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Reproductive Success of Piping Plovers on Alkali Lakes in North Dakota and Montana

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ABSTRACT -- Low reproductive success is thought to be a chief cause of the steady decline in numbers of piping plover (*Charadrius melodus*) that nest in the northern Great Plains. Surprisingly, few reproductive success data are published from alkali lakes in the region, where most breeding pairs of piping plover nest. During 1994 to 1997 we measured nest success and fledging rates of piping plovers at 32 alkali lakes across northwestern North Dakota and northeastern Montana, at the center of the species' breeding range in the Great Plains. Annual nest success and fledging rates averaged 38% (Mayfield estimate; 20 to 66 nests/year) and 0.76 chicks/pair (28 to 76 pairs/year). The mean annual fledging rate we observed approximated that previously projected for the region from a small number of major breeding areas, and was at least 33% below estimated levels needed for population stability. About one-half of the productivity losses occurred during the egg stage, especially near hatching. Our data confirm that reproductive success of piping plovers on alkali lakes probably is less than that needed to sustain the species' Great Plains population.

Key words: alkali lakes, *Charadrius melodus*, endangered species, Great Plains, piping plover, population dynamics, reproductive success.

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Since 1985 the northern Great Plains population of piping plovers (*Charadrius melodus*) has been listed as Threatened in the United States and Endangered in Canada due to a steady population decline (Haig 1985, Sidle 1985). Poor reproductive success is thought to be a major cause of endangerment. Surprisingly, this key facet of demography is reported for relatively few alkali lakes even though such habitat annually supports two-thirds to three-fourths of the Great Plains breeding population; most other plovers nest along rivers and impoundments (Haig and Plissner 1993, Plissner and Haig 2000). For example, Williams Preserve (28-km^2 area with several lakes) in central North Dakota and Big Quill Lake (635 km^2) in central Saskatchewan were the only alkali lake habitats represented in a demographic model for Great Plains piping plover (Ryan et al. 1993). These two areas are among the region's largest breeding concentrations, where there are greater than 150 total adults each (Haig and Plissner 1993, Plissner and Haig 2000). More typically, piping plover pairs on alkali lakes breed in greater isolation from conspecifics, and they generally breed on smaller alkali lakes. For example, during a 1996 population census, 51% of piping plover pairs occurred on lakes with less than 10 pairs, and 9% occurred on lakes with a single pair present (Plissner and Haig 2000). The reproductive success of such isolated pairs may differ from that of piping plover pairs in large breeding concentrations, and thus alter conclusions about population status and viability. Our goal was to measure the reproductive success of the piping plover on relatively small alkali lakes across the center of the species' Great Plains breeding range. Primary objectives were to: (1) test whether the region-wide fledging rate and limited data sources for alkali lakes in Ryan et al. (1993) were consistent with relatively small, isolated concentrations of breeding piping plovers typical of most alkali lake habitat in the region; and (2) provide a basis for justifying and monitoring local recovery efforts for the species. Because weak links in the species' breeding biology must be understood to prescribe effective management, we also sought to document nest success, the timing of losses of eggs and chicks relative to the annual breeding cycle, and the impact of late nesting on recruitment.

STUDY AREA and METHODS

About 225 breeding pairs of piping plovers nest annually on alkali lakes associated with the Missouri Coteau landform in northwestern North Dakota and northeastern Montana (Fig. 1). Within this area the piping plover nests in two broad clusters of alkali lakes: (1) the "Lostwood area" mainly in northern Mountrail County, North Dakota; and (2) the "Stateline area" of far western Divide and northwestern William counties, North Dakota and the adjoining eastern edge of Sheridan County, Montana. On average, about 60% of piping plover pairs in the Lostwood and Stateline areas annually nest on privately-owned lands. Land use is mainly dryland farming for small grains and hay, and cattle ranching on native mixed grass (*Stipa-Agropyron*)

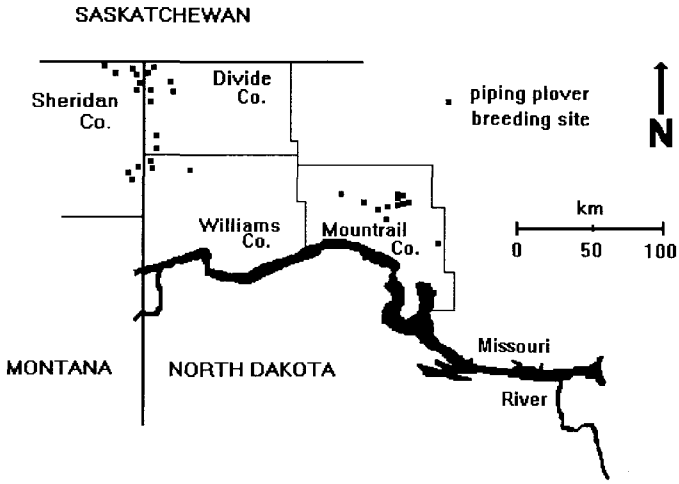

Figure 1. Alkali lake breeding sites in northeastern Montana and northwestern North Dakota where reproductive success of piping plovers was assessed during 1994 to 1997.

