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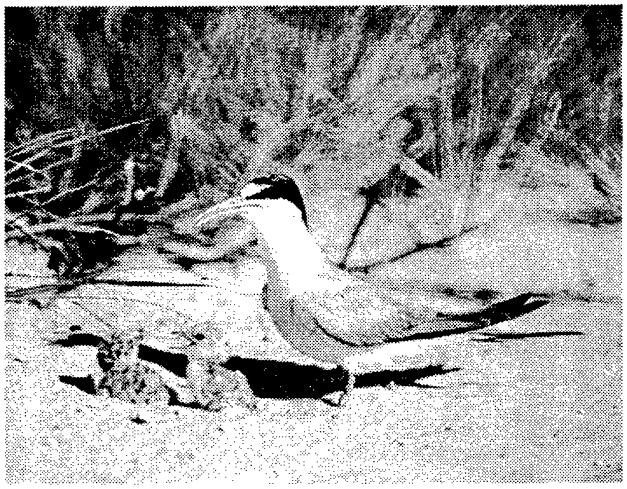
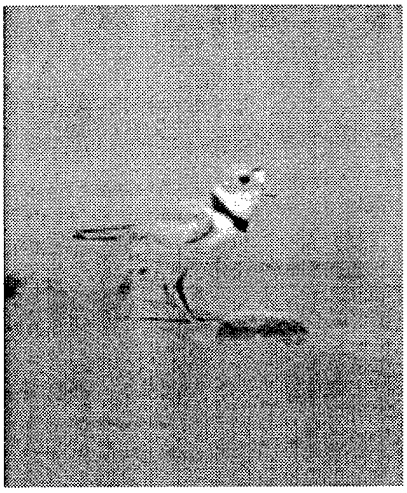
Riparian Shorebirds Potentially Impacted by USACE Reservoir Operations



Least Tern



Pipiing Plover

BACKGROUND: The piping plover (*Charadrius melodus*) and least tern (*Sterna antillarum*) are shorebirds that breed along coastal beaches and major interior river systems within North America. The interior population of the least tern and the Great Lakes population of the piping plover are federally listed as endangered, and the coastal and Great Plains populations of the piping plover are federally listed as threatened (Table 1). The state status of each species is summarized in Table 2. This report primarily addresses interior populations, which are known to be highly dependent on riparian areas associated with large river systems.

Table 1
Sensitive Riparian Shorebirds Potentially Impacted by Reservoir Operations

Common Name	Scientific Name	Protection Status[1]
Least tern	*Sterna antillarum*	State protected in 13 states (Atlantic and Gulf Coast populations) Federally endangered (Interior population) Federally endangered (California population)
Piping plover	*Charadrius melodus*	Federally endangered (Great Lakes population) Federally threatened (Northern Great Plains, Atlantic and Gulf Coast populations)

[1] Indicates priority level of protection. Refer to Table 2 for details.

Table 2
Protection Status of Sensitive Riparian Shorebirds

States	Least Tern		Piping Plover	
	Federal	State	Federal	State
Pacific				
CA	FE[1]	SE[1]		
ID				
NV		WL		
OR				
WA				
HI				
Southwest				
AZ				
NM	FE	SE		SE
OK	FE	SE	FT	ST
TX	FE[2]	SE	FT	ST
Great Lakes - Big Rivers				
IL	FE	SE	FE	SE
IN	FE	SE	FE/FT	SE
IA	FE	SE	FT	SE
MI			FE	SE
MO	FE	SE	FE	
MN			FE/FT	SE
OH			FE/FT	SE
WI			FE/FT	SE
Southeast				
AL		SSC	FT	SP
AR	FE			
FL		ST	FT	ST
GA		R	FT	ST
KY	FE	SE	FT	
LA	FE[3]	FE[4]	FT	FT[4]
MS	FE[5]	SSC	FT	SE
NC		R	FT	ST
SC		ST	FT	FT[4]
TN	FE	SE		SSC[6]

(Continued)

[1] Refers to the California least tern (*Sterna antillarum browni*).
[2] Except within 50 miles of the coast.
[3] Mississippi River and tributaries north of Baton Rouge only.
[4] State uses Federal status as their designation.
[5] Mississippi River only.
[6] Refers tp nesting birds only; possibly extirpated.

Table 2 (Concluded)

States	Least Tern		Piping Plover	
	Federal	State	Federal	State
Northeast				
CT		ST	FT	ST
DE		SE	FT	SE
ME		SE	FT	SE
MD		ST	FT	SE
MA		SSC	FT	ST
NH		ST	FT	SE
NJ		SE	FT	SE
NY		SE	FE/FT	SE
PA			FE	SSC[7]
RI		ST	FT	FT[4]
VT				
VA		SSC	FT	ST
WV				
Mountain-Prairie				
CO	FE	SE	FT	ST
KS	FE	SE	FT	ST
MT	FE	SP	FT	SP
ND	FE	SE	FT	SE
NE	FE	SE	FT	ST
SD	FE	SE	FT	ST
UT				
WY				SSC
Alaska				
AK				
Total States	**19**	**31**	**35**	**36**

[7] Extirpated in the state.

