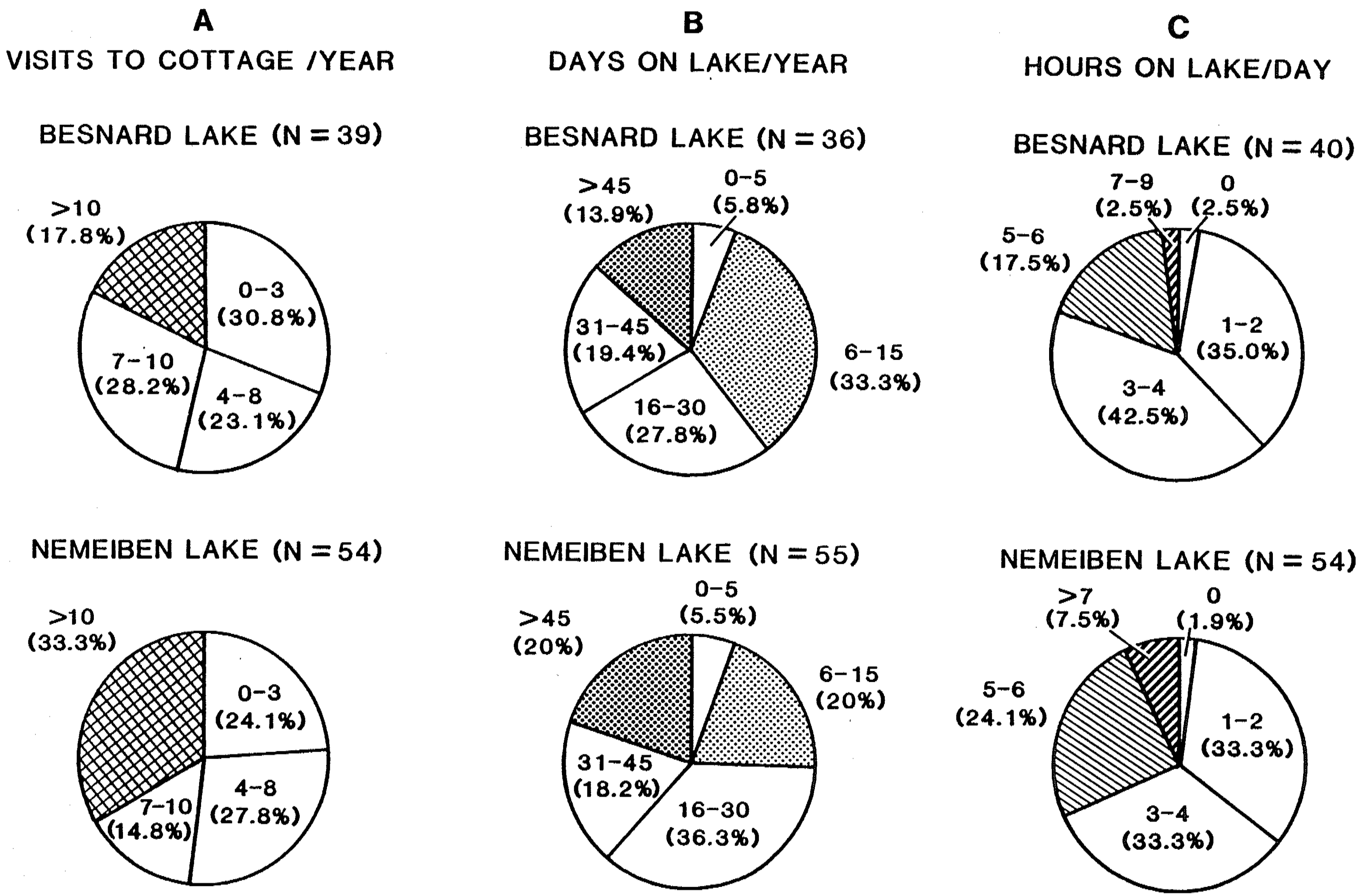
See Appendix 5 for a complete summary of questionnaire responses. Total response rate for Besnard (n = 65) and Nemeiben (n = 80) lakes was 65% and 70%, respectively. An additional 19% and 15% of the questionnaires on the aforementioned lakes were returned by Canada Post Corporation marked: "moved, address unknown". The number of respondents answering individual questions varied because of question type and/or negligence of the respondents.

The mean length of ownership of recreational cottages on Nemeiben Lake (8.1 years) was significantly longer ($P < 0.05$) than on Besnard Lake (6.1 years). On Nemeiben Lake, 84 % (n = 56) of the respondents were the original owners, compared to 83 % (n = 41) on Besnard Lake; since the vast majority are original owners, the variable of ownership length was comparable to the actual age of the cabin. Cabin occupancy and hours spent on the lake were similar (Figure 6.1a,b,c), though there was a tendency for cottage owners on Nemeiben Lake to make more numerous

Table 6.3. Distances from nests and random points to the nearest cabin on Besnard and Nemeiben lakes.

Variable	n	Besnard Lake Mean ± S.E. (Range)		n	Nemeiben Lake Mean ± S.E. (Range)	
Nest to cabin distance (m)	47	1142.0 (138 - 5313)	148.87	12	894.8 (500 - 1313)	76.09
Random point to cabin distance (m)	95	1051.1 (50 - 4750)	73.39	100	769.8 (38 - 2887.5)	48.43

Figure 6.1. Indices of cottage occupancy and human activity on Besnard and Nemeiben lakes: (A) number of visits made to cottage per year, (B) number of days spent at cottage per year, (C) number of hours spent on the lake per day.


A
VISITS TO COTTAGE /YEAR
BESNARD LAKE (N = 39)
>10 (17.8%)
0-3 (30.8%)
7-10 (28.2%)
4-8 (23.1%)
NEMEIBEN LAKE (N = 54)
>10 (33.3%)
0-3 (24.1%)
4-8 (27.8%)
7-10 (14.8%)
B
DAYS ON LAKE/YEAR
BESNARD LAKE (N = 36)
>45 (13.9%)
0-5 (5.8%)
31-45 (19.4%)
6-15 (33.3%)
16-30 (27.8%)
NEMEIBEN LAKE (N = 55)
0-5 (5.5%)
>45 (20%)
6-15 (20%)
31-45 (18.2%)
16-30 (36.3%)
C
HOURS ON LAKE/DAY
BESNARD LAKE (N = 40)
7-9 (2.5%)
0 (2.5%)
5-6 (17.5%)
1-2 (35.0%)
3-4 (42.5%)
NEMEIBEN LAKE (N = 54)
>7 (7.5%)
0 (1.9%)
5-6 (24.1%)
1-2 (33.3%)
3-4 (33.3%)

and more extended visits in addition to spending more time on the lake. The distance cabin owners resided from their respective lakes varied considerably; 18% of cottagers on Nemeiben Lake lived less than 100 km away, compared to 10% on Besnard Lake (Table 6.4).

Respondents were equally adept at differentiating beween Ospreys and Bald Eagles; however, 35% of the Nemeiben Lake cottage owners were unable to distinguish adult from immature Bald Eagles compared to 26% on Besnard Lake. All cottage owners on Besnard Lake (n = 42) were aware of and had seen Bald Eagles around the lake, whereas 51 of 55 (93%) of Nemeiben Lake cottagers were aware of eagles and 50 of 55 (91%) had seen eagles in the area. Following this trend, 48% of Nemeiben Lake cottagers did not know of any eagle nests along the lakeshore, whereas 83% of respondents on Besnard Lake were aware of nests in the area. Of the respondents on each lake that knew of eagle nests, 56% and 52% of Besnard and Nemeiben lake respondents had seen eaglets on the nests. The majority of cottagers (more than 60%, Figure 6.2) checked the nests "a couple of times per summer". More than 85% remained in their boats and a similar percentage (>85%) stayed in the vicinity of the eagle's nest for less than ten minutes. Considering the number of people on Nemeiben Lake that had not seen eagles and/or an eagle's nest, it was not surprising that 36% (Figure 6.3) of Nemeiben Lake cottagers thought Bald Eagles were rare on the lake and 51% felt there were not enough eagles on Nemeiben Lake, compared to 2.4 and 29.3%, respectively, on Besnard Lake. More than 40% of the respondents on each lake described the eagle population as stable during their residency (Figure 6.4).

In response to the hypothetical situations, most cottagers

Table 6.4. Distance from permanent residence of respondents to lake on which cottage is situated.

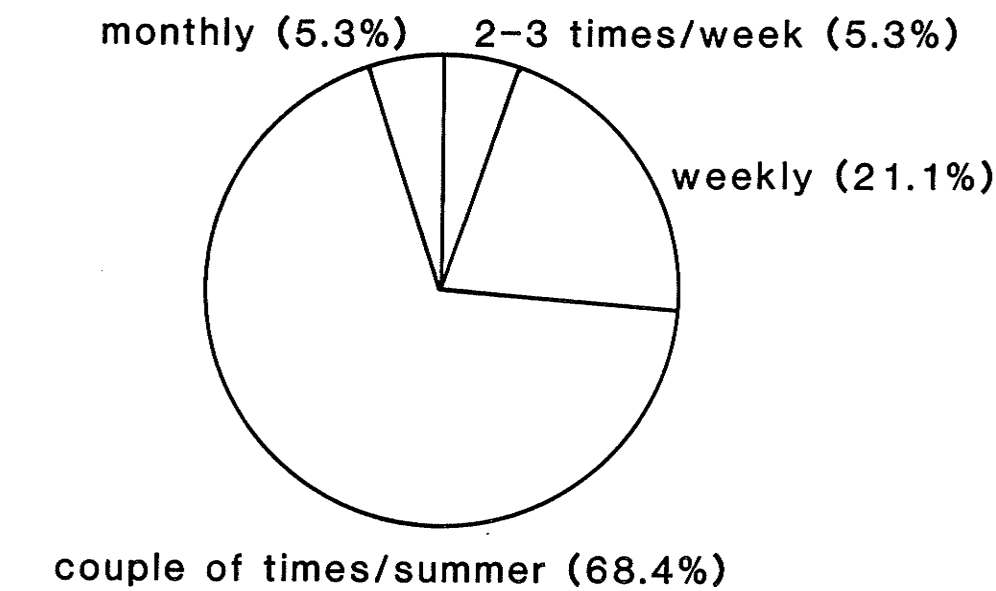
Distance (km)	Besnard Lake n[1]	Besnard Lake Percent of total respondents	Nemeiben Lake n	Nemeiben Lake Percent of total respondents
0 - 100	4	9.5	10	17.9
101 - 200	1	2.4	2	3.6
201 - 250	11	26.2	9	16.1
251 - 300	4	9.5	3	5.4
> 300	22	52.4	32	57.1
	42		56	

1 Number of respondents to questionnaire residing in the corresponding distance category from Besnard or Nemeiben lake.

Figure 6.2. Number of visits made by cottage owners to the vicinity of Bald Eagle nests.

