
# Use of Predator Exclosures to Protect Piping Plover Nests in Alberta, 1998-2001

Alberta Conservation Association

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# Use of Predator Exclosures to Protect Piping Plover Nests in Alberta, 1998-2001

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## EXECUTIVE SUMMARY

Nest depredation has been identified as a significant limiting factor to the Great Plains piping plover (*Charadrius melodus*) population. Previous studies conducted in east-central Alberta have shown that the use of predator exclosures can significantly reduce piping plover nest depredation (e.g., Heckbert and Cantelon 1996, Richardson 1999, Larson 2002). As a result, a large-scale program applying predator exclosures to piping plover nests was initiated in Alberta in 1998.

Three styles of predator exclosures were used during the course of this program: i) small (60 cm diameter), ii)medium (1.2 m diameter), iii) and large (3.0 m diameter). Medium-sized exclosures were used in a small-scale study in Alberta in 1996 and 1997 with a high level of success and therefore this style of exclosure was used in 1998 and 1999 as part of this program. However, in 1999 we recorded 26 incidents of predation by raptors on adult piping plovers at medium-sized exclosures. In three previous years of using medium sized predator exclosures, a total of four adult predations were recorded (Richardson 1998, Richardson 1999). Similar problems were encountered with medium-sized exclosures used elsewhere in North America, where the application of large exclosures had reduced the problem of raptors preying upon adults at exclosures. As a result, large exclosures were used in 2000 in an attempt to reduce predation of adult piping plover. While there was a large decrease in adult piping plover predation using the large exclosures, further refinement was still needed. In 2001, small exclosures were used for the first time with encouraging results.

In our study, we used the Mayfield method to determine nest success. Mayfield nest success for exclosed nests during the four-year program was 34.4%, compared with 24.5% for unexclosed nests. The main cause of failure for unexclosed nests was nest predation (77.1%) and for exclosed nests it was adult predation (37.3%). Overall, the

small exclosures had the highest Mayfield nest success (72.4%), large exclosures were second highest (52.4%) and medium had the lowest Mayfield nest success (24.7%).

Continued experimentation with the small exclosure design is needed. Research is also needed into predator deterrence methods that will increase chick survival rates once they have left the exclosures.

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Conservation Association and Alberta Environment, with the goal of increasing the nest success of piping plovers by reducing the number of nests lost to predators.

## 2.0 STUDY AREA

In Alberta, the majority of piping plovers breed in the east-central part of the province (Prescott 1997). As a result, the program focussed on alkali waterbodies with open gravelly beaches in this area of the province (Figure 1). Two lakes (Freshwater and Manitou) in extreme west-central Saskatchewan were also included in the study because of their proximity to the Alberta lakes. Only lakes where relatively large piping plover populations were found and/or lakes that had easy access were included in the exclosure program. Since plovers move around from year to year based on fluctuating water levels and available habitat, the particular lakes that were included in the study area varied annually based on the locations of the plovers.

