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# BIRDS

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## POPULATION SIZE AND PRODUCTIVITY OF PIPING PLOVERS AT LAKE DIEFENBAKER IN RELATION TO WATER LEVEL.

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In the breeding season Lake Diefenbaker is home to a significant, although varying, portion of the world Piping Plover population. This presents reproductive challenges to the Piping Plover, an endangered species, because water level in this huge reservoir often rises from 2-6 m between early May and late July, the plover's breeding period. There is growing concern among conservationists that reproductive losses due to flooding of nests and disappearance of brood-rearing habitat under flooded beaches may be hindering recovery efforts of this species. A simulation model developed to assess the effects of flooding on Piping Plover reproductive success at Lake Diefenbaker over the last 30 years suggests that flooding of nests and chick-rearing habitat has had a detrimental effect on productivity<sup>3</sup>. By attracting large numbers of breeding plovers to its beaches in some years, with subsequent high reproductive losses due to rising water level, Lake Diefenbaker may be a "sink" rather than a "source" for the plover population.

The 1991 and 1996 international Piping Plover censuses suggested that 64% and 60%, respectively, of the Canadian population of breeding Piping Plovers occurred in Saskatchewan.<sup>18 19</sup> This represents 23% and 21%, respectively, of the total North American population. Within Saskatchewan, Lake Diefenbaker was identified as a particularly important breeding area for Piping Plovers in some years. In 1991, 24% of the Saskatchewan population bred there, representing about 5% of the world population. However, only 6% of the Saskatchewan population bred there in 1996. Piping Plovers move from year to year in response to changing water regimes. We summarize data from various studies from 1984 to 1996 on population size, distribution, productivity, and other reproductive variables of Piping Plovers at Lake Diefenbaker. The data is standardized and presented in a uniform format in order to make comparisons among years. This summary strongly suggests that Piping Plovers are often not faring well in their reproductive efforts due to changing water level at Lake Diefenbaker. Further stud-



*Piping Plover*

*Ian W. Sadle*

ies will clarify potential management actions that may enhance the Piping Plovers' productivity in some years at this site.

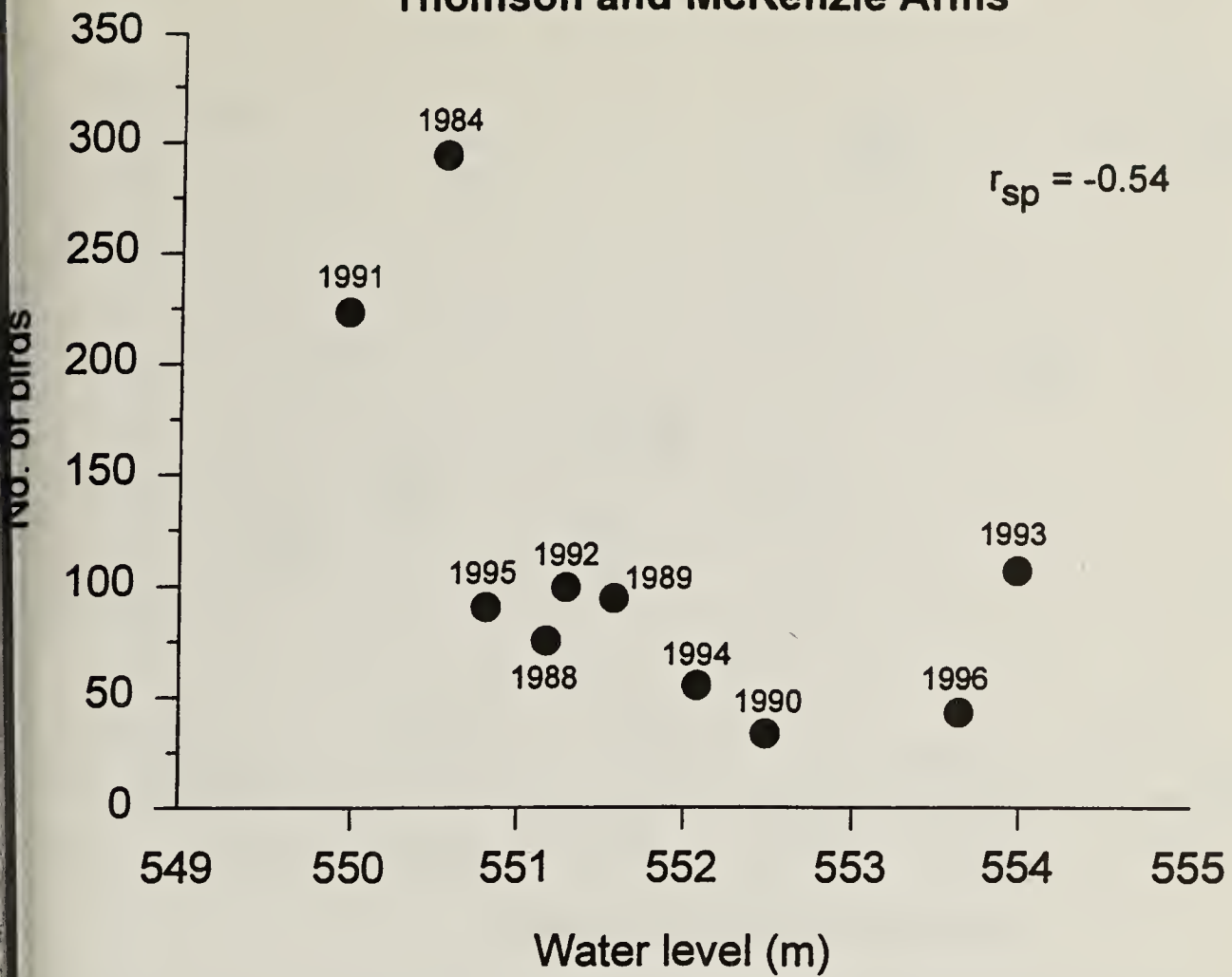
**Population Studies** Lake Diefenbaker was confirmed as an important basin to breeding Piping Plovers in 1984 when the first census was conducted there<sup>10</sup>. Survey data from 1984 to 1996 indicates that numbers of plovers using the reservoir is highly variable from year to year (Table 1).