VISITS TO EAGLE'S NEST/YEAR

BESNARD LAKE (N=18)



NEMEIBEN LAKE (N=15)

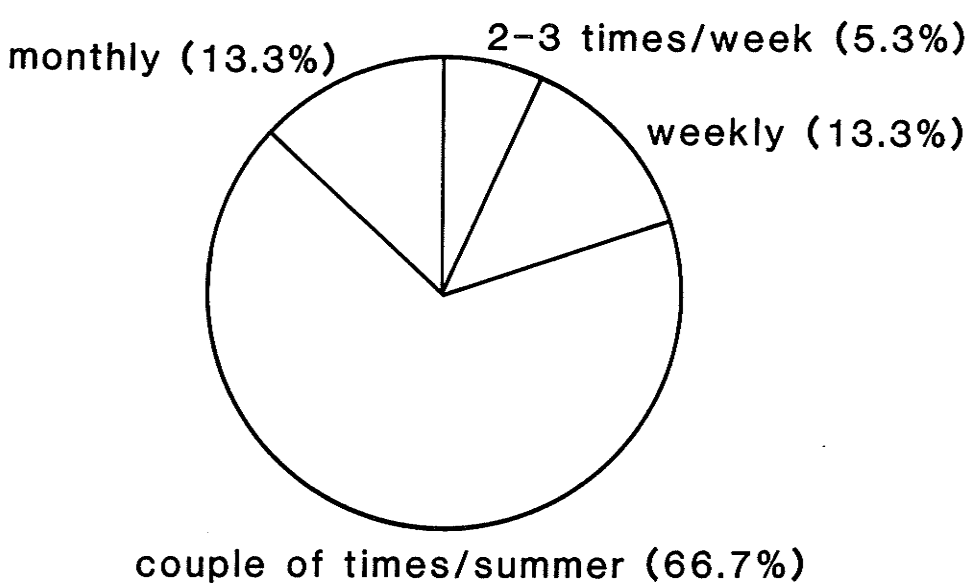
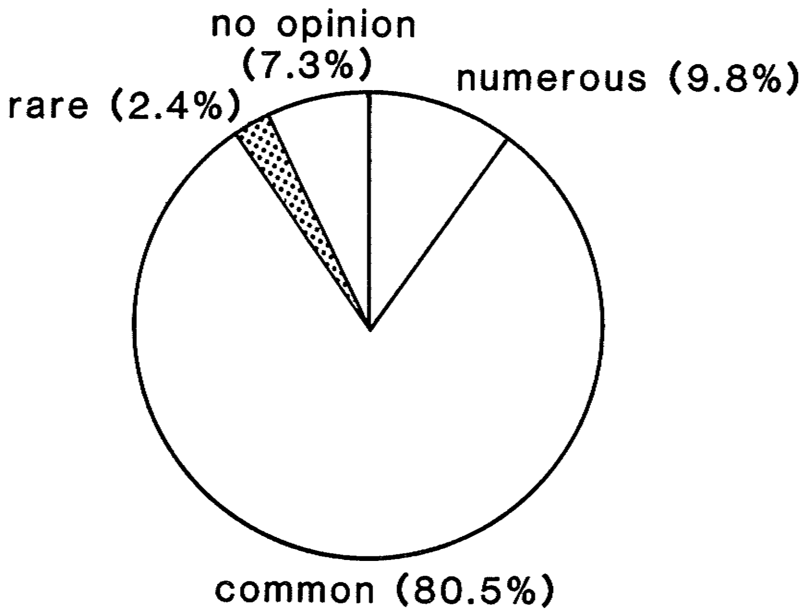


Figure 6.3. Current population status of Bald Eagles on Besnard and Nemeiben lakes as perceived by cottage owners on their respective lake.

PERCEIVED POPULATION STATUS

BESNARD LAKE (N=14)



NEMEIBEN LAKE (N 53)

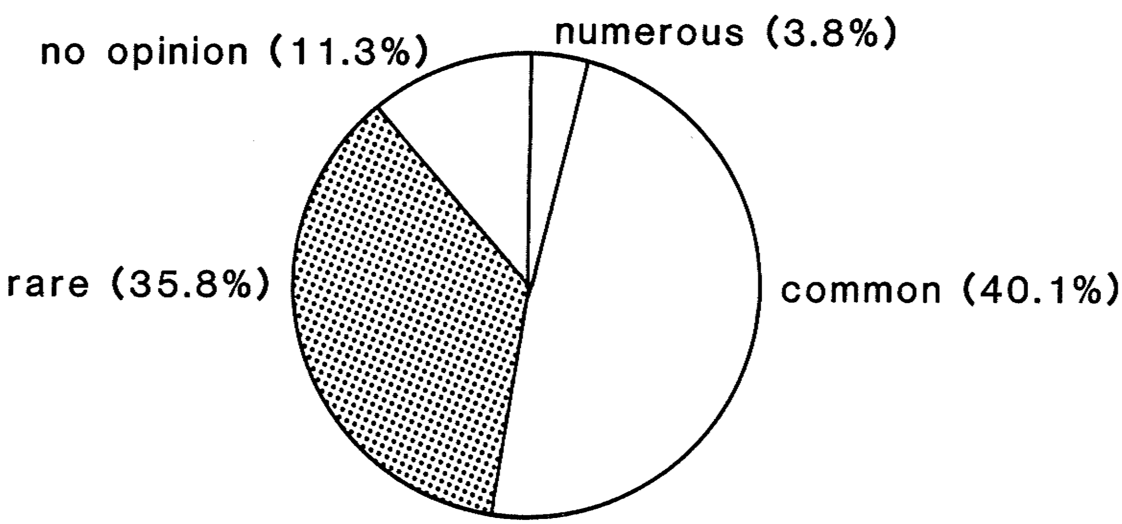
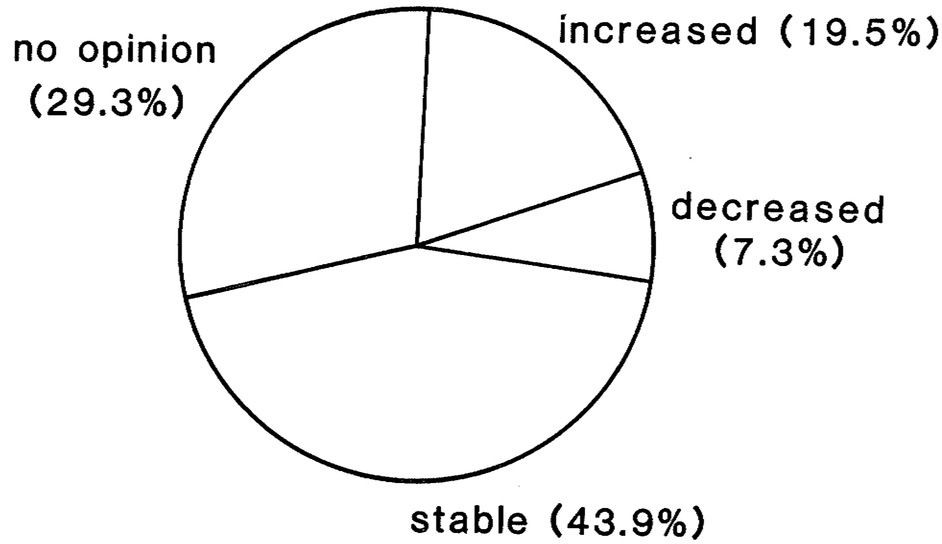


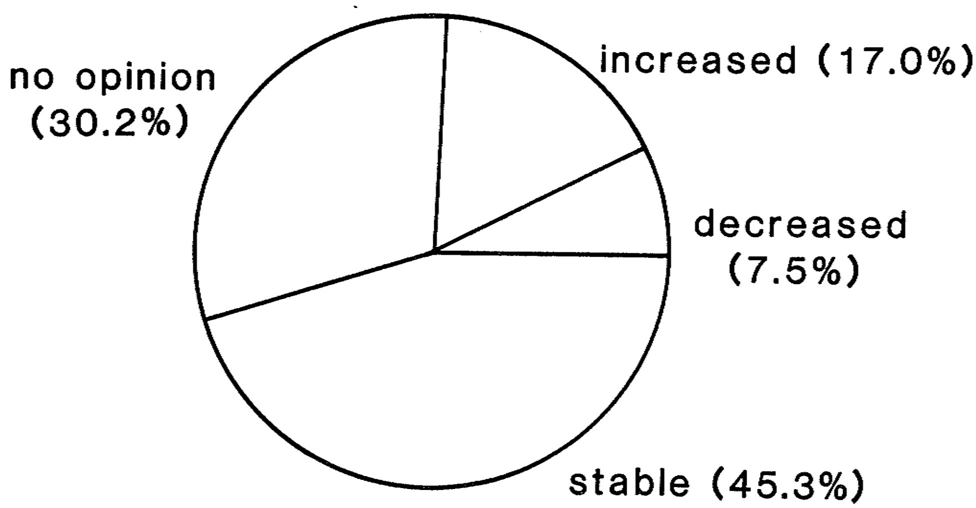
Figure 6.4. Perception of Bald Eagle population trends by cottage owners on Besnard and Nemeiben lakes during the residency of the cottage owner.