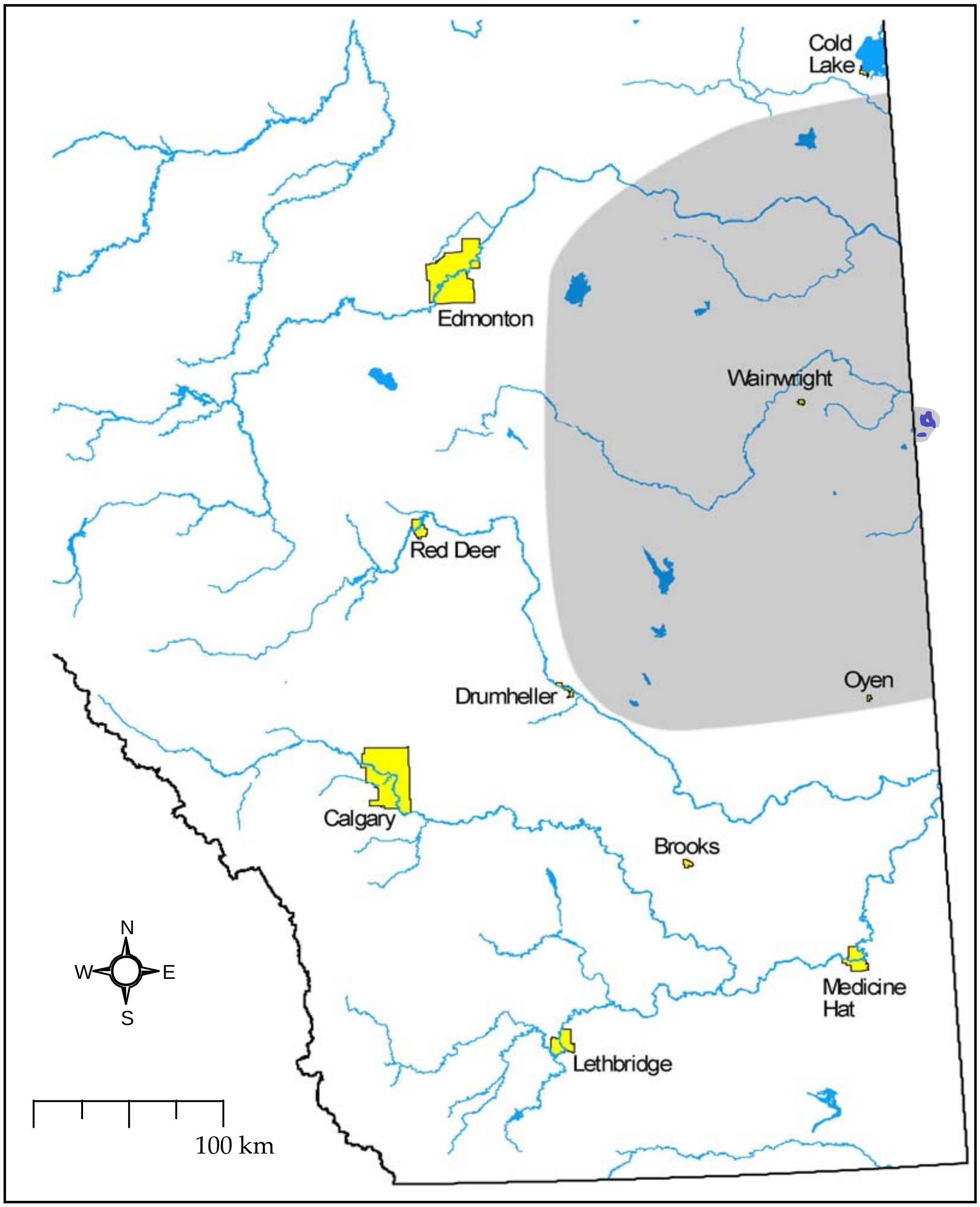


Figure 1. Location of study site (shaded area) in east-central Alberta and west-central Saskatchewan. Blue indicates major waterbodies

## 3.0 MATERIALS AND METHODS

### 3.1 Nest searches and monitoring

Beginning in early May each year, potential breeding lakes were surveyed for returning piping plovers. The locations of nests found during lake surveys were recorded in UTM NAD 83 by using Garmin 12XL GPS units. Within one day of discovery, the majority of nests had predator exclosures erected around them. Nests were monitored weekly throughout the incubation period in 1998 and 1999, and at least every three days in 2000 and 2001. To avoid disturbance to incubating adults, nests were monitored from 50-100 m away using binoculars or spotting scopes. Nests were only approached when no signs of activity were seen from a distance or when contents needed verification. The status of the nests was recorded as: active incubation, nest predation (i.e., predation of eggs), adult predation (i.e., adults preyed upon by raptors), damage to exclosures, abandonments, and hatching. Nests were considered to be successful if at least one egg hatched.

### 3.2 Exclosures

Exclosure application and monitoring techniques followed the procedures outlined by Richardson (1997). Exclosures were erected over nests regardless of stage of laying or incubation. One or two researchers carried the exclosure to the nest and secured it to the substrate using rebar and/or large nails. After application, each nest was monitored to ensure adults resumed incubation. If adults did not resume incubation within 60 minutes (less if the weather turned inclement) the exclosure was removed (Atlantic Coast Piping Plover Recovery Team 1996). In 2000 and 2001, no exclosures were applied to nests that could not be monitored at least every three days or that were within 50 m of high levels of human activity (e.g., boat launch).