A complete census occurred in only 4 of the 10 years for which population counts were conducted between the end of May and the first half of June: in 1988, 1991, 1992 and 1996. Most of the shoreline with suitable habitat was censused in the other years except for 1993, when only 5 small, but important, study sites were monitored<sup>2</sup>. In order to have the population survey information comparable among years, a population estimate was calculated for the years of incomplete censuses<sup>17</sup>. The estimates were determined as follows (except for 1993): for portions of the shoreline that were not censused in a given year, the aver-

age number of birds counted in those portions was calculated from years when the overall population count was similar to the year in question. This estimate was added to the actual count from the censused portions of the lake for that year. For 1993, the estimate was determined using the 1992 sites as an index of the total population: the 3 sites had on average, 40.7% of the total population in 3 years of complete counts (1991, 1992, and 1996)<sup>1</sup>. The 1993 count at the 3 sites was assumed to be 40.7% of the total population. Population distribution and shoreline areas censused in each year were also mapped<sup>17</sup>.

One question about population fluctuations that arises is: why are numbers so variable among years? One hypothesis speculates that years of high population numbers may occur in years when water levels are low, and thus exposed beaches are wider, at the time plovers are arriving. To examine this idea, the population counts for years of complete censuses and the estimated population for years of incomplete censuses were compared to the water level in the reservoir on May 12 of that year (Figure 1).

