USE OF PREDATOR EXCLOSURES TO PROTECT PIPING PLOVER NESTS IN ALBERTA AND SASKATCHEWAN

1998 Field Season Report

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In cooperation with:

North American Waterfowl Management Plan
Alberta Environmental Protection, Fisheries and Wildlife Management Division
Canadian Wildlife Service

ABSTRACT

Nest predation has been identified as a significant factor limiting the Great Plains Piping Plover population. In 1998, predator exclosures were applied to 40 Piping Plover nests on eight waterbodies in east-central Alberta and west-central Saskatchewan. Seventy percent of nests hatched chicks successfully. Nest survival rate in 1998 was significantly higher than that of 'natural' nests from 1994 to 1997 (P=0.0002). However, comparison of nest survival rates in individual years showed that the nest survival rate in 1998 was significantly lower than in 1995 when larger exclosures were used (P=0.0029). Adult predation and cattle damage to exclosures accounted for 42% of nest failures. Seventy-three chicks were banded with combinations identifying year and basin of origin. Sixteen band re-sightings on the breeding and wintering grounds were recorded in 1998.

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INTRODUCTION

The Piping Plover is considered an endangered or threatened species throughout its continental range (COSEWIC 1998, U. S. Fish and Wildlife Service 1998) and is listed as an 'endangered animal' under the Alberta Wildlife Act. Nest predation has been identified as a significant limiting factor to Piping Plover reproductive success in the Great Plains (Whyte 1985, Haig 1992, Heckbert 1994, Richardson, *in prep.*). Results from studies carried out in east-central Alberta from 1995 to 1997 showed that through the use of predator exclosures, Piping Plover nest predation can be significantly reduced thus increasing productivity (Heckbert and Cantelon 1996, Richardson, *in prep.*). Consequently, in the spring of 1998, a management project implementing the use of predator exclosures on a large-scale basis in Alberta and Saskatchewan was initiated.

STUDY AREA AND METHODS

One hundred predator exclosures were constructed prior to the breeding season. The design of the exclosures was square pyramidal in shape, made of four stucco wire panels with bottom width of 1.2 m and top width of 60 cm. The four panels were attached together with hog clips at the nest sites. One re-bar, approximately 1.5 m in height, was attached to each corner and inserted in the substrate for stabilization. The bottom of each exclosure was secured in place by inserting two-10 cm nails, bent at the top, into the ground on each of the four sides. Finally, to protect against aerial predators, the top was woven with bailing twine at 10 to 15 cm intervals.

Beginning in late April, potential breeding lakes in Alberta and western Saskatchewan were surveyed for returning Piping Plovers. In order to maximize the efforts of the researchers, only lakes with a relatively large Piping Plover population and easy access were chosen to be included in the management initiative. Eight lakes were included (Figure 1): the westernmost of the Reflex Lakes (hereafter called Reflex Lake), Freshwater Lake, Cipher Lake, 'Metiskow Lake' and Sunken Lake in the Provost, Alberta area, Handhills Lake near Hanna, Alberta, Birch Lake near Viking, Alberta, and Manitou Lake near Marsden, Saskatchewan.

Figure 1. Map of study area, 1998

Pair and brood surveys were carried on eight lakes: Chain Lake #4, Chappice, Handhills, Killarney, Little Fish, Reflex, 'Rider' and Rockeling. Most of these lakes have been surveyed annually since 1989 and some since 1986. Pair surveys were carried out from 25 May to 7 June and brood surveys were carried out from 3 to 11 July. Lakes were surveyed on foot by walking approximately 60 to 70% of the way between the water and the vegetation line and stopping periodically to scan for plovers (Goossen 1990). Location of adults and juveniles were recorded and mapped.

Census, exclosure application and monitoring techniques followed the procedures outlined by Richardson (1997). Exclosures were applied to every nest within one day of discovery, regardless of stage of incubation. One or two researchers carried the exclosure to the nest and secured it to the substrate with the four re-bars and the bent nails. After application, each nest was monitored from 70 to 100 m away until the adults resumed incubation. Nests were monitored weekly throughout the incubation period. Changes in nest status were noted including predation of eggs, predation of adult(s), damage to exclosures, unexplained abandonments and hatching.