In 1998 and 1999, medium-sized exclosures were used (Figure 2). These exclosures were square-pyramidal in shape, made of four 5 x 5 cm wire mesh panels with bottom width of 1.2 m and top width of 60 cm. The four panels were attached together with metal clips and the exclosure was 1.2 m high. One steel rebar, approximately 1.5 m in height, was attached to each corner and inserted 30 cm into the substrate for stability.

The bottom of each exclosure was secured in place by inserting two 25 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 sisal twine at 10 to 15 cm intervals.

In 1999, two large circular exclosures were erected at Freshwater Lake. These exclosures were made of a single length of stucco wire approximately 9 m long and 1.2 m high (Figure 2). The two ends of the stucco wire were attached with a 1.5 m length of rebar, woven through the wire where it overlapped, creating an exclosure approximately 3 m in diameter. Four additional pieces of rebar were attached to the exclosure at even intervals and inserted 30 cm into the substrate for stability.

Figure 2. Medium (left) and large (right) predator exclosures designs. Medium exclosures were 1.2 m wide at the bottom, 0.6 m wide at the top and 1.2 m high. Large exclosures were 3.0 m in diameter and 1.2 m high. Both exclosure were made from 5 x 5 cm stucco wire and 1.5 m lengths of rebar.

In an effort to protect against aerial predators, the horizontal wire along the top of the exclosure was removed in order to expose the vertical wires and the tops were covered with 2 x 2 cm plastic mesh, secured with 10 cm long cable ties. The bottom of each exclosure was secured in place by using 25 cm nails, bent at the top.

In 2000, these large circular exclosures were used on all lakes (with the exception of Birch Lake, where the medium-sized exclosures were used) in an attempt to reduce the rate of adult predation seen at medium-sized exclosures in 1999.

Two designs of predator exclosures were used during the 2001 field season. The first was the large (3 m diameter) exclosures described above. The second exclosure design used was very similar, but much smaller (Figure 3). These small exclosures were made of a single length of stucco wire approximately 2 m long and 40 cm high, creating an exclosure approximately 60 cm in diameter. The two ends of the stucco wire were attached using 10 cm nylon cable ties. The horizontal wire along the top was removed, the top covered with mesh and the bottom secured with nails in the same manner as the large exclosures.

Figure 3. Small predator exclosure design. Small exclosures were 60 cm in diameter and 40 cm high. They were constructed with 5 x 5 cm stucco wire with mesh top and anchored to the substrate with 25 cm nails, bent at the top.

### 3.3 Statistical analyses

Two methods of calculating nest success were used, with calculations being made for exclosed and unexclosed nests separately. Unexclosed nests were defined as any nest that was never exclosed at any time. Apparent nest success is defined as the number of nests hatching at least one egg divided by the total number of nests found. Apparent nest success usually overestimates success because all nests are not found at initiation and some nests are not found at all (Mayfield 1961, 1975). Nests found late in incubation are more likely to hatch than those found on the first day of incubation since they have a much shorter period of time to survive. To remedy this discrepancy, we also calculated nest survival according to Mayfield (1961, 1975), which not only takes into account the number of nests, but also the elapsed time of observations for each nest. Essentially the Mayfield method allows nests observed for longer periods of time (i.e., those found earlier in incubation) to be weighted more heavily in the overall calculation of nest success. For calculations used here, each day that a nest is under observation is called an "exposure day" (exp). Thus, a nest under observation for 25 days would contribute 25 exposure days (exp = 25) to the overall calculation. The formula used to calculate Daily Survival Rate (DSR) from exposure days is one minus nests lost divided by exposure days, where *nests lost* are the number of nests that failed while under observation and exposure days are the total days under observation for all nests. Mayfield nest success, which is the probability that a nest will survive for the entire incubation period, was calculated as $(DSR)^{d}$, where $d$ is the number of days in the incubation period. We used 35 days for $d$ in our calculations (Murphy et al. 2003a).