### Thomson and McKenzie Arms



### Riverhurst Ferry to the Dams

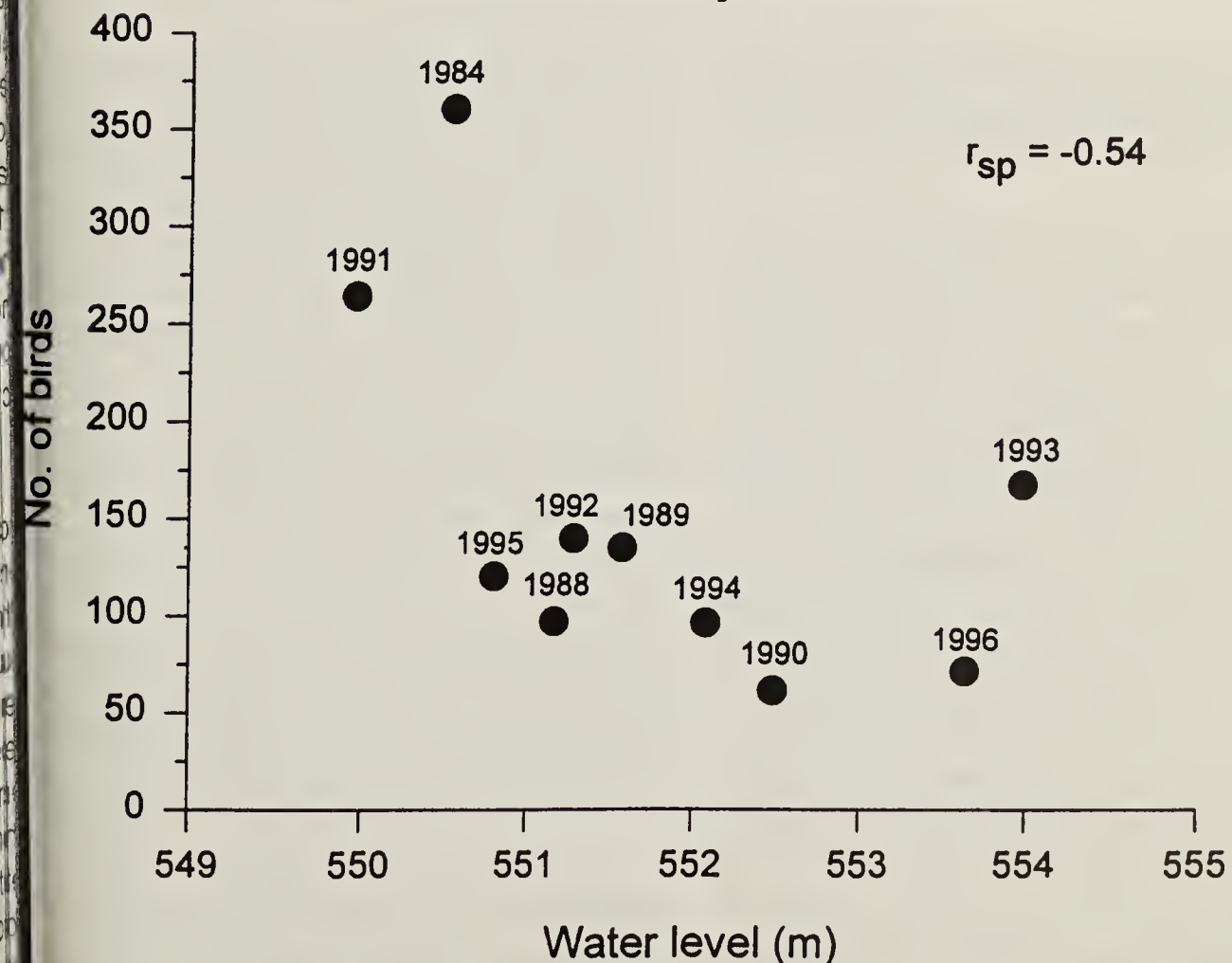
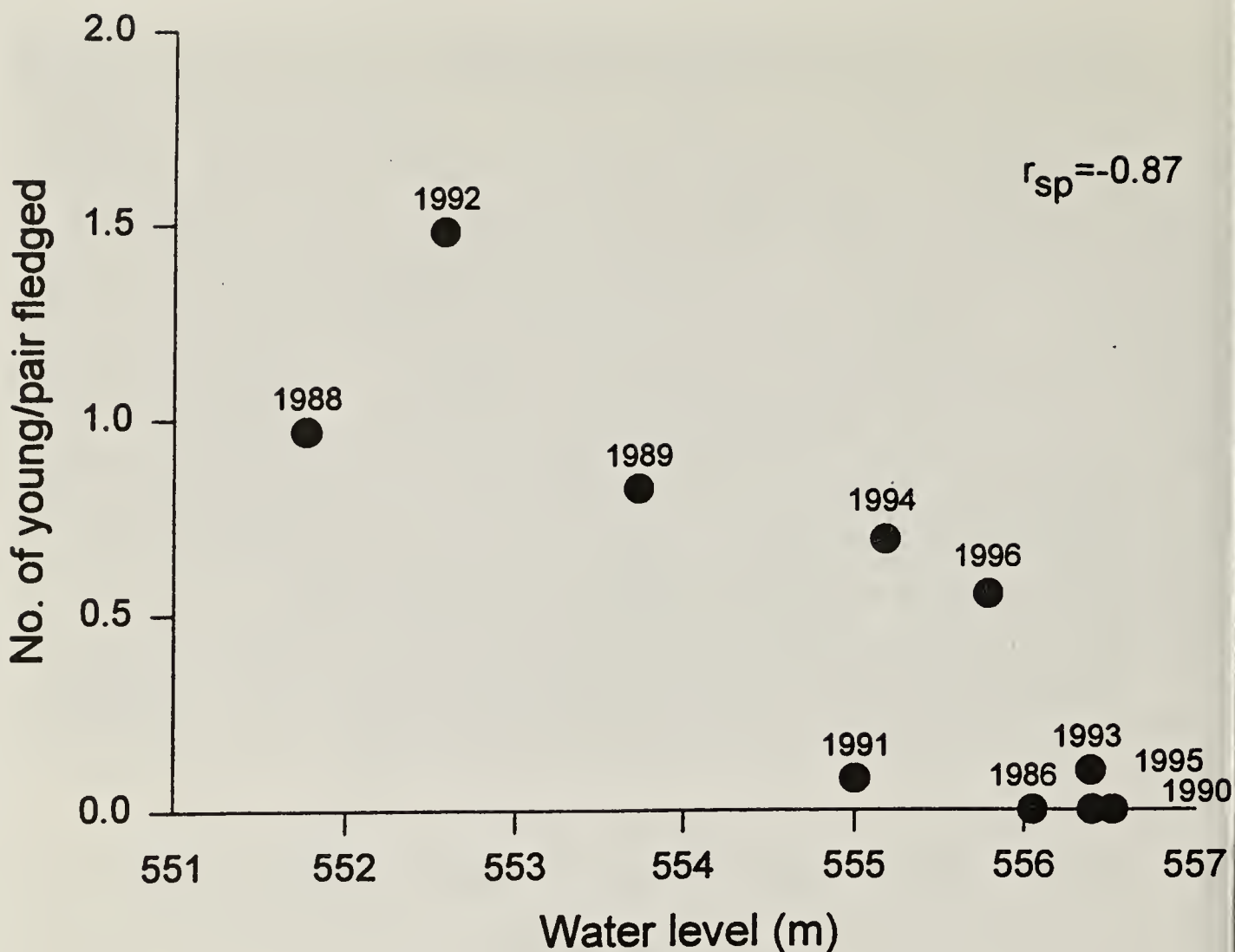