BALD EAGLE POPULATION TRENDS

BESNARD LAKE (N=41)



NEMEIBEN LAKE (N=53)



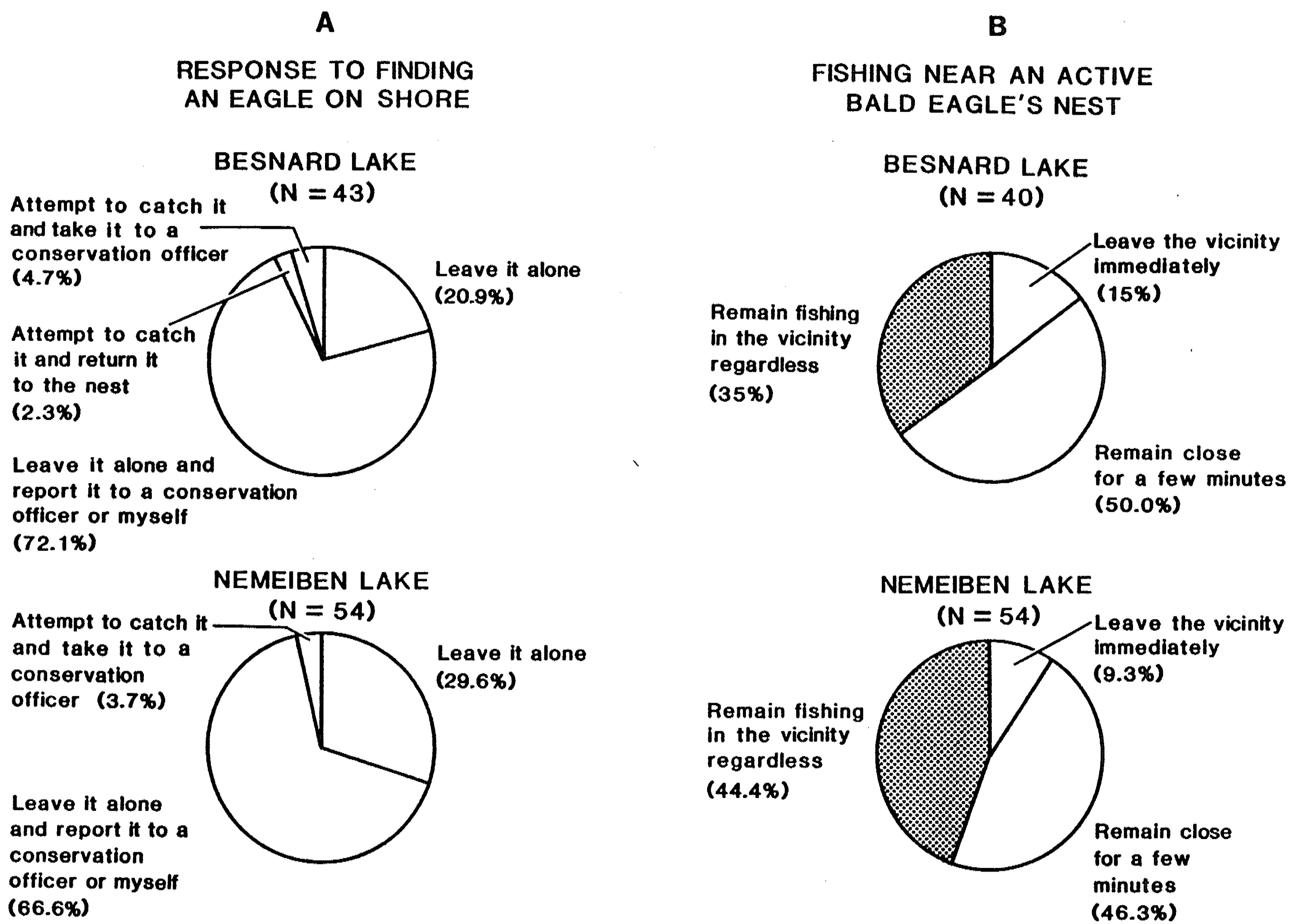
responded in a manner that shows respect and a good conservation ethic (Figure 6.5). Thirty-five percent of Besnard Lake cabin owners and 44% of Nemeiben Lake residents said they would remain fishing in the vicinity of an active eagles nest. Responses such as "they do not seem bothered by our presence" was a common explanation regarding their angling habits.

All cottage owners were "interested" in Bald Eagles, although 65.5% of Nemeiben Lake cottagers versus 45.2% of those on Besnard Lake showed only "casual" interest. Eighty-six percent of Nemeiben Lake cottagers and 91% on Besnard Lake responded that it was important to them personally to have eagles nesting on the lake. Support for research programs was very high (95% on Nemeiben Lake, 86% on Nemeiben Lake). Fifty-seven percent of Besnard Lake and 56% of Nemeiben Lake respondents were in favor of implementing restriction zones around important areas of Bald Eagle habitat.

6.3.4. Research-related disturbance

Disturbance attributable to the aerial surveys was difficult to evaluate but appears to be negligible. Activity at most nests was determined in one pass; two passes were necessary at a couple of nests. No adults in incubation position were flushed from their nest. Nesting success was low in 1986 (See Ch. 1) on both lakes; however this was likely attributable to inclement weather in the spring, rather than as a result of the aerial surveys, as success was low on most of the Churchill River system in Saskatchewan (Pers. observation). Nesting success in 1987 on Besnard Lake was comparable to previous years (Gerrard et al. 1983).

Figure 6.5. Cottage owners' responses to hypothetical situations regarding human interactions with Bald Eagles: (A) If you found an eagle on shore, apparently unable to fly properly, would you...
(B) If you were fishing and you discovered an active Bald Eagle nest, would you...,


A
RESPONSE TO FINDING AN EAGLE ON SHORE
BESNARD LAKE
(N = 43)
Attempt to catch it and take it to a conservation officer (4.7%)
Leave it alone (20.9%)
Attempt to catch it and return it to the nest (2.3%)
Leave it alone and report it to a conservation officer or myself (72.1%)
NEMEIBEN LAKE
(N = 54)
Attempt to catch it and take it to a conservation officer (3.7%)
Leave it alone (29.6%)
Leave it alone and report it to a conservation officer or myself (66.6%)
B
FISHING NEAR AN ACTIVE BALD EAGLE'S NEST
BESNARD LAKE
(N = 40)
Leave the vicinity immediately (15%)
Remain fishing in the vicinity regardless (35%)
Remain close for a few minutes (50.0%)
NEMEIBEN LAKE
(N = 54)
Leave the vicinity immediately (9.3%)
Remain fishing in the vicinity regardless (44.4%)
Remain close for a few minutes (46.3%)

Repeated visits were made to four of six nests selected on Nemeiben Lake as part of a study of eaglet growth in 1987. Two eggs were laid in all four nests and three pairs (C, F, I) fledged both young. The fourth nest (C) hatched and fledged only one young; failure of the second egg to hatch may have been a result of disturbance I caused on 26 May 1987. Eggs at two additional nests (B and H) that were to be a part of my growth study failed to hatch young and were deserted by the adults. Disturbance may have been a factor at both nests, as the pairs deserted four and six days after my first visit to the nest. However, inconsistent incubation at nest H which prompted my first climb (two eggs) continued after my visit, in contrast to the pairs which hatched their eggs. Thus, nest failure may have occurred regardless of my visit. Eagles at nest B had failed to produce young in 1986; lower success has been reported in a year following a nest failure (Whitfield et al. 1974, Gerrard et al. 1983).

Nests F and I, which were repeatedly visited in 1987, had young over 60 days old in August 1988 (Table 6.5). The other nests which were repeatedly visited in 1987, C and E, showed signs of eagle activity in August 1988 (moulted feathers from 1988, and feces on vegetation near the nest tree), but had no young on them. I climbed to the nest but could not ascertain whether eggs had been laid. A new, occupied nest was found two kms northeast of nest C. Egg(s) were laid in Nest B in 1988 as I found shell fragments among the nest material; unfortunately the tree fell down. Nest H was apparently not re-occupied. Nests which were not selected for the eaglet growth study remained active in 1988, including one which was occupied by a single adult in 1987.

Table 6.5. Status of Bald Eagle breeding areas on Nemeiben Lake, 1986-1988.

Breeding Area	1986	1987	1988
A	1[a]	1+	1+
B	A - F[b]	A - F[c]	A - F,G[d]
C	A - F,G	-	-
C'	NB[e]	2[c]	E[f] (O?)[g]
D	1+	1+	2
E	2	1[c]	E
F	2	2[c]	1
G	A - F	0	1
H	1	A - F*	E
I	A - F	2*	2
J	2	1+	Not checked.

[a] 1, 2, 1+ = nest successful with 1, 2, 1+ (at least 1) young.
[b] A - F = nest active then failed.
[c] = nest selected for eaglet growth study in 1987.
[d] G = nest tree fallen.
[e] NB = nest not built yet.
[f] E = nest empty and not occupied by adults.
[g] O = nest empty, but occupied by adult(s).