We could not determine the number of exposure days for some nests with known fate (i.e., those used to calculate apparent nest success) because it was visited too infrequently to know at what point during incubation the eggs hatched or failed. Using the mid-point between observation dates as a failure or hatch date, as outlined in Mayfield (1961), was not considered valuable if there were more than 10 days between visits. In other cases a single nest may have contributed exposure days to both the unexclosed and exclosed nest calculations. For example, a nest found three days prior to being exclosed would contribute three unexclosed exposure days and once exclosed, the remainder of days under observation would be considered exclosed exposure days.

Using the program CONTRAST (Hines and Sauer 1989, Sauer and Williams 1989), chi-square tests were used to determine if differences in daily survival rates between exclosed and unexclosed nests were significant. Standard error was calculated following Johnson (1979).

## 4.0 RESULTS

### 4.1 Number of nests

Between 1998 and 2001, 242 nests were found that had a known fate. These nests were located on 14 different waterbodies (Table 1). Of these nests, 166 (69%) had exclosures applied to them and 76 (31%) were never exclosed. The largest numbers of nests (108) were located in 1999. The fewest were found in 2001 (34).

Table 1. The number of exclosed and unexclosed nests found with known fate at Alberta and Saskatchewan lakes each year of the project.

| **Lake** | **1998** | | **1999** | | **2000** | | **2001** | |
|---|---|---|---|---|---|---|---|---|
| | Exclosed | Unexclosed | Exclosed | Unexclosed | Exclosed | Unexclosed | Exclosed | Unexclosed |
| Baxter | n/a | n/a | n/a | n/a | 0 | 3 | n/a | n/a |
| Birch | 3 | 0 | 3 | 0 | 4 | 0 | 0 | 5 |
| "Chain Lake #4" | n/a | n/a | 2 | 5 | 0 | 2 | 0 | 1 |
| Cipher | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 1 |
| Dowling | n/a | n/a | 11 | 3 | 0 | 4 | 0 | 0 |
| Freshwater | 4 | 0 | 5 | 1 | 6 | 1 | 3 | 1 |
| Handhills | 12 | 0 | 14 | 10 | 4 | 0 | 0 | 1 |
| Killarney | 0 | 0 | 6 | 3 | 5 | 0 | 1 | 0 |
| "Killarney Pond" | n/a | n/a | 1 | 0 | n/a | n/a | n/a | n/a |
| Manitou | 8 | 0 | n/a | n/a | n/a | n/a | n/a | n/a |
| "Metiskow" | 1 | 0 | n/a | n/a | 0 | 1 | 0 | 0 |
| "Piper" | n/a | n/a | 0 | 6 | 0 | 3 | 0 | 1 |
| Reflex | 9 | 0 | 24 | 10 | 19 | 4 | 16 | 2 |
| Sunken | 2 | 0 | 1 | 1 | 0 | 3 | 0 | 2 |
| **TOTAL** | **40** | **0** | **67** | **41** | **39** | **21** | **20** | **14** |

n/a = not part of the study that year.

## 4.2 Apparent nest success

For all of the 242 nests located during the four-year program, apparent nest success was calculated to be 50.8% (Table 2). Apparent nest success was 9.1% higher for unexclosed nests than for exclosed nests.

Table 2. Number of piping plover nests found and apparent nest success (%) for each year of the study and for the overall four year project.

| Year | Exclosed | | Unexclosed | | Overall | |
|---|---|---|---|---|---|---|
| | No. of nests | Apparent nest success | No. of nests | Apparent nest success | No. of nests | Apparent nest success |
| 1998 | 40 | 70.0 | 0 | n/a | 40 | 70.0 |
| 1999 | 67 | 19.4 | 41 | 39.0 | 108 | 26.9 |
| 2000 | 39 | 64.1 | 21 | 81.0 | 60 | 70.0 |
| 2001 | 20 | 80.0 | 14 | 57.1 | 34 | 70.6 |
| **Weighed Mean** | **166** | **49.4** | **76** | **53.9** | **242** | **50.8** |