Crude nest success was calculated by dividing the number of successful nests (those hatching at least one chick) by the total number of nests. The Mayfield method (Mayfield 1961, 1975) of calculating nest survival rates was used to arrive at a more accurate estimate of nest success. Conventional methods of comparing observed nest success usually overestimate success because all nests are not found at initiation and, indeed, some nests are not found at all (Mayfield 1961, 1975). To remedy this error, the Mayfield method not only takes into account the number of nests, eggs and young, but also the elapsed time of observations for each nest (Mayfield 1975). Daily survival rates of control nests calculated during studies from 1994 to 1997 were used as estimates of 'natural' nest survival rates for the area. Survival rates generated from the Mayfield analysis were compared using the program CONTRAST (Hines and Sauer 1989, Sauer and Williams 1989) at the 0.05 significance level.

RESULTS

A total of 40 nests on eight waterbodies were treated with predator exclosures (Table 1). Twenty-eight of those nests occurred in Alberta. Seventy percent (28/40) of nests found hatched at least one egg. The nest success was even higher in Alberta, where 81% (22/27) of nests hatched successfully. In comparison, from 1994 to 1997, only 37% (44/119; 36% for nests occurring in Alberta) of untreated Piping Plover nests hatched successfully (Heckbert 1994, Heckbert and Cantelon 1996, Richardson, *in prep.*).

Table 1. Nest summaries for study lakes in Alberta and Saskatchewan

Lake Name	Province	Number of Nests	Crude Hatching Success
Birch	AB	3	0.66
Cipher	AB	1	0.00
Freshwater	SK	4	1.00
Handhills	AB	12	0.92
Manitou	SK	8	0.25
Metiskow	AB	1	1.00
Reflex	AB/SK	9	0.66
Sunken	AB	2	1.00
	Total:	**40**	**0.70**

Daily survival rate of treated nests in 1998 (0.984) was significantly higher than that of 'natural' nests from 1994 to 1997 (0.960; P=0.0002). The daily survival rate in 1998 was similar to, and not significantly different from, nests treated with predator exclosures from 1995 to 1997 (P=0.2648). However, comparison of individual years showed the daily survival rate in 1998 was similar to those in 1996 and 1997 but significantly lower than that of 1995 (P=0.0029).

Table 2. Summary of nest and daily survival rates, 1994 to 1998

	'Natural'		'Treated'	
Year	Daily Survival Rate	Nest Survival Rate	Daily Survival Rate	Nest Survival Rate
1994-1997*	0.9601	0.2502	0.9901	0.7138
1994	0.9598	0.2476	n/a	n/a
1995	0.9650	0.2977	0.9980	0.9343
1996	0.9545	0.2056	0.9925	0.7767
1997	0.9577	0.2304	0.9745	0.4158
1998	n/a	n/a	0.9841	0.5813

*no treatments were applied in 1994

Thirty percent (12/40) of nests found failed in 1998. Of the nests that failed to hatch, 58 % (7/12) were linked to factors beyond the control of the researchers: one was lost when a coyote dug under the exclosure, four were abandonments attributed to severe weather, one was an abandonment likely due to the extremely dry conditions of the basin and one was an unexplained abandonment. Fourty-two percent of failures were attributed to damage to exclosures caused by cattle (2/12) and adult predation (3/12), factors that may have been influenced by the exclosure design. One case of adult predation occurred on Manitou Lake and three cases occurred within a small area on Reflex Lake. The predation of an adult male on Reflex Lake did not result in abandonment as the incident likely occurred while the chicks were hatching. The female remained with the brood, however no chicks were fledged. In all four cases, partial carcasses and feathers were found near or in the exclosures. In two cases on Reflex Lake, the carcasses found had evidence of bite marks identified as those of a Merlin (*Falco columbarius*; G. Court, pers. comm).