Qualitative evidence implied variability in the adult's responses to my visits. I found the adults at three of the nests became selectively sensitized to my approach; adults often left the nest or perch before I was within a km of the nest. They circled above my boat, vocalized and followed us to shore. Such behaviour was not observed in response to anglers in boats similar to ours.

6.4. Discussion

That human disturbance can have deleterious effects on birds is intuitive and supported by quantitative evidence (Safina and Burger 1983, Hamilton and Martin 1985, Knight and Fitzner 1985, White and Thurow 1985, Pierce and Simmons 1986). Inter- and intraspecific variability in response to human disturbance depends on many factors including the type, intensity and duration of the disturbance and seasonal timing of the occurrence (Fyfe and Olendorff 1976, Fraser 1985, Boyle and Samson 1985, Burger 1986, Postovit and Postovit 1987, Gerrard and Bortolotti 1988). The period from territory establishment through hatching is the most sensitive period for most raptors (Fyfe and Olendorff 1976); the early nestling period (first two weeks for Bald Eagles) is also a time when disturbance can be most detrimental (e.g., desertion, hatching failure due to exposure while adults off egg) (Gerrard and Bortolotti 1988). Bald Eagles arrive in north-central Saskatchewan in late March or early April and begin laying in late April and early May (as back-dated assuming a 34-36 day incubation period and known hatching in late May and early June) (Maestrelli and Wiemeyer 1975). Bald Eagles in this area will receive very little disturbance until after the lake ice thaws in mid to late May. Therefore they are protected through much of the sensitive period.

Once the lake-ice thaws, the nesting pairs will be affected by humans to varying degrees depending on temporal variation of human activities and location of eagles' nests relative to human activity. Although lake usage was low through most of May, a surge of anglers and other recreationists frequent the lakes on the Victoria day (May) long-weekend, which usually coincides with the opening of the fishing season. Campground occupancy on Nemeiben Lake in May averages almost four times that on Besnard Lake; this could be an important point in evaluating human activity as a factor influencing density differences. Angling and boating activity in June, July and August is fairly constant on both lakes, but much more intense on Nemeiben Lake. Disturbance late in the nesting cycle is difficult to evaluate as the effects, such as relocation, may not be immediate and cause-and-effect relationships are speculative. Pairs which occupy nests adjacent to well known spring angling locations or along boat travel routes are subject to intense disturbance. At least four nests on Besnard Lake, (U, A, G''',Pi') which were known to be active in various years, failed following the May long-weekend. Nest failure, as a result of nest location in relation to human disurbance has been suggested for other raptors (e.g., Prevost 1977). One nest on each of Besnard and Nemeiben lakes was near a travel route but has not failed despite a lot of boating traffic. The eagles at both of these nest have apparently habituated to the activity. Of additional significance was that the nest on Nemeiben Lake was easily visible to boaters and thus the eagles are likely subjected to additional disturbance by boaters slowing down or stopping to view the eagles.

Habituation to boating traffic and other activities is known to occur in Bald Eagles (Stalmaster and Newman 1978, Knight and Knight 1984, cf. Fraser et al. 1985b) and Ospreys (Van Daele and Van Daele 1982). Individual sensitivity to human activities, as well as spatial and temporal variation in potential disturbances, dictate the eagle's response to human activities.

The relationship between anglers and Bald Eagles is both positive and negative. Bald Eagles may benefit to some extent from angling by scavenging on fish that have died from angling-induced injuries, but this is tempered by the negative impact of monofilament and hooks remaining in the nest (Postovit and Postovit 1987). Potential benefits of food availability accrued to eagles should vary with the rate at which fish are released by anglers. For the period, 1975-1978 (-1979 for Besnard Lake), discard rates for walleye and northern pike decreased on Nemeiben Lake but increased on Besnard Lake (Ch. 3). Walleye harvests on Besnard Lake peaked in 1978 and began to decline in 1979; while northern pike populations remained strong, there was a shift toward harvesting smaller fish (A. McCutcheon, pers. comm.). Presumably discard rates on Besnard Lake would begin to decrease as harvest declined. If this is so, the positive aspect of angling for eagles (i.e. availability of injured fish) on both lakes has decreased. Angler effort, as a measure of human activity on lakes, is sometimes measured in angler-days (the amount of fishing done by one angler in one day). In 1978 there were approximately 16,500 angler-days on Nemeiben Lake and 10,600 angler-days on Besnard Lake. This represents 1.07 angler-days/ ha (water area) on Nemeiben Lake and 0.60 angler-days/ ha on Besnard

Lake. Angling will cause the most disturbance to eagles if conducted near nests. Greater fishing pressure on Nemeiben Lake increases the possibility of human disturbance playing a role in influencing existing eagle density differences.

The distribution of access points and concentrations of human activity will influence the amount of shoreline that is not suitable for successful brood rearing. Osprey distribution in Yellowstone National Park was affected by shoreline fishing and pairs that nest less than one km from campgrounds are less successful than those farther from disturbance (Swenson 1979). The localization of resort development, one primary access point on each lake, and the distribution of cottages on Besnard and Nemeiben Lakes appears to be a favorable method of development. The distribution of eagle nests on Besnard Lake may have been affected by the access point and associated activity, but the overall Bald Eagle density and productivity have not been adversely affected (Gerrard et al. 1983, Gerrard et al. 1985, Gerrard, Bortolotti, and Dzus unpublished data).

Eagles can respond in more subtle ways to human disturbance than abandonment of a breeding area. Pairs building nests in Minnesota (Fraser et al. 1985b) and Maryland (Andrew and Mosher 1982) built farther from human activity than random. In Minnesota, avoidance was greater for clumps of houses than single structures (Fraser et al. 1985b). It is difficult to evaluate avoidance of cottages by Bald Eagles when building new nests because of the regular distribution of cabins. By law cabin lease locations must be 1.6 km from the nearest cottage, active trapper's cabin and any road. The system of cabin development on Besnard and Nemeiben lakes may be such that they are not sources of significant disturbance or the reasonably regular distribution of cabins may forego significant differences from being found between nests and random points. Ecologically the former may be true and statistically the latter probably is correct. Either way, eagles could alternatively respond by building farther back from shore as is the case in Minnesota (Fraser et al. 1985b). Eagles on Nemeiben Lake may be responding to human activity in such a manner, but experimentation would be necessary for confirmation. Nesting farther from shore creates a buffer zone much like that suggested as a management technique for Bald Eagles in the United States (Stalmaster and Newman 1978, Stalmaster 1987). Another problem is that there may be no human activity at the cabins when nest locations are being selected and/or repaired (G.R. Bortolotti pers. comm.). Proper testing of the effect of cottage development may not be possible as a result of cabin distribution and usage, and the temporal aspects of nest-site selection.

From the questionnaire that was distributed to cottage owners it was revealed that their knowledge of eagles and attitudes towards the species reflected their exposure to these birds. Besnard Lake cottagers frequent an area which supports a very dense population of nesting and non-breeding Bald Eagles, and a research program with a 20-year history. It was not surprising that most owners are aware of eagles and their nests. Conversely, Nemeiben Lake cabin owners vacation at a lake which, at present, has fewer eagles and only a 4-year history of research; they are less knowledgeable and aware of eagles but feel strongly about a need for more eagles on the lake. It was disconcerting that so many cottagers would be willing to continue fishing in the vicinity of an active eagle's nest. Information should be made available regarding the ecology of the Bald Eagle and ways to minimize disturbance to help maintain and possibly expand existing eagle populations.

Cottage occupancy probably refects differing levels of accessibility and location of home residence. Nemeiben Lake cottage owners visited their cabins more frequently and spent more time on the lake than Besnard Lake cottage owners. As mentioned earlier, access to Nemeiben Lake is via a paved highway to within six kms of the lake. Such relatively easy access may play an important role in the differences found in occupancy rates of cabins. Greater visitation and days spent at cabins on Nemeiben Lake may also be affected by the greater proportion of owners living within 200 km of the lake (primarily La Ronge).

Research-related disturbance has not caused population declines when conducted appropriately (Fyfe and Olendorff 1976, Bortolotti et al. 1985). Newton (1979) expressed concern over aerial surveys, but this technique has been used to determine breeding area status and nesting success without adverse affects on productivity or density. Similar success has been found for single visits to nests for banding (Grier 1969, Fyfe and Olendorff 1976). Climbing to nests may cause an increased rate of nest change, especially if visits are repeated (Grier 1969, Bortolotti et al. 1985). However if the lifetime reproductive output of the pair is not significantly decreased, information gained should offset the disturbance. As nesting success on Nemeiben Lake was comparable to that on Besnard lake in both years of the study, it was unlikely my visits were the only cause of the nest failures. In addition to individual variation in response to human disturbance (Gerrard and Bortolotti 1988), there is the possibility that there may be a connection between lower food availability and greater susceptibility to disturbance (White and Thurow 1985, Stalmaster 1987 cf. Skagen 1981). If this relationship exists, additional caution should be taken to minimize disturbance in areas or years where/when prey availability is suspected or known to be low.