## 4.3 Mayfield nest success

A total of 229 nests contributed 3506 exposure days to the calculations of Mayfield nest success (Table 3). Of these, 161 nests had 2464.5 exclosed exposure days and overall Mayfield nest success was 34.4%. One-hundred-and-eighteen nests contributed 1041.5 unexclosed exposure days and Mayfield nest success was 24.5%. Daily survival rates between exclosed and unexclosed nests were not significantly different ($\chi^2$ = 1.8579, P > 0.15).

Table 3. Comparison of Mayfield nest success for exclosed and unexclosed nests using Chi-square ($\chi^2$) to test for significance between daily survival rates. SE = standard error and exp = exposure days.

| Year | Exclosure | | Unexclosed | | $\chi^2$ | Overall | |
|---|---|---|---|---|---|---|---|
| | Daily survival rate $\pm$ SE (exp) | Mayfield nest success | Daily survival rate $\pm$ SE (exp) | Mayfield nest success | | Daily survival rate $\pm$ SE (exp) | Mayfield nest success |
| 1998 | 0.9844 $\pm$ 0.0047 (704) | 57.6 | 1.0000 (6) | 100 | n/a | 0.9845 $\pm$ 0.0046 (710) | 57.9 |
| 1999 | 0.9348 $\pm$ 0.0092 (721) | 9.5 | 0.9430 $\pm$ 0.0101 (526) | 12.8 | 0.3642 (P>.50) | 0.9383 $\pm$ 0.0068 (1247) | 10.7 |
| 2000 | 0.9811 $\pm$ 0.0054 (634.5) | 51.3 | 0.9843 $\pm$ 0.0070 (319) | 57.5 | 0.1310 (P>.75) | 0.9822 $\pm$ 0.0043 (953.5) | 53.3 |
| 2001 | 0.9901 $\pm$ 0.0049 (405) | 70.7 | 0.9685 $\pm$ 0.0127 (190.5) | 32.3 | 2.5719 (P>.10) | 0.9832 $\pm$ 0.0053 (595.5) | 55.3 |
| **Overall** | **0.9700 $\pm$ 0.0034 (2464.5)** | **34.4** | **0.9606 $\pm$ 0.0060 (1041.5)** | **24.5** | **1.8579 (P>.15)** | **0.9672 $\pm$ 0.0030 (3506)** | **31.1** |

## 4.4 Causes of nest failure

Adult piping plover predation was the leading cause of nest loss for exclosed nests. (Table 4). Evidence of adult kills was typically found directly outside or inside of the exclosures. Remains ranged from a few contour feathers to partial carcasses including combinations of wings, sternum, head, and feathers. Five partial carcasses were found inside exclosures where the eggs remained intact. Bird feces were found on five of the exclosures at kill sites suggesting that birds had been perching on the cages. Thirty-one nest failures resulted from predation of adult piping plovers. The second leading cause of nest failure for exclosed nests was abandonment (n= 25 nests) for unknown reasons. For unexclosed nests, the primary cause of failure was nest predation (27 nests), while the second leading cause was weather related (n=4) (Table 4).

Table 4. Summary of the causes of nest failures at exclosed and unexclosed nests in each year of the project.

| Cause of net failure | Exclosed | | | | Unexclosed | | | |
|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 2001 | 1998[1] | 1999 | 2000 | 2001 |
| Adult predation | 3 | 26 | 2 | 0 | 0 | 0 | 0 | 0 |
| Cattle disturbance | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Human disturbance | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| Infertile eggs | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Nest predation | 1 | 5 | 1 | 0 | 0 | 25 | 3 | 6 |
| Nest predated after removal of exclosure | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unexplained abandonment | 2 | 10 | 9 | 2 | 0 | 1 | 1 | 0 |
| Weather | 4 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| Unknown | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |

[1]In 1998, unexclosed nests were not monitored.