prairie. Annual precipitation averages about 40 cm. Weather during the May to July piping plover breeding season often is cloudless and mild (10 to 25° C) but varies from cold (to -5° C) and rainy with occasional snow squalls (May and June), to dry and hot (to 38° C) with severe, local thunderstorms with hail (July) (U.S. Fish and Wildlife Service-Lostwood National Wildlife Refuge, unpubl. data).

Alkali lakes in the northern Great Plains are shallow, semi-permanent to permanent, hypersaline to eusaline wetlands (Cowardin et al. 1979). We monitored piping plovers on alkali lakes that averaged 1.9 km^2 (range 0.2 to 9.9 km^2). Piping plover habitat on the lakes is salt-encrusted, gravelly beaches sparsely vegetated by alkali-grass (*Puccinellia nuttalliana*), saltwort (*Salicornia rubra*), and inland saltgrass (*Distichlis spicata*) (Prindiville Gaines and Ryan 1988). Beaches typically are shared by nesting American avocet (*Recurvirostra americana*). Potential predators of piping plover eggs and chicks include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), ring-billed gull (*Larus delawarensis*), California gull (*L. californicus*), northern harrier (*Circus cyaneus*), and American crow (*Corvus brachyrhynchos*) (R. Murphy and M. Rabenberg, U.S. Fish and Wildlife Service, unpubl. data).

We monitored reproductive success of piping plovers at 12 alkali lakes in the Lostwood area and at 20 lakes in the Stateline area (Fig. 1). Lakes known to host

nesting piping plovers in previous years were surveyed on foot during late May and early June, when piping plovers initiated nests (Appendix A in Murphy et al. 1999). Reproductive success of pairs was sampled across the study area each year, except during 1994 and 1995 the Stateline area was under-sampled (32% and 24% of all pairs) due to few personnel. An unusually high abundance of up to 50 breeding pairs of piping plover occurred on a small (1.9-km^2), isolated wetland named Appam Lake. Reproductive fates of nearly all breeding pairs on Appam Lake were monitored intensively in 1996 and 1997, as part of another study (Murphy et al. unpubl. data). In contrast, our goal herein was to survey reproductive success extensively. To avoid over-representing Appam Lake in our study, we randomly omitted data for all but nine pairs. This was the maximum number of piping plover pairs we annually monitored on any other lake, and the maximum number of pairs on most lakes in the region (Plissner and Haig 2000). We also excluded data for pairs that had eggs or chicks protected from predators by exclosures, such as at Lostwood National Wildlife Refuge (Smith et al. 1993).

We used standard methods and terminology to assess and describe piping plover reproductive success (Murphy et al. 1999). Typically we located nests by observing incubating adults; we avoided approaching within 2 to 3 m of nests or handling eggs to determine incubation status. Using 10x binoculars or 20-45x spotting scopes, we rechecked breeding territories from uplands or from boats 30 to 200 m away at five- to eight-day intervals until a given pair failed and clearly abandoned its territory, or fledged chicks. If a nest failed, we continued to revisit the respective territory to track possible renesting. We considered chicks reaching 18 to 20 days of age to have fledged (Murphy et al. 1999). We considered nests initiated after 10 June to be late nests because chicks potentially produced from such nests would not fledge until August, after most area piping plovers migrate (Appendix A in Murphy et al. 1999).

RESULTS

We monitored reproductive fates of up to 76 unmanaged breeding pairs of piping plover each year during 1994 to 1997 (Table 1). The annual fledging rate averaged 0.76 chicks per pair, but varied among years (Kruskal-Wallis test: $H = 10.3$, $df = 3$, $P = 0.016$) and was particularly low in 1995. We likewise noted significant yearly variation in the proportion of nesting pairs that contributed to the reproductive output ($X^2 = 16.7$, $df = 3$, $P < 0.01$) (Table 1). Highest fledging rates (greater than 1.7 chicks per pair, n = 4 to 9 pairs) occurred at lakes surrounded by treeless rangeland in the Stateline area.