Direct persecution and disturbance of Bald Eagles was one aspect not addressed in my study. Illegal shooting remains the greatest known source of Bald Eagle mortality (Evans 1982, Stalmaster 1987). Killing an eagle used to be a status symbol to youths in northern Saskatchewan and negative attitudes toward eagles were common (Davis 1966). Attitudes toward Bald Eagles have changed and shooting of eagles has declined on Besnard Lake since the inception of the research project (J.M. Gerrard, pers. comm.). The educational efforts of J.M.G., other researchers and conscientious lake residents have benefited both eagles and recreationists. Numerous cottagers said they had become more aware of eagles as a result of my research and questionnaire. Eagles are still shot in Saskatchewan, but I have no way of assessing this as a factor influencing interlake density differences. A trapper and long-time resident of Nemeiben Lake told me of one individual who repeatedly shot birds such as eagles and loons (*Gavia immer*) on Nemeiben Lake and north to Lower Foster Lake, but the time frame of these activities is unknown. Another trapper on Nemeiben Lake told me that one person was known to shoot eagles on sight and chop nest trees down with great frequency only ten years ago. One active nest on Nemeiben Lake is currently supported by a tree with one third of its base chopped away. Mortality and injury as a result of being caught in traps set for furbearers is another source of human disturbance (Gerrard and Bortolotti 1988). However I have no data suggesting persecution is or ever was more prevalent on Nemeiben than Besnard lake.

Management policies specifically designed to protect Bald Eagles do not exist in Saskatchewan. The government can designate "Reserves of 30 to 90 m of forest vegetation along streams and lakeshores.... where protection is required." (Dept. of Tourism and Renewable Resources, procedure number 420-41, effective 1 Sept. 1979). These reserves would protect against harvesting of trees, but there are no policies regarding recreational use of the lakes and adjacent shoreline. Pioneering efforts in Bald Eagle management began in Minnesota (e.g., Mathisen et al. 1977) and much work is currently being done in other areas of the United States (see review in Stalmaster 1987). Eagles on Besnard Lake appear to have habituated to increased levels of human activity, but may not have reached some tolerance threshold that has been surpassed on Nemeiben Lake, with an accompanying population decline. With increasing use of northern lakes it may become necessary to implement new management policies should eagle populations show signs of negative impact. At present the most beneficial activity that should be undertaken is to increase awareness and ecological respect in people wishing to use our natural resources and for researchers to continue monitoring eagle population while maintaining professional standards of conduct.

6.5. Summary

Human activities and their possible effects on the eagle populations of Besnard and Nemeiben Lakes were investigated. Campground occupancy and angling pressure on Nemeiben Lake were twice that on Besnard Lake. Questionnaires distributed to cottage owners on both lakes revealed Nemeiben Lake cottagers made more frequent visits and spent more time at their cabins per year; differences may be explained by better road access to Nemeiben Lake and more owners living closer to this lake. Knowledge of eagles was lower and a desire to see a larger eagle population was more prevalent on Nemeiben Lake. Differences in knowledge and attitudes probably reflect limited exposure to eagles because of the lower eagle density on Nemeiben Lake. Eagle nests were not located further from cabins than random on either lake, but nests on Nemeiben Lake were farther from shore. Research-related activity did not cause a loss of productivity, but an increased incidence of nest relocation may have onccurred. The impact of shooting and trapping is not quantifiable, but has likely diminished. It is difficult to speculate on the influence human activities have had in creating density differences between the two lakes in the absence of historic evidence on the Nemeiben lake population.

CONCLUSIONS

Various aspects of the forest nesting habitat, prey base and human activities have been presented in the preceding chapters in an attempt to gain a better understanding of factors influencing local variation in Bald Eagle density in north-central Saskatchewan. In this section I will present a synthesis of the results and speculate on the relative contribution each factor may have in influencing eagle density.

Besnard Lake supports a Bald Eagle population (adults and immatures) approximately 3.3 times larger and with 2.5 times more active breeding areas than Nemeiben Lake. If eagle numbers were directly proportional to water area or available forest habitat within 200m of shore, the size difference between lakes would only account for a factor of 1.1-1.4 of the difference in eagle numbers. This leaves the vast majority of the variation to be explained by other factors.

Bald Eagles on both lakes preferred large trees which were close to shore and predominately in mixed-wood forest stands dominated by coniferous trees. The proportion of suitable nesting habitat within 200m of shore is 35% on Besnard Lake and 36% on Nemeiben Lake. With these values being essentially identical, the availability of suitable nesting habitat cannot be considered a factor limiting eagle density on Nemeiben Lake.

Aquatic based differences in the food chain represent the best explanation for existing differences in eagle numbers. The standing crop of plankton and bottom fauna on a kg/ha basis was 2.1 and 2.4 times greater on Besnard Lake than Nemeiben Lake. Commercial fisheries catch/ha/licence on Besnard Lake was 1.4 times greater than on Nemeiben

Lake. Sports-fishing catch/ha (1978) on Besnard Lake was 1.6 times greater than on Nemeiben Lake; the difference in the size of fish populations is probably even greater considering fishing effort on Nemeiben Lake was 1.8 times that on Besnard Lake. White sucker and cisco are the most important fishes in the eagle's diet. The only available data on these species is from previous biological surveys and my netting. In previous surveys, white suckers contributed slightly more (1.3 X) to the total catch on Nemeiben Lake, whereas ciscoes made a greater contribution by number (1.4 X) and weight (4.0 X) to the Besnard Lake catch. I caught 8.3 times more ciscoes , but the catch of white suckers was about the same. Taken together, differences in the prey base may account for up to a two-fold difference in the variation of eagle numbers found between Besnard and Nemeiben lakes, leaving approximately 30% of the variation to be accounted for by other factors.

Additional support for the idea that food resources are limiting the Bald Eagle population on Nemeiben Lake comes from analysis of eaglet growth and hatching order of the sexes. As in Bortolotti's (1984a,b) Besnard Lake study of eaglet growth, the timing of growth events are one aspect of growth where intersexual differences exist. However, in contrast to the findings on Besnard Lake, growth rate was slower (than males) and the timing of developmental events delayed more than Besnard Lake females in the two females from MF broods. These differences in growth relate to the intersexual differences in growth being exaggerated because of the hatching order of the sexes. The males have a greater competitive advantage when they hatch first in a mixed-sex brood because of their faster growth and earlier inflection points. The sex combination, MF, was the most common brood on Nemeiben Lake; this is in strong contrast to Besnard Lake, where MF broods were rare. The hatching order MF has the highest probability of brood reduction, and production of such a hatching order may be an adaptive response by female eagles on Nemeiben Lake to less favourable levels of food resources.

Human activity, as a factor influencing variation in eagle populations, is difficult to assess without historical data on eagle populatons, human activity on the lakes and the interaction of eagles and humans. However, an adverse effect of human activity on the eagle population on Nemeiben Lake is possible in view of the cumulative effect such activity may have. Nemeiben Lake has had 15 more years of road access than Besnard Lake, with an accompanying greater use of the lake. Data available for 1976 to 1987 shows human use on Nemeiben Lake is more than twice that on Besnard Lake and in May, when human activity is potentially most disturbing, campground occupancy is 3.6 times more than on Besnard Lake. Cabin density and use is also greater on Nemeiben Lake. Nemeiben Lake had (and probably still has) more fishing activity, smaller catches and smaller discard rates than Besnard Lake, which give credence to a potential role for differences in human activity and possible differences in availaility of "hooked" fish on the density of Bald Eagles. The quality of road access may be important in explaining some of the differences in human activity. In 1986 and 1987, nesting success was similar on both lakes; as such, current levels of activity may not be affecting the existing population. Pairs currently nesting on Nemeiben Lake may have adapted to higher levels of human activity by building their nests further from shore. Levels of human activity on

Nemeiben Lake may explain some of the variation in eagle numbers relative to Besnard Lake. In contrast, levels of human activity on Besnard Lake have not had a negative impact on the Bald Eagle population (in terms of size or productivity). Information to date will form an important baseline for future reference. Continued monitoring of eagle populations and human activity may illuminate the subject of eagle-human interactions in the future.

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Appendix 1. Mean Height and Basal Area of Balsam Fir, Black Spruce and White Spruce on nest and random point transects on Besnard and Nemeiben lakes.

HEIGHT[1] (m)

Lake[2]	Shore type[3]	Species[4]	Stratum 1 X̄	1 S.E.	2 X̄	2 S.E.	3 X̄	3 S.E.	4 X̄	4 S.E.	5 X̄	5 S.E.
B	R	bS	9.3	0.34	11.7	0.51	13.4	0.50	13.2	0.41	12.8	0.44
N	R	bS	9.6	0.33	11.8	0.30	12.1	0.38	11.5	0.39	11.6	0.46
B	N	bS	11.6	0.52	13.4	0.66	11.3	0.37	13.9	0.45	12.1	0.40
N	N	bS	10.9	0.63	13.7	1.04	14.0	0.90	14.1	0.81	13.8	0.70
B	R	bF	8.4	0.42	9.3	0.65	11.7	0.88	9.3	0.56	10.3	0.89
N	R	bF	9.5	1.74	10.6	1.18	11.0	1.36	9.6	0.93	10.8	1.09
B	N	bF	10.5	0.37	11.9	0.57	10.8	0.39	10.9	0.62	10.7	0.64
N	N	bF	11.2	1.31	14.0	1.21	12.4	1.45	8.7	1.22	11.6	1.13
B	R	wS	13.4	0.60	15.5	0.81	15.2	0.89	13.2	0.99	15.1	1.07
N	R	wS	13.3	0.85	17.1	1.56	14.2	0.77	13.8	0.99	18.3	1.44
B	N	wS	14.1	0.62	15.3	0.62	13.9	0.72	13.9	0.69	15.3	0.83
N	N	wS	14.2	1.11	17.8	1.55	13.9	1.24	16.3	1.21	16.0	1.23

BASAL AREA (cm^2)

Lake	Shore type	Species	1 N	1 X̄	1 S.E.	2 N	2 X̄	2 S.E.	3 N	3 X̄	3 S.E.	4 N	4 X̄	4 S.E.	5 N	5 X̄	5 S.E.
B	R	bS	64	106	13	59	150	14	62	189	19	83	179	12	79	168	13
N	R	bS	111	123	10	145	151	10	106	152	12	99	140	13	74	161	19
B	N	bS	61	173	19	36	163	14	77	111	11	92	200	18	95	145	14
N	N	bS	20	147	24	22	199	36	35	243	35	50	229	26	47	200	26
B	R	bF	17	101	13	17	114	19	18	146	20	17	91	15	9	116	26
N	R	bF	6	140	72	10	133	34	10	147	36	7	114	23	14	144	35
B	N	bF	68	141	14	53	189	22	65	118	9	28	135	21	25	157	22
B	N	bF	6	188	37	12	245	46	6	153	45	6	124	33	5	124	30
B	R	wS	55	363	45	51	443	63	38	415	73	27	324	79	28	322	55
N	R	wS	39	460	76	19	624	144	39	277	45	34	387	87	17	555	97
B	N	wS	69	477	54	73	383	38	66	369	53	69	322	55	49	391	60
N	N	wS	29	492	95	28	739	129	19	307	54	17	623	123	14	438	83

[1] Sample sizes for height and basal area are the same.
[2] B - Besnard Lake, N - Nemeiben Lake.
[3] R - random point transect, N - nest transect.
[4] bS - black spruce, bF - balsam fir, wS - white spruce.