Losses of adults on Reflex Lake were not significant enough to cancel out the increase in juvenile recruitment resulting from the use of predator exclosures (Table 3). The projected 1999 breeding population resulting from breeding activity on Reflex Lake in 1998 is still 8% higher than would have resulted without the use of the exclosures. However, had the losses not occurred, the projected breeding population would have been increased by an additional 11%.

Table 3. Estimated population impact of three adult losses at predator exclosures on Reflex Lake

	Adult Survival[1]	**Juvenile Recruitment[2]**	**Projected Breeding Population in 1999[3]**
Without exclosures	20	5	25
With exclosures and 3 adult losses	18	9	27
With exclosures, without adult losses	20	10	30

[1] Based on estimated adult survival rate of 0.66 (Root et al. 1992) and starting breeding population of 30 adults.
[2] Number of birds, from original 30 adults plus juveniles, estimated to return to breed in 1999.
[3] Based on recruitment estimates of 0.5 and 1.09 chicks per pair for untreated and treated nests, respectively (Richardson, *in prep.*), and estimated juvenile survival of 0.60 (Ryan et al. 1993).

Seventy-three chicks were banded in 1998. Bands were placed in combinations identifying year and lake of origin (Table 4). In addition to observations of newly banded chicks, eight re-

sightings of birds banded in Alberta and Saskatchewan from 1996 to 1997 were recorded, plus three observations of birds banded during the previous winter (Table 5). Furthermore, observations of two birds banded in Alberta and Saskatchewan from 1996 to 1997 and of two birds banded during the 1998 breeding season were made on the wintering grounds during 1998. Fourteen re-sightings can be traced back to their original banding sites.

Table 4. Summary of banding on study lakes in 1998

Lake	Band Combination	No. of birds banded
Birch	-,G m:B/W,-	6
Freshwater	-,-:B/W,W m	10
Handhills	-,Y m:B/W,-	17
Manitou	-,W m:B/W,-	15
Reflex	-,O m:B/W,-	22
Sunken	-,B/W m:B/W,-	3
		Total: 73

Table 5. Summary of sightings of banded Piping Plovers in 1998

No.	Date of re-sighting	Band Combination[3]	Location of re-sighting	Date banded	Original banding location
1[1]	Winter 1997/98	-,-:W m,-	South Padre Isl., TX	Summer 1997	Manitou Lake, SK
2[2]	Winter 1997/1998	-,-:-,Y m	Mexico	Summer 1996 or 1997	Killarney Lake, AB 1996 or Reflex Lake, AB 1997
3[2]	26 May 1998	-,-:-,Y m	Manitou Lake, SK	Summer 1996 or 1997	Killarney Lake, AB 1996 or Reflex Lake, AB 1997
4	26 May 1998	m,-:W,-	Manitou Lake, SK	Summer 1997	Manitou Lake, SK
5	27 May 1998	-,-:W m,-	Manitou Lake, SK	Summer 1997	Birch Lake, AB
6	1 June 1998	B/W m,-:-,-	Handhills Lake, AB	Summer 1996	Reflex Lake, AB
7	3 June 1998	-,R/W:R,Y	Reflex Lake, AB	Winter 1997/98	South Padre Island, TX
8	5 June 1998	-,-:W m,-	Manitou Lake, SK	Summer 1997	Manitou Lake, SK
9	13 July 1998	B,B:-,R/W:	Manitou Lake, SK	Winter 1997/98	South Padre Island, TX
10	15 July 1998	B/W m,-:-,-	Birch Lake, AB	Summer 1996	Reflex Lake, AB
11[1]	7 July 1998	Y,Y:W m,R/W	Reflex Lake, AB	Winter 1997/98	South Padre Island, TX
12	7 July 1998	W m,-:-,-	Reflex Lake, AB	Summer 1997	Manitou Lake, SK
13	26 July 1998	-,-:Y,m	Bolivar Flats, TX	Summer 1997	Killarney Lake, AB
14	10 Oct. 1998	B/W,?:?,?	South Padre Isl., TX	Summer 1996	Reflex Lake, AB
15	11 Oct. 1998	-,W m:B/W,-	South Padre Isl., TX	Summer 1998	Manitou Lake, SK
16	2 Oct. 1998	-,W m:B/W,-	Nueces County, TX	Summer 1998	Manitou Lake, SK

