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Boat census of Bald Eagles during the breeding season.—Subadults, birds in predefinitive plumage, and non-breeding adult Bald Eagles (*Haliaeetus leucocephalus*) are poorly censused by breeding season aerial surveys (Whitfield et al. 1974). This study tests whether a boat survey provides a reliable estimate of the number of individuals in a summer (May–August) population of Bald Eagles on a moderately large lake. Boats have been used to locate nests (Hodges 1982, Gerrard et al. 1983), but should also be suitable for counting eagles since these birds spend much time at the aquatic-terrestrial interface (Leighton et al. 1979, Gerrard et al. 1980, Gerrard and Bortolotti 1988). A second objective was to test whether eagle numbers fluctuated in response to the availability of dead fish. Preliminary studies showed occasional congregations of immatures and non-breeding adults on small lakes adjacent to Besnard Lake; we censused such lakes to achieve a third objective—to find out whether changes in the population on Besnard Lake resulted from movements to and from these nearby lakes.

Study area and methods.—Besnard Lake (55°25′N, 106°00′W) lies along the southern boundary of the Canadian Shield region in north-central Saskatchewan. The lake has an irregular outline with rocky shores and numerous islands. The shoreline length is 400 km (as measured using 1:15,000 scale maps) with a surface area of 197 km², of which 177 km² is open water and the remainder is occupied by 255 islands (Chen 1974). It is surrounded by low, forested hills, not exceeding 100 m in height. White spruce (*Picea glauca*) and trembling aspen (*Populus tremuloides*) predominate near the lake shore. The study area also includes six small lakes of 0.4 to 3.7 km² water area near Besnard Lake. The character of the shores and forests surrounding these lakes was similar to Besnard Lake, except that one of the small lakes had extensive shallow, reedy areas. Eagles breeding on these lakes were not significantly affected by DDT, and the population has been stable from 1973 to 1989 (Gerrard et al. 1983, Gerrard 1985).

Bald Eagle surveys.—Twenty-three boat censuses of Besnard Lake were conducted; nine in 1976, eight in 1977, two in 1978 and four in 1984. At least one census was conducted per month from May to August each year, except for 1978 when the July and August censuses were omitted. The design of the boat census was based on an earlier raptor census by Craighead and Craighead (1969). The shoreline was divided into 50 sections of 8 km each. To reduce the total time of the census, each census consisted of a survey of half of the shoreline of the lake; a pilot census in 1975 showed that surveying fewer than half the sections reduced the accuracy of the overall census. Alternate sections (i.e., 25 sections total) around the lake were censused by one or more observers traveling 100 m from shore in a motorized canoe or other boat at a speed of 8–16 km/h. If an eagle was flushed, it tended to fly into the next section (i.e., one that was not on the present census) thus reducing the likelihood of counting any eagles twice. Censuses were conducted during daylight hours when winds were less than 32 km/h and visibility was good. No censusing was done in moderate or heavy rain. A complete census of 25 sections took three to eight days ($\bar{x} = 4.8$), depending on the weather.

TABLE 1
AVERAGE NUMBER OF EAGLES PER SECTION 1976–1978

	Sections with active nests (147)[a]	Sections with empty-occupied nests (66)	Other sections (262)
Adults	1.65	1.64	0.50[b]
Subadults	0.41[c]	0.80	0.65

[a] Number of such sections surveyed.
[b] $\chi^2 = 78$, $P < 0.001$ that the number of adults in other sections is lower than that in sections with nests.
[c] $\chi^2 = 7.0$, $P < 0.01$ that the number of subadults in sections with active nests is lower than that in all the remaining sections.

Census sections were divided into those with an active nest (a nest with incubating adult or young present), those with an empty-occupied nest (those containing a nest attended by a pair of adults but with neither eggs nor young at the time of the census), and other sections (see Gerrard et al. 1983). The status of each nest or breeding area was monitored during the summer, both during the surveys and by additional visits. For the population estimate we used a stratified sampling approach with two strata based on the relative distribution of adults and immatures (Table 1). For adults, the lake was stratified into sections with occupied nests (those with active and empty-occupied nests combined) and other sections. For immatures, the lake was stratified into sections with active nests and all other sections (i.e., empty-occupied and other sections).