Figure 1. Number of Piping Plovers at Lake Diefenbaker versus May 12 water level



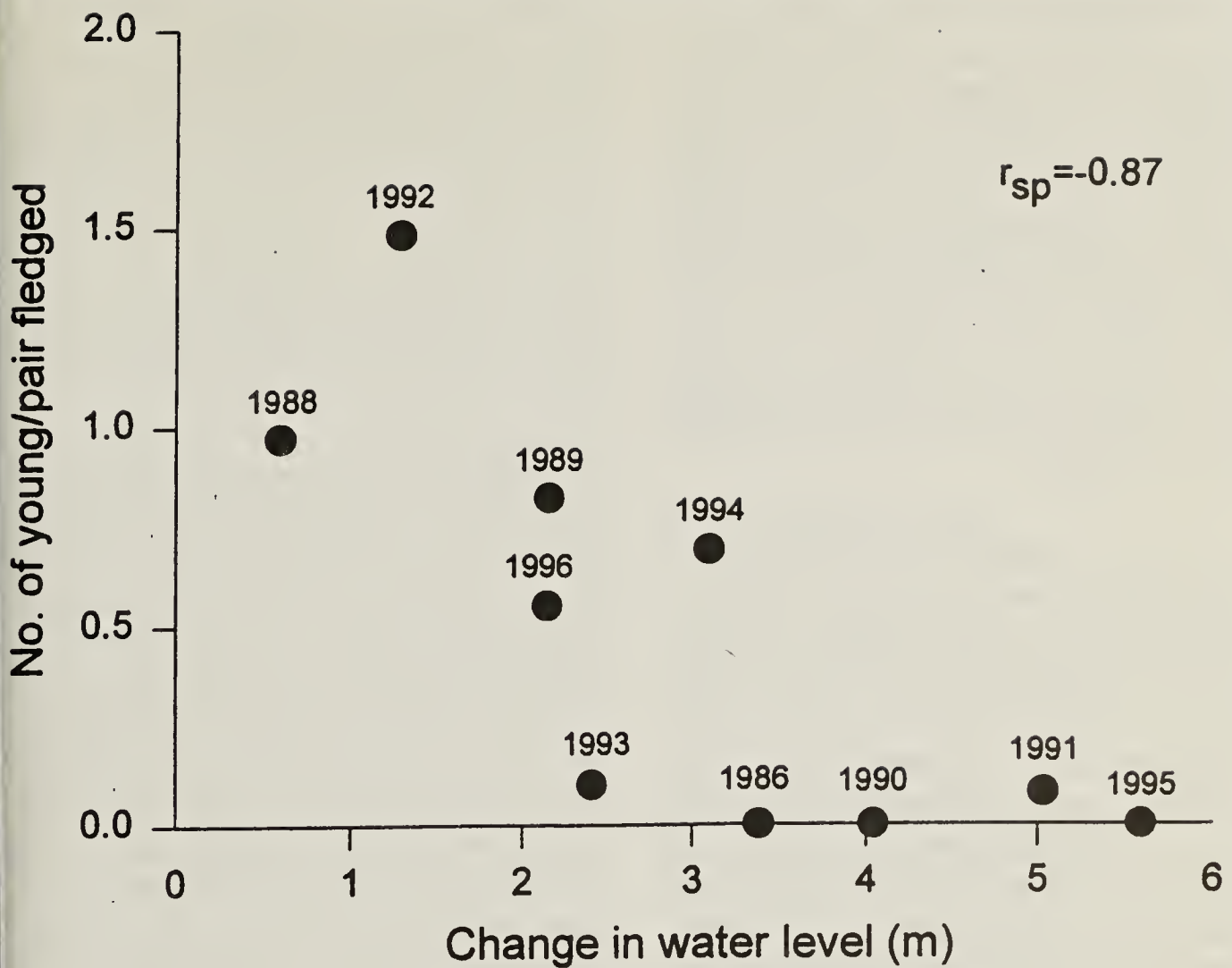
**Figure 2.** Fledging rate of Piping Plovers at Lake Diefenbaker versus July 1 water levels.