Nest success of piping plovers averaged 38% (Mayfield estimate, Table 1). Causes of nest losses generally were unknown but most probably were due to depredation, especially in 1995. Only 1.2% of nest losses were due to abandonment

Table 1. Reproductive success of unmanaged piping plovers[a] breeding on alkali lakes in northwestern North Dakota and northeastern Montana, 1994 to 1997.

Year	No. lakes[b] monitored	% Mayfield nest success[c] (n nests)	Fledglings/pair[d] (n pairs)	% pairs with ≥ 1 fledgling
1994	6	38.2 (20)	0.86 (28)	42.9
1995	11	16.3 (40)	0.24 (37)	8.1
1996	19	53.0 (36)	0.74 (39)	41.0
1997	32	45.6 (66)	1.18 (76)	46.0
mean	17	38.3	0.76	34.5
SE	5.7	7.9	0.20	8.9

[a] Excludes breeding pairs in areas where predators were excluded or reduced, or habitat was otherwise improved specifically for piping plovers.
[b] As delineated in the National Wetland Inventory (U.S. Fish and Wildlife Service, Denver, CO).
[c] Modified estimator according to Johnson (1979).
[d] Mean number of 18- to 20-day old chicks produced per pair.

and few (2.5%) were attributed to trampling by cattle. Overall, nearly one-half of the loss in potential reproductive output occurred during the egg stage (Fig. 2). However, the greatest rate of loss occurred within roughly five days before to five days after hatching, and involved nearly one-third of the potential output. Losses were fewest when piping plover chicks were two to three weeks old; about 90% of chicks survived this period.

We detected 13 late nests for piping plover, four of which produced fledglings. The late nests contributed nine (5.9%) of 152 fledglings documented during the study. Chicks from late nests fledged from 4 to 18 August. Because adults were unmarked, we were unsure whether late nests stemmed from renesting efforts.

DISCUSSION

Reproductive success of piping plovers that we documented at scattered, relatively isolated alkali lakes was similar to a characterization of the species across the Great

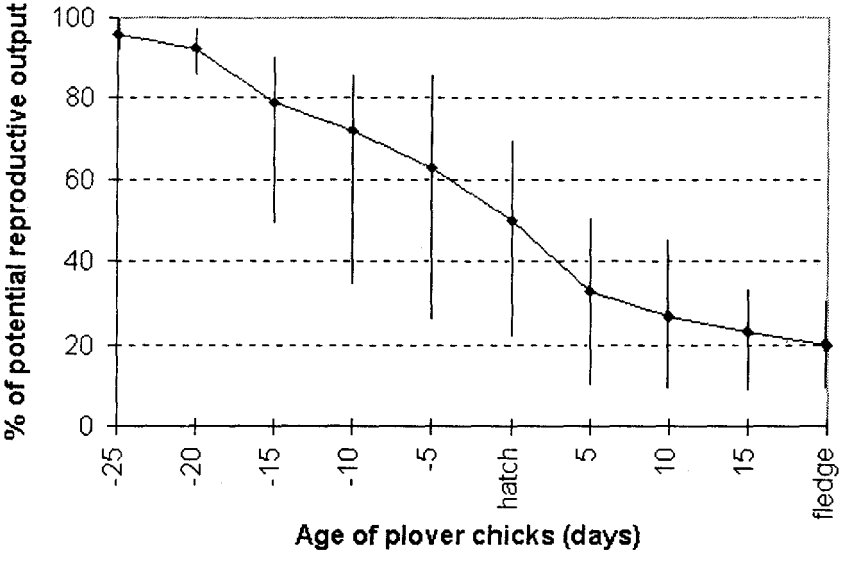

Figure 2. Timing of attrition of piping plover eggs and chicks on alkali lakes in northwestern North Dakota and northeastern Montana, based on four-year average (1994 to 1997, n = 28 to 76 breeding pairs monitored per year). Vertical bars indicate ranges observed among years (minimum and maximum = 1995 and 1997, respectively). Numbers of eggs were approximate because clutch size usually was unmonitored after initial nest discovery. Excludes likely renesting efforts.

Plains region. The mean fledging rate we observed (0.76 chicks per pair) was close to 0.86 chicks per pair used by Ryan et al. (1993) to represent the Great Plains population, but was only two-thirds of the estimated level needed for population stability (1.13 chicks per pair) in the region (Ryan et al. 1993). Our data confirm that piping plover reproductive success probably is inadequate to sustain populations on alkali lakes across the northern Great Plains. The mean fledging rate we observed also was close to that at each of two major breeding concentrations on alkali lakes, i.e., about 1.0 for 182 pairs over five years calculated from data in Prindiville Gaines and Ryan (1988), and Mayer and Ryan (1991) for Williams Preserve; about 0.9 for 20 pairs over two years calculated from data in Whyte (1985) for Big Quill Lake.