## 4.5 Comparison of exclosure designs

Exclosures were applied to 166 nests throughout the four-year program (see Table 2). Medium-sized exclosures were applied to 110 nests and large exclosures were applied to 46 nests. In 2001, small exclosures were applied to 10 nests.

The highest Mayfield nest success for any exclosure design was 72.4%, which was recorded for the small exclosures (DSR = 0.9908 $\pm$ 0.0065, Exp = 218). The lowest Mayfield nest success, 24.7%, was recorded for the medium-sized exclosures (DSR = 0.9608 $\pm$ 0.0050, Exp = 1480.5), with large exclosures falling in the middle with 52.4% Mayfield nest success (DSR = 0.9817 $\pm$ 0.0048, Exp = 766). Daily survival rates of different exclosure designs were statistically significantly different ($\chi^2 = 15.84$, $P<0.001$). Small exclosures had significantly higher daily survival rates than medium exclosures ($\chi^2 = 13.38$, $P < 0.001$), and large exclosures also had a significantly higher daily survival rate than medium exclosures ($\chi^2 = 9.09$, $P < 0.005$). There was not a statistically significant difference in daily survival rates between small and large-sized exclosures ($\chi^2 = 1.27$, $P > 0.25$).

The highest percentage of nest failures occurred as a result of adult predation (raptors preying upon adult piping plovers), the majority of which occurred at medium-sized exclosures (Table 5). Small exclosures had the least failures, but they also had the smallest sample size (n = 10).

Table 5. Percentage of nests that failed and associated causes for small, medium and large sized exclosure designs.

| **Cause of failure** | **Exclosure design** | | |
|---|---|---|---|
| | Small | Medium | Large |
| Adult predation | 0 | 26.4 | 4.3 |
| Cattle disturbance | 0 | 6.4 | 0 |
| Human disturbance | 20.0 | 0.9 | 0 |
| Nest predation | 0 | 5.5 | 2.2 |
| Unexplained abandonment | 0 | 10.9 | 23.9 |
| Weather | 0 | 3.6 | 0 |
| Infertile eggs | 0 | 0.9 | 0 |
| Nest predated after removal of exclosure | 0 | 4.2 | 0 |
| Unknown | 0 | 0 | 2.2 |

## 5.0 DISCUSSION

In Alberta, nest predation was by far the single biggest cause of failure for unexclosed nests, with more than three times as many nests lost to predation as to all other causes combined. Predation of nests appears to be more prevalent on alkali wetlands in Alberta than in other jurisdictions on the Great Plains. For example, in Alberta from 1999 to 2001 (1998 was omitted because of small sample size), mean Mayfield nest success for unexclosed nests was 24.5%. Over a two-year period from 1996-1997, Richardson (1999) found Mayfield nest success for unexclosed nests in Alberta to be 21.7%. These were both substantially lower than Mayfield nest success reported for unexclosed nests by Murphy et al. (2000) in North Dakota and Montana (38.3%) over a four-year period. Similarly, Mayfield nest success in Alberta (21.7% and 24.5%) was much lower than the 35% reported for a two year study in North Dakota (Mayer and Ryan 1991).

Larson et al. (2002) has shown that improving reproductive success is key to recovering piping plover populations. Intuitively, we know that an improvement in productivity requires minimizing the number of nest failures and chick losses. The current project concentrated on minimizing nest failures through the use of predator exclosures. Some nest failures, such as those resulting from severe weather are unavoidable and will occur whether nests are treated with exclosures or not. Ryan et al. (1993) also suggested that the protection of nests, in combination with other strategies such as enhancement of nesting habitat, could lead to substantial increases in reproductive rates.