May 12 was used because it is the mean initiation date for Piping Plover nests at Lake Diefenbaker (Table 2).

A relationship between May 12 water level and the number of plovers inhabiting Lake Diefenbaker is apparent (Figure 1). At water levels below 550.8 m (above sea level), the number of plovers increases to high levels. In 1993, the estimated population appears slightly anomalous being somewhat higher than expected with a May 12 water level of 554.0 m. The population estimate for 1993 will be less reliable than that of other years for 2 reasons. First, this was the year when the least amount of shoreline was actually censused and thus the greatest extrapolation was required. Second, the estimate is based on more thorough and numerous counts than the typical count and therefore may be higher.

An alternative hypothesis to the question of why numbers are so variable among years is that years of high population numbers may follow years of high fledging success because birds may return to areas where they successfully bred at higher rates than unsuccessful breeders, and young may also home. This hypothesis predicts that years of high productivity would be followed by years of higher populations. A cursory comparison between the number of plovers in one year, and the fledging success the previous year strongly suggests that no relationship exists between these two parameters. Hence the productivity hypothesis is rejected.

The apparent relationship between population level and May water level in the reservoir suggests some possible water management options. Because rapidly rising water level in June and th



**Figure 3.** Fledging rate of Piping Plovers at Lake Diefenbaker versus change in water level from May 12 to July 1.

first half of July has been identified as the major threat to Piping Plover productivity at Lake Diefenbaker, it may be desirable to keep the population of plovers at Lake Diefenbaker low in years when rapid increases in water levels are expected over the summer<sup>2,7,8,9,11,13,14,20</sup>. Alternatively, it may be desirable to keep plover populations low in all years, although perhaps with the exception of extended periods of drought when Lake Diefenbaker's importance to plovers may increase as habitat at smaller basins diminishes<sup>16</sup>. The data from 1984 to 1996 strongly suggests that population levels of Piping Plovers can be minimized by keeping water levels >550.8 m on May 12 (Figure 1).

**Productivity Studies** The hatching and nest success of Piping Plovers was determined from a sample of the population for 5 years from 1991 to 1996 (Ta-

ble 1). A measure of fledging success is determined from samples for 10 years from 1986 to 1996 (Table 1).

Hatching success (the number of chicks hatching per pair) varied from 0.6-2.4 young/pair. In all years the nests examined were distributed around the lake, with the exception of 1993 when most nests were located near the Qu'Appelle Dam<sup>2</sup>. Hatching success may be slightly inflated for 1993 as 1992 data (subset, Table 1) indicates slightly higher hatching success near the Qu'Appelle Dam than overall at the lake.