[1] Banded bird from observation 1 and 11 was confirmed to be the same individual.
[2] Banded bird from observation 2 and 3 may be same individual.
[3] Leg band combinations read as follows: upper left, lower left: upper right, lower right. Dashes (-) mean no bands were located on that part of the leg. The lowercase letter 'm' refers to a metal band, uppercase letters refer to the colours of plastic bands, and letters separated by a slash (/) are striped bands. Consecutive letters mean bands were stacked where the first letter refers to the colour of the band highest on the leg.

Adult and brood surveys were carried out on eight waterbodies (Table 6). Numbers of Piping Plovers were the lowest in five years on all the lakes surveyed except for Reflex Lake (Table 7). The population on Reflex Lake counted during the adult survey in 1998 was the third highest recorded number in the last 10 years. The number of adults recorded during the brood survey, although the highest number recorded on the lake since 1986, likely includes a high number of migrating adults and therefore is not a good measure of the breeding population on the lake.

Table 6. Summary of 1998 Adult and Brood Surveys

Lake	Adult Survey	Brood Survey		Observer
	# Adults	#Adults	#Young	
Chain Lake #4	1	Not done	Not done	E. Hofman
Chappice	0	0	0	M. Wendlandt
Handhills	31	44	18	M. Wendlandt, I. Richardson
Killarney	2	0	0	M. Wendlandt
Little Fish	0	0	0	E. Hofman
Reflex (entire)	27	69	21	M. Wendlandt
'Rider'	0	0	0	R. Bjorge
Rockeling Bay	0	0	0	R. Bjorge

Table 7. Number of adult Piping Plovers observed on selected lakes in Alberta between 1986 and 1997[a]. Where repeat surveys were conducted in the same year, maximum numbers are given. (after Prescott 1997)

	YEAR											
LAKE	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Chain #4	13	14	13	11	12	5	22	17	23	20	13	
Chappice	17+	11[b]		15	11	2	5	4	1		1	
Handhills	37	44	71	36	27	20	20	37	52	37	69	
Killarney				8-10		22		29	48	40	25	14
Little Fish		10-17	18	41-49	48	19	18	11	3	2	0	
'Rider'	15			11	17	7	16	7	12	6	0	0
Rockeling Bay	18			30	22	6	9	12	17	13	0	0
Reflex	46+	35+		20	21	12	11	16	28	37	19	33

[a] sources: Bjorge (1996), Goossen (1991, 1994, *in prep.* and unpubl. data), Goossen and Biel (*in prep.*), Heckbert (1994), Heckbert and Cantelon (1996), Hofman (1990, 1991, 1992, 1993, 1994 and unpubl. data), Lord (1989), Wershler (1988, 1992), Wershler and Wallis (1987).

[b] partial survey

DISCUSSION

The reduction in numbers of adults counted during adult and brood surveys in 1998, especially in the eastern portion of the province, may be the result of extremely dry conditions. For instance, Killarney Lake, which has supported good numbers of breeding adults for the past decade, was completely dry in 1998. Two adults were observed on the lake during the adult survey, however, the birds were not identified as a pair and neither bird remained to breed on the lake. Dry conditions were also the case at Chappice Lake and Chain Lake #4. No Piping Plovers have been recorded at Little Fish Lake, 'Rider Lake' or Rockeling Bay since 1995.

Banding information acquired in 1998 was invaluable to the collection of data on prairie Piping Plovers. For example, one bird's history over its first year is well documented. This bird was

banded as a chick on Manitou Lake during the summer of 1997 with one colour band and one metal band. It was captured in a mist net on South Padre Island, Texas in the early spring of 1998 where three additional colour bands were added by biologists carrying out a wintering ecology study (K. Drake, pers. comm.). It was last seen there on 6 May. On 7 July 1998, this bird was seen on Reflex Lake. It is not known how long the bird had been on Reflex Lake as the observer was not certain whether this bird was associated with a nest attempt on the lake. Sightings of Alberta and Saskatchewan birds on the wintering grounds have also helped to alleviate the extreme scarcity of wintering information. As the banding of chicks continues, it is anticipated that more information of this nature will be collected.