In Alberta, the use of predator exclosures from 1998 through 2001 had mixed results. For exclosed nests, mean Mayfield nest success was 34.4%, well below the 81% calculated from Melvin et al. (1992) and the 84% calculated by Murphy et al. (2003a). It is difficult to compare nest success between studies, given the confounding problems of year effects, and our results were greatly affected by the large number of nests lost in 1999 due to adult predation. While the exclosures were successful in reducing the number of nests that were lost to predators, adult plovers were killed at 31 (26 at medium exclosures in 1999 alone) exclosures during the course of the program. It is unknown what caused this drastic increase in mortality in 1999; however, we suspect that merlins (*Falco columbarius*) were responsible for the losses. In two cases on Reflex Lake, the carcasses found had evidence of bite marks identified as those of a merlin (G. Court, Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, Alberta, pers. comm.) and in one case a merlin was observed striking an exclosure and capturing the incubating adult as it exited the exclosure. In the Reflex Lake area, where exclosures have been used since 1995, it is possible that merlins learned that adult plovers were an easy target once they left an exclosure. However, exclosures were used for the first time on Dowling and Chain Lake #4 in 1999 and adults were also killed at those lakes. Bird feces were found on five (16%) of the exclosures at kill sites suggesting that birds had been perching on the cages. Problems with adult predation at similar sized exclosures were recorded in the United States and also attributed to raptors (Murphy et al. 2003b). However, in the United States, they were able to greatly reduce the incidence of adult predation by increasing the size and modifying the design of the exclosures used (B. Murphy, United States Fish and Wildlife Service, Des Lacs National Wildlife Refuge Complex, Kenmare, North Dakota. pers. comm. 2000). Reducing nest predation was deemed to be key to recovering piping plover populations so research continued in 2000 and 2001 on refining exclosure designs.

Large exclosures, similar to those used in the United States, were used in 2000 in an attempt to reduce adult predation, while at the same time reducing nest predation. In 2000, only two adults were killed at exclosed nests and we think this is due to the increased size of the exclosure providing a larger buffer for the adult plovers. While this was a large improvement over previous years, the number of losses was still deemed to be unacceptable, and given the high number of unexplained abandonments in 2000, there was still concern that the number of adults lost may have been higher than what could be confirmed. In addition, on beaches where cattle were present, livestock were inclined to rub against the medium and large exclosures, using them as scratching posts. Cattle damage to exclosures consisted of heavy trampling around the perimeter and the sides being pushed in. Cattle would cause an incubating adult to flush off a nest, and remain a distance away, while cattle loafed directly outside an exclosure. This could disturb adults to the point of abandoning the nest. Seven nests were abandoned in 1999 as a direct result of cattle damage (Michaud and Prescott 1999). In 2000, cattle damaged one exclosure, however nest still hatched (Engley and Michaud 2000). With these problems identified, refinement of techniques was still needed and in 2001 the use of small exclosures with greatly reduced height were experimented for the first time (Engley 2001).

No literature could be found on the use of small (60 cm diameter, 40 cm high) exclosures. One hypothesis was that merlins, at least initially, were not keying into the medium and large-sized exclosures, but rather saw them as a good place from which to hunt. Upon flying up to perch on the exclosure, merlins would flush the adult plover from the nest and were able to capture it before it could take flight. It was suggested that using small exclosures would make them less enticing as perching sites. However, given that exclosures of this size had not been tried before, we were cautious of potential problems. Most notably there was some concern that the small size would lead to an increase in nest abandonments. By putting these exclosures out early in the season, we believed that if these nests were abandoned at a high rate, plovers would have the opportunity to re-nest. Our initial results suggested that nests were not abandoned more due to small exclosure size.

No significant difference in survival rates between small and large exclosures was found ($P > 0.25$). However, there were many advantages to the small exclosures. No adults were killed at any exclosures in 2001 and disturbance to the birds was minimized as the small exclosures could be placed over the nest and staked down by a single researcher in about 30 seconds. Conversely, the larger exclosures required at least two researches and generally took between five and ten minutes to set up. In addition, the smaller exclosures were well camouflaged when placed on nesting beaches and cost only about $1.50 to produce compared with $25 for the large exclosures. No evidence of cattle approaching the small exclosures was recorded. As a result of the small sample size in 2001 ($n = 10$), continued application of the small exclosures is needed in order to properly evaluate their overall effectiveness.