Appendix 2. Relative Density of White Birch, Trembling Aspen, White Spruce, Black Spruce and Balsam Fir, and Abolute Density (Species Combined) on nest and random point transects on Besnard and Nemeiben lakes.

Density (trees / $100m^2$)

			Stratum 1			Stratum 2			Stratum 3			Stratum 4			Stratum 5		
Lake[1]	Shore type[2]	Spp.[3]	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.
B	R	wB	9	5.1	1.7	13	3.3	0.7	10	2.4	0.4	11	3.0	0.6	11	3.0	0.9
N	R	wB	16	4.4	1.4	14	2.2	0.4	15	4.6	1.2	11	4.1	0.8	11	2.8	0.7
B	N	wB	22	2.4	0.5	25	2.5	0.5	24	2.5	0.5	18	2.7	0.6	17	2.8	1.0
N	N	wB	5	2.2	0.7	6	1.8	1.1	6	1.4	0.5	5	1.4	0.4	4	1.7	0.6
B	R	tA	8	3.3	1.2	12	3.0	0.8	12	3.8	1.6	11	3.5	1.0	9	3.9	1.1
N	R	tA	6	5.0	2.4	6	3.8	1.8	10	3.5	1.0	7	3.1	0.9	5	1.6	0.3
B	N	tA	18	3.3	0.5	17	5.4	0.8	16	4.0	0.8	14	2.8	0.6	16	3.8	0.7
N	N	tA	7	2.6	0.7	9	2.7	0.8	8	2.7	0.9	6	3.9	2.1	7	3.7	1.6
B	R	wS	12	3.8	0.8	12	5.0	1.5	11	3.1	1.0	10	2.7	0.8	9	3.3	1.0
N	R	wS	11	3.1	0.6	6	2.8	0.6	10	6.0	2.2	9	4.4	1.6	7	2.2	0.6
B	N	wS	23	3.1	0.6	21	3.3	0.7	18	3.1	0.5	17	5.7	2.2	17	3.2	0.9
N	N	wS	8	3.2	1.1	8	1.7	0.3	6	1.5	0.3	5	2.8	1.3	4	2.9	1.1
B	R	bS	13	5.9	1.7	12	4.5	0.9	11	6.1	2.3	16	9.0	3.2	14	12.0	4.5
N	R	bS	17	10.2	3.6	19	11.1	2.5	17	9.3	2.2	15	10.3	1.9	10	11.2	3.9
B	N	bS	16	3.5	0.7	11	2.6	0.5	16	7.0	1.7	14	8.3	1.9	16	7.1	1.1
N	N	bS	6	2.8	1.2	7	2.1	0.6	6	4.3	1.0	6	6.3	1.3	7	8.0	2.1
B	R	bF	5	3.8	1.9	8	2.0	0.7	7	2.4	0.8	6	3.1	1.4	6	1.6	0.5
N	R	bF	4	1.5	0.4	5	1.6	0.3	5	1.7	0.4	6	1.2	0.2	4	2.7	0.8
B	N	bF	16	6.9	1.8	14	4.0	0.7	11	5.7	0.9	9	3.0	0.7	9	3.0	0.5
N	N	bF	3	1.5	0.4	2	5.4	3.4	3	1.3	0.1	3	2.1	0.9	2	3.0	0.5
B	R	.	19	12.6	1.9	19	11.8	1.4	18	11.0	1.8	18	15.4	2.8	17	17.1	3.4
N	R	.	20	15.8	3.3	20	15.0	2.3	20	16.9	1.9	18	16.3	2.0	15	14.6	2.8
B	N	.	31	13.5	1.5	31	11.6	1.1	31	13.1	1.3	28	13.4	1.6	26	13.2	1.2
N	N	.	10	9.1	1.1	10	8.0	1.1	10	6.9	1.2	10	8.8	1.4	9	12.3	1.5

1 B - Besnard Lake, N - Nemeiben Lake.
2 R - Random point transect, N - Nest transect (Ch. 2 for details).
3 wB - white birch, tA - trembling aspen, wS - white spruce, bS - black spruce, bF - balsam fir, . - species combined (absolute density).

Appendix 3. Areal summary of nesting habitat available within 200 m of shore, by species association and height class.

BESNARD LAKE - MAINLAND

Species[1] Associ-/ Height ation / Class(m)	Area Detail Report (ha.) 5	10	15	20	25	Total
S wS	0.0	0.0	0.0	42.2	11.4	53.6
S bS	1.6	123.5	207.4	7.4	0.0	339.9
S jP	2.3	67.2	24.2	7.8	0.0	101.5
S bS jP	9.0	141.8	306.6	48.9	0.0	506.3
SH sP tA	0.0	57.5	444.1	237.6	33.6	772.8
SH jP tA	15.2	130.1	114.8	95.8	0.0	355.9
HS tA sP	2.3	98.5	440.7	199.6	0.0	741.1
HS tA jP	2.7	276.2	115.3	147.6	0.0	541.8
H tA	3.1	421.8	245.2	120.3	0.0	790.4
H wB	2.7	26.6	29.3	0.0	0.0	58.6
					Total	4261.9

1. S = softwood, SH = softwood dominated mixed-wood forest, HS = hardwood dominated mixed-wood forest, H = hardwood forest. wS = white spruce, bS = black spruce, jP = jackpine, lT = larch, sP = spruce spp., tA = trembling aspen, wB = white birch.

Appendix 3. continued

BESNARD LAKE - ISLANDS						
Species[1] Associ-/ Height ation / Class(m)	Area Detail Report (ha.) 5	10	15	20	25	Total
S wS	0.0	0.0	3.9	16.4	0.0	20.3
S bS	0.0	216.9	79.8	15.6	0.0	312.3
S jP	0.0	66.8	0.0	0.0	0.0	66.8
S bS jP	14.1	36.0	62.5	6.6	0.0	119.2
SH sP tA	0.0	76.5	190.6	74.2	0.0	341.3
SH jP tA	0.0	14.8	57.8	0.0	0.0	72.6
HS tA sP	0.0	50.3	130.1	0.0	0.0	180.4
HS tA jP	1.6	80.1	12.9	0.0	0.0	94.6
H tA	0.0	61.0	25.8	0.0	0.0	86.8
H wB	9.4	209.1	11.4	0.0	0.0	229.9
					Total	1542.2

1. S = softwood, SH = softwood dominated mixed-wood forest, HS = hardwood dominated mixed-wood forest, H = hardwood forest. wS = white spruce, bS = black spruce, jP = jackpine, lT = larch, sP = spruce spp., tA = trembling aspen, wB = white birch.

Appendix 3. continued

NEMEIBEN LAKE - MAINLAND						
Species[1]	Area Detail Report (ha.)					
Associ-/ Height ation / Class(m)	5	10	15	20	25	Total
S wS	0.0	0.0	0.4	38.3	0.0	38.7
S bS	18.4	207.8	209.3	53.2	17.6	506.3
S jP	12.8	119.9	60.9	0.8	0.0	194.4
S lT	0.0	6.3	1.2	0.0	0.0	7.5
S bS jP	29.3	315.6	641.8	93.8	0.0	1080.5
SH sP tA	34.4	108.3	446.0	221.9	0.0	810.6
SH jP tA	3.1	66.1	225.8	41.4	0.0	336.4
HS tA sP	0.0	109.5	402.7	264.0	0.0	776.2
HS tA jP	0.0	62.1	91.7	0.4	0.0	154.2
H tA	0.0	244.1	74.6	40.6	0.0	359.3
H wB	0.0	70.2	64.5	0.0	0.0	134.7
					Total	4398.8

1. S = softwood, SH = softwood dominated mixed-wood forest, HS = hardwood dominated mixed-wood forest, H = hardwood forest. wS = white spruce, bS = black spruce, jP = jackpine, lT = larch, sP = spruce spp., tA = trembling aspen, wB = white birch.

Appendix 3. continued.