"Adult" eagles have white heads and tails. Birds with minute brown spots on the head and tail (the Basic IV plumage; Palmer and Gerrard 1988, McCullough 1989) were also included in this category, but birds with a stripe through the eye, brown crown or brown terminal band on the tail were excluded (Basic III plumage; Palmer and Gerrard 1988, McCullough 1989). Five nestlings marked on Besnard Lake and resighted when four years of age all had adult plumage. Thus, adults are presumed to be four years of age or older. The term "immature" is used to include all other younger eagles, and by comparison with known-age birds marked on the lake (Gerrard et al. 1978) were one, two, or three years old at the time of the census. A hatching-year bird was an eagle raised in the year of the census. No hatching-year birds fledged before the last two days in July and most were in the nest until mid-August. Except where specifically noted, hatching-year birds, readily identified by plumage and behavior, were excluded from counts of immatures for the purpose of the census.

The shorelines of six small lakes near Besnard Lake were surveyed during 1976 and 1978. Ninety km of shoreline were searched during May and June and 120 km during July. To calculate eagle numbers using a Petersen estimate, and to monitor local movements, we used patagial tags to color mark 56 nestling eagles on Besnard Lake from 1973–1975 (Gerrard et al. 1978).

Fish survey.—Fish are the primary prey of eagles in our study area and are often captured injured or dead on the water surface (Gerrard and Bortolotti 1988). During the surveys in 1976 and 1977, one observer watched for dead or injured fish floating on the lake surface. Since the ability to see such fish varied with the height of the waves, the distance from the boat at which fish could be seen was estimated. The distance travelled was then multiplied by the visibility on each side of the boat to give an estimate of the area of lake surface scanned for fish.

Besnard Lake population.—There was a consistent trend for the number of eagles on

TABLE 2
RESULTS OF BESNARD LAKE BALD EAGLE CENSUSES 1976–1984

Month	No. of surveys	Estimated adult population	Estimated immature population		Total population
		No.	No.	%	No.
May	6	49.4 ± 2.3*	20.1 ± 2.2[a]	29%	69.5 ± 1.1[a]
June	6	41.6 ± 2.0	20.7 ± 2.5	33%	62.6 ± 3.5
July	6	60.5 ± 3.5	45.0 ± 5.2	42.5%	105.8 ± 4.1
August	5	60.3 ± 2.1	31.1 ± 6.5	33.9%	91.8 ± 7.5

[a] Results are presented as the mean ± SE of the estimates from the individual surveys.

Besnard Lake to be lower in May and June and higher in July (Table 2). The number of adults present on the lake on all May and June censuses averaged 45.5 ± 1.9 ($\bar{x}$ ± SE, N = 12), while in July and August there was a significant increase ($P < 0.0001$, unpaired t-test) to a mean of 60.6 ± 2.1 adults (N = 11) (Fig. 1, Table 2). The number of immatures on the lake averaged 20.4 ± 1.6 (N = 12) on the May and June censuses, while it increased

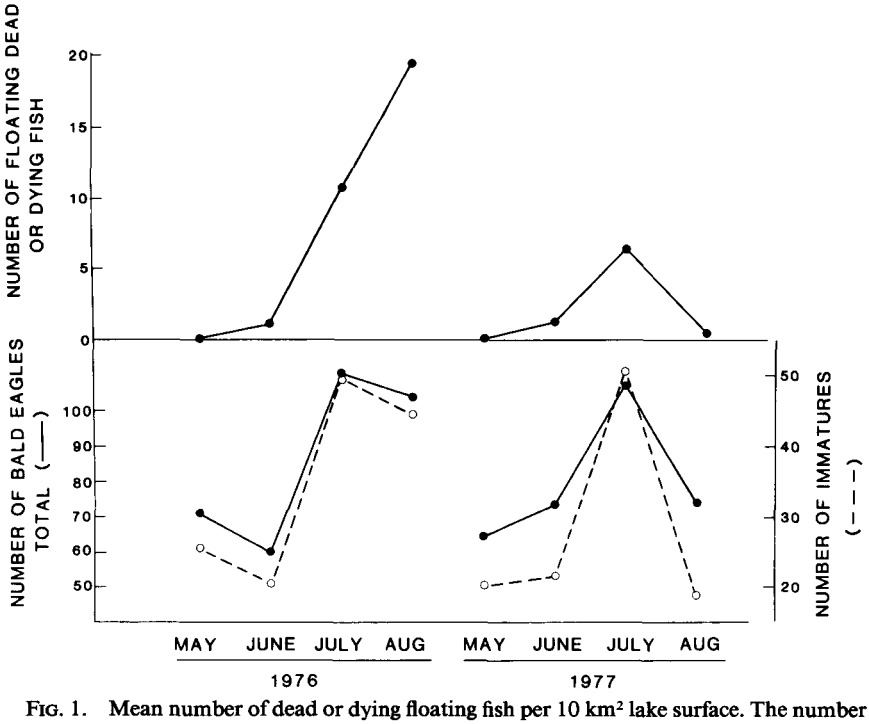

FIG. 1. Mean number of dead or dying floating fish per 10 km² lake surface. The number of Bald Eagles and the number of immatures on Besnard Lake are shown as the mean for all censuses in a given month.