Nest success (per cent of nests hatching >1 chicks) varied from 7-60% and was often low. Calculated nest success, or Green's estimator of calculated nest success, are used (rather than observed apparent nest success) as these more accurately reflect actual nest success

by determining a success rate from the time a nest is located until it hatched or failed<sup>12,4</sup>. The proportion of nests lost to flooding was high (40-60% of all nests) in 4 of the 5 years: 9 of 22 nests in 1991, 1 of 30 nests in 1992, 23 of 39 nests in 1993, 13 of 32 nests in 1995, and 8 of 20 nests in 1996<sup>14,20,2,13,11</sup>.

Fledging success (the number of chicks fledging per pair) was calculated in 1 of 2 ways:

(1) In some years a brood census was conducted in early July. An estimated fledging success was determined for each of these years in the following manner: the number of young on the brood census was compared to the number of pairs that were counted over the same census area on the late May to early June pair census. Data and maps from reports were used to determine number of pairs and census areas. Territorial individuals are included as pairs; in 1991 Harris and Lamont found all territorial birds ( $n=13$ ) to be associated with nests<sup>9</sup>. Fledging success calculated from a July brood census represents an index of fledging success, rather than actual fledging success. This index may vary from actual fledging success because it assumes all young counted on a brood census survive to fledging (averaging 1 week later), and that a one-time brood census is as accurate as regularly monitoring a brood.

(2) In the other years, fledging rate was determined by the more accurate method of monitoring a specific sample of nests through until fledging. This occurred from 1991-1996 excluding 1994. In some instances the index to fledging success may reflect a truer fledging success as it includes a larger and more broadly distributed sample. In 1991, no young fledged from the sample of 22 nests, whereas an estimated fledging success index of 0.1 young/pair was

determined from an early July brood census of the Arms (91 pairs), which yielded 7 young<sup>14,9</sup>. In 1992, the fledging rate was determined from a sample of nests in which most were located at one study site<sup>1</sup>. The estimated fledging success index for this year determined from an early July brood census, may again be more representative of the lake as a whole<sup>20</sup>.

Fledging success, like the population count of plovers at Lake Diefenbaker, is highly variable among years. When fledging success is compared to July 1 water level in the reservoir, a strong relationship is apparent (Figure 2). By July 1 most nests have hatched (mean hatch date is June 14; Table 2), and sufficient chick-rearing habitat is critical to fledging success (mean fledge date is July 9; Table 2). When July 1 water level is above 556.0 m, fledging success is consistently near zero. In 2 of the 3 years when the July 1 water level was 555.0-556.0 m, fledging success was noticeably higher than the other year (1991) when fledging success was near zero. In the 2 years of higher fledging success (1994 and 1996), birds may have been nesting higher up on beaches than in 1991 because the May 12 water level in 1991 was very low compared to 1994 and 1996. This may have provided considerably more opportunity for birds to nest lower on the beaches in 1991, and thus resulted in a higher risk of loss to flooding as water level rose.

When fledging success is compared to the increase in water level between May 12 and July 1 another strong relationship emerges (Figure 3). Higher fledging rates occurred at lower changes in water level. When water level increases were  $>3.1$  m, complete or nearly complete reproductive failure occurred. It is apparent that both May 12 water level and increase in water level between May 12 and July 1 are important

to fledging success. The 2 years with the highest fledging success (1988 and 1992) had the lowest May 12 water level (#550.8 m) and the lowest change in water level between May 12 and July 1 (#1.3 m).

The strong relationship between fledging success and both July 1 water level and increase in water level between May 12 and July 1 provides another opportunity for water management. In the 5 years when the July 1 water level was <556.0 m and the water level rise between May 12 and July 1 was <3.1 m (1988, 1989, 1992, 1994, and 1996), complete or nearly complete reproductive failure was avoided and fledging success averaged 0.90 young/pair ( $n = 5$  years; range = 0.6-1.5 young/pair). In the 5 years when water regimes did not follow this pattern, fledging success was near zero. The data suggests that water regimes conforming to the former parameters would greatly improve productivity of plovers at Lake Diefenbaker.

The suggested reproductive success for an annual population increase of 1% for this endangered species is 1.16 young per pair<sup>15</sup>. Although the fledging success was above the 1.16 young/pair rate in only 1 year (1992), the average fledging success of 0.90 young/pair for the 5 years approaches this value. A water management regime that averages 1.16 young per pair over all years would enhance recovery of this species overall.