We observed marked variation in annual fledging rates, which indicated the importance of multi-year studies of piping plover reproductive success. An extremely low fledging rate in 1995 was due mainly to depredation of eggs by unknown predators. On nearby Lostwood National Wildlife Refuge, where most predators were excluded from piping plover nests and beaches by specialized fences, the 1995 fledging rate was

four times greater than it was for piping plover pairs we studied away from the refuge (U.S. Fish and Wildlife Service, unpubl. data). Low rates of reproductive success in 1994 and 1996 were at least partly due to cold, rainy weather during late June, when eggs in most piping plover nests were hatching, i.e., 15 to 30 June 1994 and 1996: mean of daily average temperatures = 17° C, minimum to 3° C; total rainfall over four to six days = 2.3 to 3.6 cm (U.S. Fish and Wildlife Service-Lostwood National Wildlife Refuge, unpubl. data). In late 1980's investigations conducted in the Montana portion of the Stateline area (Rabenberg et al. 1993), the piping plover fledging rate was 50% higher than our mean rate. This contrast might be partly due to weather more conducive to piping plover productivity, i.e., late 1980's were drier and warmer, but might also relate somehow to quality of habitats sampled, e.g., our fledging rate might have been higher had we not under-sampled the Stateline area in two years of our study. We suspect land use and make-up of local predator communities strongly influence piping plover reproductive success, as they do for prairie-nesting ducks in the region (Greenwood et al. 1987, Sovada et al. 1995). Knowledge of local patterns of piping plover reproductive success might help resource personnel optimally target management efforts.

Most reproductive loss occurred during the egg stage and just after hatching. Survival was relatively high among older piping plover chicks, as noted earlier in central North Dakota (Prindiville Gaines and Ryan 1988). Simple predator exclusion fencing over nests probably would increase piping plover reproductive success on alkali lakes as in other regions (Melvin et al. 1992), but would not protect chicks, which appear particularly vulnerable within about a week of hatching. Fencing of entire beaches may further protect chicks, at least from mammalian predators (Mayer and Ryan 1991, Smith et al. 1993). Regardless, limited funding and personnel shortages might make it impractical to widely sustain such intensive management for piping plovers across alkali lakes in the Great Plains.

Late nesting pairs of piping plovers can be overlooked or disregarded as unimportant. Our data indicated that about 6% of piping plover fledglings on alkali lakes originated from eggs that were laid in mid-June and hatch in mid- to late-July. Under a widespread recovery effort for piping plover in the Great Plains, a 6% boost in production could change a stable population to one that is increasing at about 2% per year (Ryan et al. 1993). Resource personnel seeking broad opportunities to increase the species' productivity on alkali lakes should be cognizant of management needs and the potential contribution of late-arriving or potentially renesting pairs of piping plovers.

Cattle have been associated with reduced piping plover nest success on alkali lakes (Prindiville Gaines and Ryan 1988), but we found little evidence of such losses even though cattle were common on the study area. Instead, some of the highest levels of productivity in our study occurred at lakes surrounded by rangeland occupied by cattle. Trampling of beaches is seldom problematic in the area because substrates tend

to be firm gravels (Smith et al. 1993). In the absence of livestock grazing or other defoliation, vegetation encroaches on alkali lake beaches, which makes them less suitable for piping plover breeding (Rabenberg et al. 1993, Root 1996). Other than natural flooding regimes, no other options exist for maintaining sparse vegetation along alkali lake shores on privately-owned lands, where most piping plovers on the Missouri Coteau nest. Livestock exclusion efforts could focus on springs and outlets of small fens bordering alkali lakes (Rabenberg et al. 1993). These are particularly important feeding sites for piping plover chicks (Smith 1991) and adults (RKM, pers. obser.).

In summary, we sampled the reproductive success of piping plovers nesting on alkali lakes across the center of the species' breeding range in the northern Great Plains. The mean fledging rate documented by us supported Ryan et al.'s (1993) characterization of fledging rate for the population. The fledging rate we observed also approximated that on two major breeding concentrations on alkali lake habitat and was below that needed to sustain a stable breeding population. Most losses occurred during incubation through hatching, so efforts to improve reproductive success might initially focus on increasing nest survival.

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