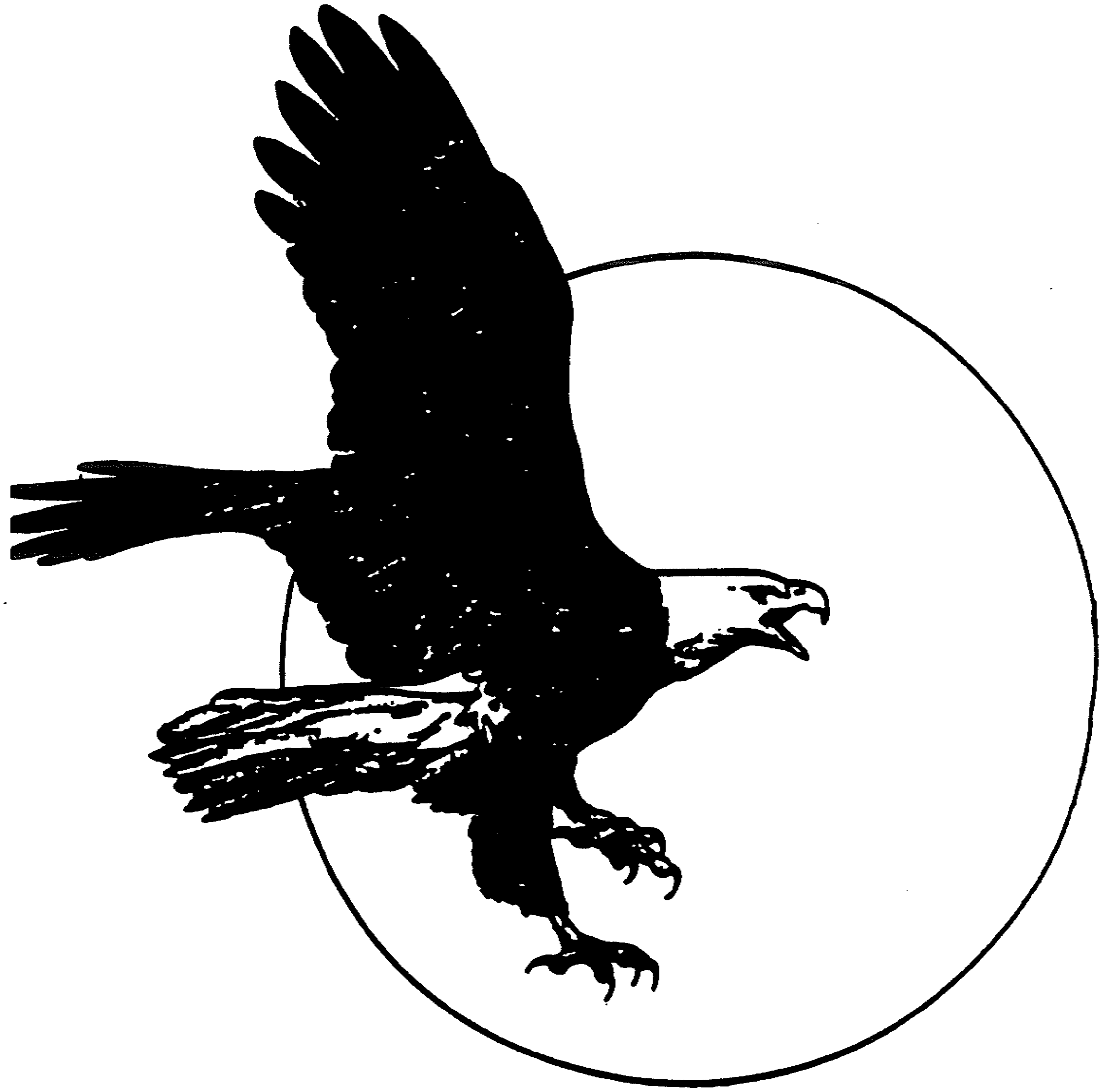
NEMEIBEN LAKE - ISLANDS

Species[1] Associ-/ Height ation / Class(m)	Area Detail Report (ha.) 5	10	15	20	25	Total
S wS	0.0	0.0	5.1	10.5	9.4	25.0
S bS	0.0	50.4	218.0	30.8	0.0	299.2
S jP	0.0	0.0	0.8	27.3	0.0	28.1
S bS jP	0.0	35.5	74.2	2.7	0.0	112.4
SH sP tA	0.0	15.2	132.4	220.7	0.0	368.3
SH jP tA	2.0	0.0	19.5	0.0	0.0	21.5
HS tA sP	0.0	20.7	80.1	50.0	0.0	150.8
HS tA jP	5.1	0.0	2.0	7.0	0.0	14.1
H tA	0.0	4.3	28.5	9.0	0.0	41.8
H wB	4.7	0.0	1.6	0.0	0.0	6.3
					Total	1067.5

1. S = softwood, SH = softwood dominated mixed-wood forest, HS = hardwood dominated mixed-wood forest, H = hardwood forest. wS = white spruce, bS = black spruce, jP = jackpine, lT = larch, sP = spruce spp., tA = trembling aspen, wB = white birch.

Appendix 4

The Bald Eagle in North-central Saskatchewan: a Questionnaire Mailed to Owners of Cottages on Besnard and Nemeiben lakes.



THE BALD EAGLE

IN NORTH-CENTRAL SASKATCHEWAN

DEFINITIONS

occupied nest - a nest that has a mated pair consistently using the area. Occupied nests include those with:
- an incubating adult (a bird laying in the nest)
- egg(s) or young , please do not attempt to climb eagle nest trees or any nearby trees.
- a pair of adults within 100 meters of the nest
- an average of one or more adults seen wihin .8 km (½ mile) of the nest on multiple visits to the nest area. (Eggs need not be laid. This can be thought of as a married couple living in a house but not raising any children.)

active nest - this is a subgroup of the occupied nests
- only includes those nests in which at least one egg is laid (a nest is considered active if an adult is seen in incubating position on the nest).

empty nest - a nest not associated with a mated pair
- less than an average of one adult seen within .8km (½ mile) of the nest on multiple visits
- these nests may appear to be in normal condition or may be in a state of disrepair (dilapitated or falling apart)
- a nest may be empty one year and occupied and active the next, because some eagle pairs have two nests in their territory which serve as alternates.

BALD EAGLE QUESTIONAIRE

1. Is your cabin at this lake commercial, residential, recreational, or traditional?

   ____

2a. Including 1985, how many years have you occupied this cabin site? ___________years

b. Are you the original leaser of this site?
   a) yes
   b) no

3. Are you a (a) spring/summer resident only; go to #4 and continue
   (b) year round non resident i.e. visit the cabin occasionally in all seasons; go to #4 and continue
   (c) permanent resident of the lake; go to #5 and continue
   (d) winter resident only; go to #4 and continue?

4a. If not a permanent resident, how many visits do you usually make per year to your cabin?
   a) 0 - 3
   b) 4 - 6
   c) 7 - 10
   d) more than (>) 10

b. How many days in total do you spend at the lake in a year?
   a) 0 - 5
   b) 6 - 15
   c) 16 - 30
   d) 31 - 45
   e) > 45

c. For each category, fill in the appropriate number of days, weekends, etc. that you spend at your cabin.
   a) April: _____week days, ______weekends, ______long weekends
   b) May: ______week days, _____weekends, _____long weekends
   c) June: ______week days, ______weekends, ______long weekends

d. In the summer of 1986, when and for how long so you plan to stay at the lake? (Circle applicable dates.)

APRIL

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

MAY

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

JUNE

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

JULY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

AUGUST

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

SEPTEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

5a. Do you plan future building or related activities at you cabin site? This includes tearing down any existing structures.
  a) yes
  b) no

b. If yes, describe the activity, including probable years, months, and length of proposed activity.

____

____

6a. What activities are you involved in while at the lake? (check)

_____fishing	_____hiking
_____boating	_____trapping
_____water skiing	_____hunting
_____canoeing	_____swimming
_____bird watching	_____snorkeling
_____sailing	_____snow mobiling
_____other (specify)______________	

b. Roughly how many hours per day do you spend on the lake in a boat?
  a) 0
  b) 1 - 2
  c) 3 - 4
  d) 5 - 6
  e) 7 - 9
  f) >9

7a. The pictures below illustrate an immature Bald Eagle / adult Bald Eagle

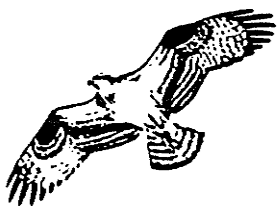
Did you know that only adult Bald Eagles (4 years and older) have a white head and tail; and that younger eagles (immatures) are brownish all over, mottled with varying amounts of white?
  a) yes
  b) no

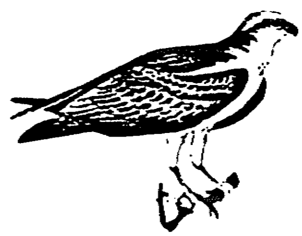
OSPREYS (fish hawks) are worldwide in distribution near fresh or salt water. Fish, the only prey, are taken at or just below the surface. The birds hover, often 50' to 150' high, then suddenly plunge, sometimes going completely under the water.

OSPREY *Pandion haliaetus*

Uncommon; along seacoasts, lakes, and rivers. Conspicuous crook in long wings and black "wrist" mark confirm identification of adults and young at great distances. Plumage is dark above, white below. Except when migrating at a height, they flap more than they sail. Wingbeats are slow and deep. Wings are held in an arched position. Call, a series of loud, clear whistles.

b. Pictured below is an Osprey or "fish hawk".





L 22" W 54"

flight profile

In the past, were you able to distinguish between Bald Eagles and Ospreys?
- a) yes
- b) no If no, comment on what you thought you were seeing?

8a. Are you aware that there are Bald Eagles on the lake in the summer?
- a) yes
- b) no

b. Have you seen any Bald Eagles around the lake?
- a) yes, go to #8c
- b) no, go to #9

c. During your residency (permanent or temporary) has the Bald Eagle population appeared to have
- a) increased
- b) decreased
- c) remained stable
- d) no opinion.

d. Would you say
- a) Bald Eagles on this lake are very numerous
- b) Bald Eagles are fairly common on this lake
- c) Bald Eagles are relatively rare on this lake
- d) no opinion.