Fledging success might also be increased if other management action were taken near the Qu'Appelle Dam where high concentrations of nesting plovers consistently occur. In 1991-1996, from 10-35% of the reservoir's population were counted along the shore west of the Dam in the vicinity of Summit Creek. In 1992, when overall

fledging success was estimated at 1.5 young/pair, the success at a study site north of Summit Creek was very high at 2.5 young/pair (48 chicks from 19 nests)<sup>20,1</sup>. With its high concentration of plovers and high fledging rate in years when nests are not flooded, maintenance and possibly enhancement of this beach area, and/or management of the plovers which nest there, may be considered.

## Acknowledgements

We are grateful to the many people involved in the studies of Piping Plovers at Lake Diefenbaker over the past years. The completeness of this summary is due to their dedication and effort in collecting data. We thank Don McKinnon for calculating the Green's estimator for nest success, Steve Davis for help with the graphs, and Dave Richards for providing Lake Diefenbaker water levels.

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**Table 1.** Population size and productivity of piping plovers at Lake Diefenbaker, Saskatchewan, from ferry to the Gardiner and Qu'Appelle Dams. Productivity is determined from a sample of the population

Year	No. <sup>a</sup> of birds	No. of pairs	No. of nests in sample <sup>3</sup>	No. of young hatched	Hatching success (yg/pr)	Nest success (%) <sup>b</sup>	No. <sup>c</sup> of young fledged	Fledging success (yg/pr) <sup>c</sup>	Pair success (%) <sup>d</sup>
1984 <sup>1c</sup>	360 E [217]	[98]	--	--	--	--	--	--	--
1986 <sup>d</sup>	low	low	--	--	--	--	0	0	0
1988	97 <sup>e</sup>	46 <sup>e</sup>	35 <sup>e</sup>	--	--	--	34 <sup>7</sup> E	1.0 E	--
1989 <sup>7</sup>	135 E [94]	[35]	35	--	--	--	27 E	0.8 E	37.1 E
1990 <sup>8</sup>	61 E [33]	[11]	7	--	--	--	0	0	0
1991	264 <sup>19</sup>	116 <sup>9</sup>	22 <sup>14</sup>	13 <sup>14</sup>	0.6 <sup>4</sup>	20.5 <sup>14</sup> G	0 <sup>14</sup>	0 <sup>14</sup>	0 <sup>14</sup>
1991 Arms only			91 <sup>9</sup>	--	--	--	7 <sup>9</sup> E	0.1 <sup>9</sup> E	6.6 <sup>9</sup> E
1992 <sup>20</sup>	140	78	40 62 E	96 --	2.4 --	47.7 G --	-- 92 E	-- 1.5 E	-- 61.3 E
subset of above <sup>1</sup>			30	83	2.8	60.1 G	55	2.0	71.4
1993 <sup>2</sup>	167 E [78]	[39]	39	33	0.8	8.6 G	4	0.1	5.1
1994 <sup>e</sup>	96 E [83]	[39]	39 E	--	--	--	27 E	0.7 E	38.5 E
1995 <sup>13</sup>	120 E [102]	[45]	29	21	0.7	6.8 C	0	0	0
1996	71 <sup>18</sup>	28 <sup>16</sup>	20 <sup>1</sup>	35 <sup>11</sup>	1.8 <sup>11</sup>	33.0 <sup>11</sup> C	11 <sup>11</sup>	0.6 <sup>11</sup>	25.0 <sup>11</sup>

<sup>a</sup>E denotes an estimate (see text for explanation); actual number counted is in [ ].

<sup>b</sup>Nest success is the percent of nests hatching  $\geq$  yg. Calculated (C) percent determines success from time a nest is located<sup>12</sup>. Green's estimator (G) converts observed success to an estimate of Mayfield's calculated success<sup>4</sup>.

<sup>c</sup>E denotes an estimate: assumes all yg counted on a July brood census fledged. Pair success is the observed percent of prs fledging  $\geq$  1 yg.

<sup>d</sup>W.C. Harris, Unpubl. data. Counted 0 birds on a 28 June census; little beach area due to high water.

<sup>e</sup>D. Hjestaas, Unpubl. data. A 30 May-1 June census of most of the habitat (3 sections not censused). A 6-7 July brood census (34 adults). *Fledging success*: assumes the 27 yg were from 39 nests. *Pair success*: assumes the 15 prs with  $\geq$  yg on the brood census all fledged  $\geq$  1 yg.