Predator exclusion is only one tool that can be used to increase nest success. Additional predator deterrence methods should be explored. Mayer and Ryan (1991) found that electric fences decreased predation rates on piping plover nests and chicks and a comprehensive literature review on different predator deterrence methods available (e.g., scent deterrents, direct removal, effigies, noise repellents) has been completed (Schmelzeisen et al. 2003), which suggests that the use of chick shelters and electrified fencing might be promising methods. Livestock and off-highway vehicle activity on nesting beaches during the breeding season have proven detrimental to piping plovers (Michaud and Prescott 1999, Engley and Michaud 2000, Engley 2001). Stewardship, education, and outreach initiatives would likely prove valuable in promoting grazing practices and recreational vehicle restrictions that would facilitate successful piping plover nesting.

## 5.1 Management implications

The high levels of adult mortality recorded in this study negated any benefits attained from using exclosures. Nevertheless, nest predation is still a limiting factor therefore, research on and refinement of this management technique should continue in order to maximize potential increases in productivity. The use of predator exclosures is only one in a long list of tools that could be used to increase piping plover numbers in Alberta. Given this, we recommend that:

1) Small exclosure be used on a larger scale in the future, be monitored at least every three days, and be evaluated as to their overall effectiveness in increasing productivity.

2) Efforts should be made to follow broods to fledging age. This will allow researchers to calculate fledging success from exclosed and unexclosed nests. Fledging success is ultimately the measure needed to gauge progress being made towards achieving the goal of 1.25 chicks per pair per year outlined in the National Recovery Plan for Piping Plover (Goossen et al. 2002) and the Alberta Piping Plover Recovery Plan (Alberta Piping Plover Recovery Team 2002).

3) Implementation of some of the predator deterrence methods outlined in Schmelzeisen et al. (2003) should be considered and approved by the Alberta Piping Plover Recovery Team.

4) The implementation of stewardship activities should be explored, working cooperatively with landowners to limit cattle access to nesting areas during the nesting period from early May to late July. This would eliminate nest lost resulting from livestock disturbance.

This program should continue to evolve, refining exclosure designs and being proactive in developing and implementing new methods to enhance piping plover productivity. Much of what has been learned from the past four years of this program will be beneficial in carrying out future activities aimed at enhancing piping plover populations in Alberta.

## 6.0 LITERATURE CITED

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# 1.0 INTRODUCTION

## 1.1 General introduction

The piping plover (*Charadrius melodus*) is a bluebird-sized shorebird that nests on gravel or sandy beaches. Three breeding populations are recognized: the Atlantic coast (*C. m. melodus*) the Great Plains (*C. m. circumcinctus*) and the Great Lakes (*C. m. circumcinctus*) populations. Large population declines led Canada to designate it as Endangered in 1985 (Goossen et al. 2002). It is listed as either Threatened or Endangered throughout the United States (U.S. Fish and Wildlife Service 2005) and was designated as Endangered under Alberta's Wildlife Act in 2000 (Alberta Piping Plover Recovery Team 2002).

Results from the 2001 International Piping Plover Breeding Census found 5945 piping plovers throughout its range in North America (Ferland and Haig 2002). This represents an increase of 8.4% from the first census conducted in 1991 (Ferland and Haig 2002). However, while the Great Lakes and Atlantic coast populations have shown encouraging increases over the past decade, the Great Plains population has declined dramatically. Populations in prairie Canada have dropped 42.4% since 1991, and during the same time period the Alberta population has dropped 45.7% to 150 adults (Prescott 2001).

## 1.2 Study rationale

Nest loss has been identified as a significant limiting factor to piping plover reproductive success in the Great Plains (Whyte 1985, Heckbert 1994, Richardson 1999, Murphy et al. 2000, Kruse et al. 2002). Results from studies carried out in east-central Alberta from 1995 to 1997 showed that piping plover nest predation can be significantly reduced through the use of predator exclosures, thus increasing productivity (Heckbert and Cantelon 1996, Richardson 1999). Studies from other jurisdictions within the Great Plains have had similar results (Rimmer and Deblinger 1990, Melvin et al. 1992, Larson et al. 2002, Murphy et al. 2003a). Consequently, a management project implementing predator exclosures on a large-scale basis was initiated in Alberta in 1998 by the Alberta

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