It is difficult to assess the success of an endeavor when treatments and controls are not assigned in the same year. In this case, however, four years of previous study on Piping Plover breeding biology and exclosure use in the same study area supplied estimates for comparison. It is undeniable that at the simplest level, the predator exclosures used protected the nests from predators and resulted in higher nest success rates than would have occurred had the nests been left alone. Nevertheless, the question remains as to whether changes in procedure or approach may further increase nest success and, consequently, recruitment.

Intuitively, we know that an improvement in productivity stems from minimizing the number of nest failures and chick losses. This project focuses on minimizing nest failures, as the exclosures do nothing to protect precocial young. Some nest failures, such as those resulting from severe weather or poor habitat conditions (e.g. dry basin) are unavoidable and will occur whether nests are treated with exclosures or not. However, the design of the exclosures, specifically their small size, may have contributed to failures caused by adult predation and cattle damage.

Predation of adults by raptorial birds was confirmed at 10 % (4/40) of nests in 1998. Cases of adult predation also occurred at a small exclosure in 1997 (Richardson, *in prep.*), and at a large exclosure in 1995 (Heckbert and Cantelon 1996). Furthermore, some raptor kills may have been misinterpreted as nest abandonments in the past. In North Dakota, losses of adults to predation at 6.8 % of exclosures between 1993 to 1997 were attributed to birds of prey 'keying in' on small (1.7 m diameter) exclosures (Murphy et al., *in prep.*). In 1998, both large (3 m diameter) and

small exclosures were used at the same study site. No adult losses were reported at the large exclosures while adults were predated at 5 % of small exclosures (B. Murphy, pers. comm.). Murphy et al. (*in prep.*) speculated that the exclosures made adults vulnerable by providing visual cues and by providing convenient perches for raptors. Larger exclosures, on the other hand, may provide adequate distance for adults to escape and may make it more difficult for predators to pinpoint vulnerable prey within the structures (Murphy et al., *in prep.*).

Cattle damage to exclosures consisted of heavy trampling around the perimeter and the sides being pushed in. The dimensions of the exclosures used resulted in a nest being a maximum of 85 cm from the outer perimeter. It is not hard to imagine that an incubating adult would easily flush off a nest, and remain a distance away, while cattle loaf directly outside an exclosure. Side panels pushed in by cattle also resulted in exclosures becoming more closed-in. This could disturb adults to the point of abandoning the nest. In addition to the two abandonments attributed to cattle damage in 1998, four such abandonments occurred at nests treated with the same design of exclosure from 1996 to 1997 (Richardson, *in prep.*). Heckbert and Cantelon (1996) used a larger design of exclosure (a triangular structure with 3.6 m sides) in 1995 and had three of their exclosures damaged by cattle. The damage was continuous and the exclosures had to be repaired frequently, however, only one of the three exclosures resulted in abandonment (Heckbert and Cantelon 1996). In North Dakota, cattle damage to large and small exclosures resulted in one abandonment at a small exclosure (B. Murphy, pers. comm.).

Although sample sizes are small, there is an indication that larger exclosures afford better protection against predators and cattle. Heckbert and Cantelon (1996) reported significantly higher nest success using large exclosures in 1995 than was found in 1998. Results from North Dakota also favour large exclosures. Smaller designs of exclosures are more convenient to transport and apply to nests. However, in areas where cattle or adult predation pose problems, larger designs of exclosures may result in higher success.

Despite set backs, Piping Plover hatching success was increased through the use of predator exclosures in 1998. However, losses of adults and nest abandonments caused by cattle have raised concerns as to the full impact the cages may have on local Piping Plover populations.

Adult losses, however, are not currently high enough to contradict increases in recruitment. As predator exclosures become more widely used in the Great Plains, further investigation into their effects would be prudent.