<sup>1</sup>Data from 3 study sites, each approx. 1.5 km: near Qu'Appelle and Gardiner Dams, and w of Sage Bay. *Nest success*: 23 of 30 nests hatched  $\geq$  1 yg; 1 nest was lost to flooding, 6 to unknown predators or human disturbance. *Fledging success*: 28 nests with known fate fledged 55 yg. Assumes yg not fledged by 23 July survive. *Pair success*: 20 of 28 nests fledged  $\geq$  1 yg.

<sup>2</sup>Data from the 1992 study sites<sup>1</sup> and 2 additional sites, each approx. 1.5 km: e of Sage Bay and 10 km nw of town of Elbow. *Nest success*: 9 of 39 nests hatched  $\geq$  yg; 23 nests were lost to flooding, 7 to unknown predators. *Pair success*: 2 of 39 prs fledged  $\geq$  yg.

<sup>3</sup>A 27-31 May census. The 30 prs and 5 territorial singles counted in the Thomsom and McKenzie Arms are assumed to be 35 prs with nests.

<sup>7</sup>In 1988, 34yg on an early July brood census of the ASrms. Fledging success assumes the 34 yg were from 35 nests. In 1989, a 6-8 June census of most of the Arms; Riverhurst Ferry to the Arms not censused. *Fledging success*: 8 and 11 July brood census (56 adults, 13 family groups). Assumes the 27 yg were from 35 nests.

<sup>8</sup>A 14 June census of the Arms; Riverhurst Ferry to the Arms not censused. No birds on a 4 July brood census.

<sup>9</sup>Counted 91 nests (223 adults) in the Arms on a 1, 2 and 8 June census. *Fledging success*: 6-7 July brood census of the Arms (20 adults, 6 family groups). Assumes the 7yg were from 91 nests.

<sup>10</sup>A 9-10 July census of shoreline totalling 243 km; several sections of habitat not censused.

<sup>11</sup>One nest not found but pr was subsequently located with 2 yg (4 eggs, all hatching, are assumed). *Pair success*: 5 of 20 prs fledged  $\geq 1$  yg.

<sup>13</sup>Counted 96 adults (45 prs) on an early June census of selected beaches; 6 more without nest counted by T. Tyndall in 2 additional areas. *Pair success*: 1 yg survived  $>1$  wk, likely did not fledge due to high water and greatly reduced habitat.

<sup>14</sup>Monitored 22 nests at 3 sites: 8 near Qu'Appelle Dam, 7 near Gardiner Dam, and 7 near Sage Bay. *Nest success*: may be an overestimate as (unlocated) nest may have flooded before monitoring began on 9 June. Of 22 nests, 13 hatched  $\geq$  yg; 9 were lost to flooding.

<sup>20</sup>A 2-15 June census. *Number of pairs*: 54 pairs and 24 territorial singles. *Nest success*: 27 of 40 nests hatched  $\geq 1$  yg. *Fledging success*: 8-13 July brood census (104 adults; 50 prs); estimate that 62 nested in the area censused. Assumes the 92 yg were from 62 prs and that all yg not fledged by 23 July survive.

**Table 2.** Nest Chronology for Piping Plovers at Lake Diefenbaker, Saskatchewan

Year	Number of nests	Mean nest initiation date (range) <sup>a</sup>	Mean hatch date (range)	Mean fledge date (range) <sup>b</sup>
1991 <sup>14</sup>	13	May 14 (May 11-28)	June 17 (Jun 14-Jul 1)	July 14 (July 11-28)
1992 <sup>1</sup>	22	May 11 (May 5-June 1)	June 14 (Jun 8-Jul 5)	July 11 (July 5-32)
1993 <sup>2</sup>	9	May 7 (May 3-13)	June 10 (June 6-16)	July 7 (July 3-13)
1995 <sup>13</sup>	6	May 8 (May 6-13)	June 11 (June 9-16)	July 8 (July 6-13)
1996 <sup>11</sup>	5	May 19 (May 14-28)	June 22 (Jun 17-Jul 1)	July 19 (July 14-28)
Average		May 11	June 14	July 11

<sup>a</sup>Initiation date is calculated using six days average laying time plus 28 days for incubation period.<sup>5</sup>

<sup>b</sup>Fledge date is calculated as 27 days after hatch date.<sup>5</sup>

<sup>1</sup>Excludes 1 probable reneest (hatched 12 July).

<sup>11</sup>Excludes 2 probable reneests (hatched 16 and 28 July).