($P < 0.005$) to an average of 45.0 ± 5.2 (N = 6) on the July censuses. In August of 1976, the number of immatures on the lake averaged 44.0, while in August, 1977, it declined to an average of 17.2.

When the number of fledglings ($\bar{x} = 27.8$ for the four years) is added to the number of adults and subadults on the lake, the average number of eagles on the lake in August was 119.5 which is 0.30 eagles/km shoreline or 0.68 eagles per km² water area.

Distribution of eagles.—All nests at Besnard Lake in 1976 to 1978 and in 1984 were within 200 m of the lake shore. Eagles were not distributed evenly along the shoreline. More adults were in sections with active or empty-occupied nests (Table 1). Immatures were less likely to be found in sections with active nests (Table 1). Immatures were less likely than expected to be found closer than 2.4 km to an active nest (mean 5.1 immatures/100 km in 875 km shoreline searched) and more likely to be found more than 2.4 km from an active nest (mean 10.1 immatures/100 km in 724 km searched) (Chi-square test, $\chi^2 = 12.1$, df = 2, $P < 0.01$). Our observations of territorial behavior on Besnard Lake, similar to those of Mattson (1974) and Swenson et al. (1986), showed that immatures are actively excluded from the region near an active nest but not from the region near an empty-occupied nest.

Immatures often exhibited clumped distributions (Table 3), and were not seen regularly in the same sections. To test if the immatures consistently occupied the same survey sectors, we made use of May to July surveys of odd numbered sectors done in 1976. We counted the number of absences of immatures over the five surveys in each sector. Assuming that the occurrence of one or more immatures in a given sector in a survey is independent of that in other surveys, we expected a binomial distribution. We calculated the binomial probabilities, with $P = 18.20/25 = 0.7280$, which is the average fraction of sectors having no immatures. A Kolmogorov-Smirnov test showed no significant departure of the observed frequencies from those expected ($D = 0.06$, $P > 0.2$).

TABLE 3

MEAN, VARIANCE (S^2) AND COEFFICIENT OF DISPERSION (CD) FOR THE NUMBERS OF IMMATURES PER SECTOR, BY SURVEY NUMBER

Survey number	Date	For all sections			Sections without active nests
		$\bar{x}$	S^2	CD[a]	CD
1	May 24–June 1	0.44	0.923	2.18**	2.11**
2	May 24–June 1	0.52	1.093	2.10**	2.4**
3	June 5–8	0.28	0.210	0.75 ns	0.59 ns
4	June 18–25	0.52	0.843	1.62*	1.34 ns
5	June 18–25	0.40	0.500	1.25 ns	1.18 ns
6	July 5–10	0.80	2.830	3.53**	3.83**
7	July 19–23	1.04	3.870	3.72**	2.71**
8	Aug. 2–5	0.72	1.043	1.45 ns	1.56 ns
9	Aug. 16–20	1.00	1.500	1.50 ns	1.52 ns
All surveys					
Sections without active nests		0.71	1.51	2.13**	
Sections with active nests		0.46	1.25	2.72**	

[a] ns $P > 0.05$; * $0.05 > P > 0.01$; ** $P < 0.01$ (the significance of departure of the coefficient of dispersion from unity was tested using $\chi^2 [N - 1] = [N - 1]S^2/\bar{x}$).

TABLE 4

THE NUMBER OF TERRITORIES ON BESNARD LAKE DURING THE YEARS OF THE STUDY

Year	Number of territories			Number of young fledged
	Occupied	Active	Successful[a]	
1976	21	15	14	24
1977	22	20	18	29
1978	23	19	17	27
1984	24	23	18	31

[a] Successful territory was one where young were raised to fledging.

Population movements in response to prey availability.—There were few sightings of floating dead or injured fish on Besnard Lake during May and June 1976 and 1977 (Fig. 1). A considerable increase occurred in July of both years. In 1976, numbers of fish continued to be high throughout August, while in August 1977 the number of fish declined to low levels. Using data from each census, there was a significant correlation between the number of floating dead fish per km^2 water surface and the lake population of immatures (Pearson product moment correlation $r = .67$, df = 15, $P = 0.009$), of adults ($r = .58$, df = 15, $P = 0.03$) and of all eagles ($r = .70$, df = 15, $P = 0.005$).