RECCOMENDATIONS

The benefits of using predator exclosures support their continued use on Piping Plover breeding lakes in the Canadian prairies. However, efforts should be made to continue research on this management technique in order to maximize increases in productivity.

1. Efforts should be made to minimize damage to exclosures in areas where nesting beaches are accessed by livestock. It is likely that the size and mere presence of exclosures on beaches entices cattle to use the structures as 'scratching posts'. Restricting cattle from nesting areas during the nesting period (i.e. May to July) would eliminate this as well as lessening degradation of soft nesting substrate by deep footprints. Alternatively, the use of the larger design of exclosures used by Heckbert and Cantelon (1996) may alleviate some of the impacts of cattle on exclosed nests.

2. The effects of large versus small exclosures on adult predation should be examined. Until new designs are discovered, it is recommended that, in areas where predation of adults has been identified as a problem (e.g. the west portion of Reflex Lake), larger exclosures be used.

3. Alternative exclosure designs should be studied as to their effects on cattle damage and adult predation. For instance, exclosures smaller than the present design, without tall rigid sides, may be less attractive to cattle. However, smaller exclosures would likely still be used by raptors as perching sites (G. Court, pers. comm.). According to G. Court (pers. comm.), an expert on raptor behaviour, the exclosure design should be modified so the top ends in a sharp spike, making impossible for birds of prey to land.

4. Banding Piping Plover chicks should continue as recoveries and sightings of banded birds are important to increasing the knowledge base for the species. The International Piping Plover

Census planned in the year 2001 will provide increased opportunity for observations of banded birds across the Piping Plover's winter and summer range.

5. Since predator exclosures are only a partial solution to increasing Piping Plover reproductive success, efforts to address other limiting factors should continue. For example, securing the nesting habitat on the Alberta portion of Reflex Lake means that cattle no longer have access to that area. Exploring ways to improve existing habitat, such as reducing vegetation encroachment or reducing human disturbance, should also be examined.

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APPENDIX 1. Original data from 1998 field season.

Table 8. Summary of data from 1998 field season

Nest No. (1)	Eggs Laid	Eggs Hatched	Mortality Factor	Exposure Days (2)
BILA-98-1	4	4		29
BILA-98-2	4	0	Unexplained abandonment	14
BILA-98-3	4	4		9
CILA-98-1	4	0	Dry basin	20
FRLA-98-1	4	4		30
FRLA-98-2	4	4		7
FRLA-98-3	4	4		16
FRLA-98-4	4	4		10
HALA-98-1	4	4		19
HALA-98-2	4	4		27
HALA-98-3	4	4		11
HALA-98-4	3	0	Coyote dug under exclosure	29
HALA-98-5	4	4		14
HALA-98-6	4	4		26
HALA-98-7	4	4		14
HALA-98-8	4	4		22
HALA-98-9	3	3		31
HALA-98-10	4	4		5
HALA-98-11	4	4		19
HALA-98-12	4	4		14
MALA-98-1	4	2		28
MALA-98-2	4	0	Cattle damage	25
MALA-98-3	4	0	Severe weather	25
MALA-98-4	4	0	Severe weather	20
MALA-98-5	4	0	Severe weather	20
MALA-98-6	4	0	Severe weather	20
MALA-98-7	4	4		34
MALA-98-8	4	0	Severe weather	25
MELA-98-1	4	4		26
RELA-98-1	4	4		24
RELA-98-2	4	4		7
RELA-98-3	4	0	Adult predated	5
RELA-98-4	4	0	Adult predated	12
RELA-98-5	4	4		25
RELA-98-6	4	0	Cattle damage	11
RELA-98-7	3	3		17
RELA-98-8	4	4		10
RELA-98-9	4	4		17
SULA-98-1	4	4		26
SULA-98-2	4	3		15

(1) Lake codes: BILA- Birch, CILA- Cipher, FRLA- Freshwater, HALA- Handhills, MALA- Manitou, MELA- Metiskow, RELA- Reflex, SULA- Sunken

(2) Refers to the number of days from the day the nest was found until it hatched or was confirmed unsuccessful (see Mayfield 1961, 1975).