9. Are you aware of any Bald Eagle nests on the shores of this lake (mainland or island)?
   a) yes
   b) no, go to #11

   If yes, please mark past or present nest locations (X) on the map provided.
   Beside each nest location, put the most recent year that you know the nest was present to the best of your knowledge. If you do not know the exact nest location, or you think you know the general area where a nest may be, circle the area on the map provided. Please mark your cabin location (●) on this map as well. Go to #10.

10a. Are you able to determine if these nests are occupied/active or empty (see definitions provided)?
   a) yes
   b) no

b. Have you ever seen young Bald Eagles (eaglets) on the nest?
   a) yes
   b) no

c. Do you return to these nests each summer?
   a) yes, go to #10d
   b) no, go to #11

d. Do you check the nests:
   a) daily
   b) two or three times a week
   c) weekly
   d) a couple of times a summer
   e) monthly

e. How close do you approach the nest?
   a) 400m from shore
   b) 200m from shore
   c) 100m from shore
   d) 50m from shore
   e) <50m from shore
   f) I go on shore

f. When visiting a nest do you?
   a) remain in your boat
   b) go ashore on an adjacent body of land and observe from there
   c) go ashore to investigate the immediate nest area

g. How long do you watch the nest?
   a) 5 minutes
   b) 10 minutes
   c) 20 minutes
   d) 30 minutes
   e) >30 minutes

h. While observing do you
   a) remain silent and still
   b) carry on normal conversation
   c) make abrupt movements or loud noises

i. Do you approach the nest (note: there are 2 answers for this question)
   a) quickly
   b) slowly
   c) by a direct route
   d) by an indirect route?

11a. If you were fishing and you discovered an active Bald Eagle nest would you
   a) leave the vicinity of the nest immediately
   b) remain close only long enough to take a few pictures or watch it for a couple of minutes
   c) remain fishing in the vicinity regardless
   d) go ashore and investigate?

b. If you found an eagle on shore, apparently unable to fly properly, would you
   a) leave it alone
   b) leave it alone and report it to a conservation officer or to me
   c) attempt to catch it
   d) attempt to catch it and return it to the nest
   e) attempt to catch it and take it to a conservation officer
   f) kill it to put it out of its misery?

12. Are you interested in Bald Eagles?
   a) yes, very much so
   b) yes, but my interest is only casual
   c) no

13. Is it important to you as a lake resident to have a Bald Eagle population nesting on the lake?
   a) yes
   b) no
   c) no opinion

14. Are there enough Bald Eagles on this lake?
   a) yes
   b) no
   c) no opinion

comment:

15. Would you be in favor of implementing restriction zones to exclude fishing, forest cutting, road building, cabin development, etc. from within 500m or 1000m of Bald Eagle nests and other important areas to Bald Eagle habitat eg. fish spawning streams?
    a) yes
    b) no
    c) no opinion

    comment:

16. Do you believe research programs looking at the ecology of Bald Eagles is of importance to Bald Eagle management?
    a) yes
    b) no
    c) no opinion

17. Your comments and opinions:
    You are invited to comment below about your knowledge, attitudes, and experience regarding Bald Eagles on this lake and in Northern Saskatchewan in general. Include anything you feel would be important to or of interest to my study that I did not include in my questionaire. Use additional paper if required.

Appendix 5

Bald Eagle Questionaire - Summary of Responses

			Percent			
			Besnard		Nemeiben	
			n	%	n	%
1.	Is your cabin at this lake:	commercial	1	2.4	1	1.8
		residential	1	2.4	1	1.8
		recreational	38	90.5	52	92.9
		traditional	2	4.8	2	3.6
2a.	Mean length of lease (mean +/- s.e.):					
2b.	Are you the original leaser:	Yes	34	82.9	47	83.9
		No 7	17.1	9	16.1	
3.	Type of residency:	spring/summer 26	61.9	26	47.3	
		year-round non-resident	15	35.7	29	52.7
		permanent 1	2.4			
4a.	Number of visits made per year:	0 - 3	12	30.8	13	24.1
		4 - 6	9	23.1	15	27.8
		7 - 10	11	28.2	8	14.8
		> 10	7	17.9	18	33.3
4b.	Total number of days spent at lake in a year:	0 - 5	2	5.6	3	5.5
		6 - 15	12	33.3	11	20.0
		16 - 30	10	27.8	20	36.4
		31 - 45	7	19.4	10	18.2
		> 45	5	13.9	11	20.0
5a.	Plans of future building activity:	Yes	11	26.8	17	30.4
		No	30	73.2	39	69.6
6b.	Approximate number of hours spent on the lake per day in a boat	0	1	2.5	1	1.9
		1 - 2	14	35.0	18	33.3
		3 - 4	17	42.5	18	33.3
		5 - 6	7	17.5	13	24.1
		7 - 9	1	2.5	3	5.6
		> 9			1	1.9
7a.	Able to distinguish adult from immature Bald Eagle:	Yes	31	73.8	36	65.5
		No	11	26.2	19	34.5
7b.	Able to distinguish Ospreys and Bald Eagles:	Yes	33	84.6	44	81.5
		No	6	15.4	10	18.5

			Besnard n	Besnard %	Nemeiben n	Nemeiben %
8a.	Aware of Bald Eagles on lake in the summer:	Yes	42	100.0	51	92.7
		No			4	7.3
8b.	Have you seen Bald Eagles on the lake:	Yes	42	100.0	50	90.9
		No			5	9.1
8c.	During residency, has the eagle population appeared to have:	Increased	8	19.5	9	17.0
		Decreased	3	7.3	4	7.5
		Stable	18	43.9	24	45.3
		No Opinion	12	29.3	16	30.2
8d.	Bald Eagles are _________ on this lake:	numerous	4	9.8	2	3.8
		common	33	80.5	26	49.1
		rare	1	2.4	19	35.8
		No opinion	3	7.3	6	11.3
9.	Aware of Bald Eagle nests on on the shores of this lake:	Yes	35	83.3	28	51.9
		No	7	16.7	26	48.1
10a.	Able to determine if nests are occupied/active or empty?	Yes	24	68.6	19	65.5
		No	11	31.4	10	34.5
10b.	Have you ever seen eaglets on the nest?	Yes	20	55.6	15	51.7
		No	16	44.4	14	48.3
10c.	Do you return to these nests each summer?	Yes	17	48.6	17	60.7
		No	18	51.4	11	39.3
10d.	Do you check the nests:	Daily	0		0	
		Two/three times per week	1	5.3	1	6.7
		Weekly	4	21.1	2	13.3
		A couple of times per summer	13	68.4	10	66.7
		monthly	1	5.3	2	13.3
10e.	How close do you approach the nest?	400 m	5	26.3	4	25.0
		200 m	7	36.8	5	31.3
		100 m	4	21.1	2	12.5
		50 m	0	0.0	3	18.8
		<50 m	2	10.5	1	6.3
		I go on shore	1	5.3	1	6.3
10f.	When visiting a nest do you:	remain in the boat	17	89.5	14	87.5
		go ashore on an adjacent body of land	1	5.3	2	12.5
		go ashore to investigate the immediate area	1	5.3	0	

		Besnard n	Besnard %	Nemeiben n	Nemeiben %
10g. How long do you watch the nest?	5 min.	9	52.9	7	46.7
	10 min.	8	47.1	6	40.0
	20 min.	0		0	
	30 min.	0		0	
	>30 min.	0		2	13.3
10h. While observing do you:					
	remain silent and still	11	68.8	6	40.0
	carry on normal conversation	5	31.3	9	60.0
	make abrupt movements or loud noises	0		0	
10i. Do you approach the nest:	Quickly	3	23.1	0	
	Slowly	10	76.9	11	100.0
10j. Approach to the nest is:	Direct	8	50.0	5	50.0
	Indirect	8	50.0	5	50.0
11a. If you were fishing and you discovered an active Bald Eagle nest would you:					
	- leave the vicinity of the nest immediately	6	15	5	9.3
	- remain close only long enough to take a few pictues or watch it for a couple of minutes	20	50.0	25	46.3
	- remain fishing in the vicinity regardless	14	35.0	24	44.4
	- go ashore and investigate	0		0	
11b. If you found an eagle on shore, apparently unable to fly properly, would you:					
	- leave it alone	9	20.9	16	29.6
	- leave it alone and report it to a conservation officer or to me	31	72.1	36	66.7
	- attempt to catch it	0		0	
	- attempt to catch it and return it to the nest	1	2.3	0	
	- attempt to catch it and take it to a conservation officer	2	4.7	2	3.7
	- kill it and put it out of it's misery	0		0	
12. Are you interested in Bald Eagles?					
	Yes, very much so	23	54.8	19	34.5
	Yes, but interest is only casual	19	45.2	36	65.5
	No	0		0	
13. Is it important to you as a lake resident to have a Bald Eagle's nesting on the lake					
	Yes	38	90.5	47	85.5
	No	1	2.4	2	3.6
	No opinion	3	7.1	6	10.9

		Besnard		Nemeiben	
		n	%	n	%
14. Are there enough Bald Eagles on this lake?	Yes	12	29.3	11	20.0
	No	12	29.3	28	50.9
	No opinion	17	41.5	16	29.1
15. Would you be in favour of implimenting restriction zones to exclude fishing, forest cutting, road building, cabin development, etc.from within 500 m or 1000 m of Bald Eagle nests and other important areas of Bald Eagle habitat, e.g. fish spawning streams.	Yes	24	57.1	31	56.4
	No	9	21.4	11	20.0
	No opinion	9	21.4	13	23.6
16. Do you believe research programs looking at the ecology of Bald Eagles is of importance to Bald Eagle management?	Yes	36	85.7	52	94.5
	No	1	2.4	0	
	No opinion	5	11.9	3	5.5