Population size on small lakes.—Surveys of several small lakes adjacent to Besnard Lake in 1976 and 1978 showed no active breeding areas but an eagle density in May and June (0.50 eagles/km shoreline) which was much higher than the May and June density of eagles on Besnard Lake (0.17 eagles/km shoreline). In July, the density of eagles along small lakes (0.22 eagles/km shoreline) was similar to that on Besnard Lake (0.27 eagles/km shoreline).

The results of the census show a considerable influx of immature and non-breeding adults onto Besnard Lake each year in July. The influx was associated with an increase in the availability of dead fish floating on the lake surface. The precise cause of the fish die-off has not been established, but may result from an increase in water temperature and a decrease in the dissolved oxygen. Observations in 1970 suggested there might be congregations of immatures at small lakes adjacent to Besnard at a time when white sucker (*Catostomus commersoni*), northern pike (*Esox lucius*), and walleye (*Stizostedion vitreum*) spawn in streams feeding from these lakes into Besnard Lake. The results of the present study showed an increase in the numbers of immatures and non-breeding adults using these small bodies

TABLE 5

SIGHTINGS OF MARKED SUBADULTS DURING 1977

Date	No. of marked birds seen	No. of birds seen well enough to see markers	Percent marked
July 1–15	2	29	6.9%
July 16–31	10	107	9.3%
Aug. 1–Sept. 15	4	49	8.2%
Total period	16	185	8.13 ± 0.69[a]

[a] $\bar{x} \pm$ SE.

of water during spawning in May and June and a decrease in July and August and they are consistent with a movement of eagles from the small lakes to Besnard Lake at the end of June. Observations of two color-marked birds confirmed such a movement. A similar seasonal pattern has been suggested to occur in Minnesota (Fraser et al. 1985).

Accuracy and reproducibility of censuses.—Several observations suggest that the survey provided an accurate and reproducible estimate of the number of eagles around Besnard Lake. First, based on results from three occasions when two lake surveys were done simultaneously, the coefficient of variation for the number of adults seen on a single survey was 12.2%, for the number of immatures 8.4% and for the total eagle population 4.3%. Second, in May and June, adults not associated with nests were virtually absent from Besnard Lake. The number of adults seen on the surveys was close to a predicted value of two times the number of occupied breeding areas on the lake (Table 4). For 1976 the mean number of adults on the May and June surveys was 40.6, while the expected was 42. For 1977 the comparable numbers were 47.9 and 44, for 1978 they were 49.5 and 46, and for 1984 they were 47.4 and 48. Third, sightings of color-marked birds showed that resighting of individuals on a given survey was rare. Of 23 color-marked birds seen on the censuses, only one was seen twice on the same census.

Fourth, in 1977, during one sixteen-day period, 107 immatures were seen well enough to tell whether color markers were present. Ten of these birds were marked and represent a minimum of four individuals. Based on these sightings and on a mean of 8.13 ± 0.69% ($\bar{x}$ ± SEM) of birds on the lake being marked (Table 5), a Petersen estimate can be used to calculate a minimum of 49.2 (45.4–53.8) subadults on the lake during this period. Three of the marked eagles sighted were from a small group which were "batch" marked with similar colors. If these are counted as unmarked to reduce the uncertainty of whether these sightings represented one or more birds, then there were in the 107 sightings, seven marked sightings of three different birds. This information, under assumptions similar to that of the Petersen method is sufficient to form a maximum likelihood estimate of the subadult population. This method was worked out by Arnason et al. (unpubl. data), and gives a most likely estimate of 46. These figures can be compared to results of two censuses done during this period which estimated a lake population of 48 and 54 subadults respectively.

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Male Eastern Bluebird rears four broods during one nesting season.—The Eastern Bluebird (*Sialia sialis*) is multi-brooded and rears either two or three broods over most of its range. Peakall (1970) found that: (1) two broods are reared in most of the range, (2) three broods are common in the central portion of the range, and (3) one brood is most common in Canada. Although four clutches of eggs have been reported (Laskey 1943, Thomas 1946), the maximum number of successful broods to be reported is three. This paper reports a male Eastern Bluebird that apparently reared four broods during the 1987 nesting season by alternately mating with two females.

The study area consisted of an improved pasture located in Cullman County, Alabama. Nest-boxes were equipped with shutter-traps (Fischer 1944) and placed along fencerows.