A recent survey, conducted as part of the U.S. Army Corps of Engineers (Corps) Ecosystem Management and Restoration Research Project (EMRRP) work unit entitled "Reservoir Operations - Impacts on Habitats of Target Species," indicated that the least tern and piping plover were sensitive species on Corps projects. Although other sensitive shorebirds may be impacted by project operations, these were the only species reported from projects in the survey. The least tern and piping plover were reported to occur at 20 and 13 projects, respectively, in the central and southern United States; both species were reported to occur at 12 of these projects. Corps projects reporting the occurrence of these species were in the Albuquerque, Omaha, Kansas City, and Tulsa Districts; the least tern was also reported at projects in the Little Rock District. After this survey was completed, several colonies of interior least terns were discovered in the Vicksburg District nesting in the Red River Waterway near Shreveport, Louisiana.[1] Because a large percentage of the interior population nests on the lower Mississippi River, Districts within the Mississippi Valley Division have made major efforts to inventory, monitor, protect, and manage habitat for the recovery of the least tern on the Mississippi River. This technical note is a product of the EMRRP work unit,

1 Personal Communication, 17 Mar 2000, Julie Marcy, U.S. Army Engineer District, Vicksburg.

"Reservoir Operations: Impacts on Habitats of Target Species" (see Dickerson, Martin, and Allen (1999); Kasul, Martin, and Allen (2000)). Details on the status of each species, its distribution, habitat, behavior, reproduction, food habits, impacts, and management are presented in this document.

GENERAL HABITAT REQUIREMENTS: Nesting behavior and habitat requirements are similar for inland populations of the least tern and piping plover. Nesting occurs in riverine populations within the same time period; however, piping plovers usually arrive earlier on breeding grounds and depart by mid-summer, whereas least terns remain throughout the summer. These species utilize similar riverine habitats, which consist primarily of sparsely vegetated sand and gravel beaches of shorelines, sandbars, and dredged material islands. The nests of both species are shallow scrapes in the sand. Foraging requirements are different for the two species. The least tern feeds on small fishes from nearby shallow-water areas, whereas the piping plover feeds chiefly on invertebrates from the intertidal zone.

IMPACTS AND RECOVERY: Since the 1950s, impacts to interior populations of the least tern and piping plover have resulted chiefly from habitat alteration and destruction. Because of similar nesting requirements, these species have experienced similar impacts to nesting habitat along inland waterways in the United States. Corps operations that may cause habitat impacts include channelization, reservoir construction and operation, dredging practices, and water flow control for locks and dams. Human disturbance, especially through recreational use of beaches and sandbars, causes significant impacts to nesting habitat, nests, and young.

The inland populations of both species were placed on the federal list of threatened and endangered species in the mid-1980s. Recovery efforts were implemented by the Corps, U.S. Fish and Wildlife Service (USFWS), Bureau of Land Management, state natural resource/wildlife agencies, The Nature Conservancy, The Audubon Society, and other private organizations. The interior population of the least tern has stabilized through these intensive interagency efforts, but the piping plover population has continued to decline. Reproductive and behavioral characteristics of the least tern may have enhanced its potential for recovery. The least tern completes the process of egg laying, incubation, and fledging more rapidly than the piping plover, and it has more opportunity to successfully renest because it remains on the breeding grounds longer. The least tern is also colonial, which helps offset the effects of predation.

Recovery strategies for both species have emphasized protection of beaches and sandbars from both predators and human disturbance. Recovery plans suggest controlling vegetation, creating habitat, creating barriers against disturbance, monitoring active nests, inventorying for new nests, and managing riverflow regimes to protect nesting habitat. The Corps has implemented various recovery strategies that have proven to be effective. Most Districts monitor populations annually and maintain databases for each species present. Protection and provision of nesting habitat have been priorities since these inland populations were federally listed. Water flow from dams is controlled so that spring releases will not destroy nests or force birds to nest too far from the shoreline in poor quality habitat. Measures are taken to protect birds and nests from human intruders and predators. Highly vulnerable areas may be roped off during nesting season and information signs erected to prevent human disturbance, while cages or fences are used to assist with predator control.

The Corps has created nesting habitat by constructing islands and sandbars, chiefly with dredged material (U.S. Army Corps of Engineers (USACE) 1999). Some Districts have altered existing islands and sandbars to improve habitat; for example, elevating dredged islands by only 3 ft (0.9 m) has improved the nesting success of least terns in the Arkansas River.[1] In the lower Mississippi River (LMR), new dikes have been designed with notches (300 ft [91 m] wide at the top of the dike) that allow water to flow through the deepest part of the chute, thus preventing sedimentation that would connect dikes to the shore and allow predator access to nesting areas.[2] Dikes have been moved or removed to accommodate nesting least terns on the LMR, and construction schedules are modified from mid-May to 1 August to avoid impacts during the nesting season. Because epibenthic invertebrates (e.g., caddisfly and midge larvae) are important fish food, the surfaces of concrete revetments are roughened to create additional substrate for these organisms; this should benefit the piscivorus least tern by increasing its food supply (USACE 1999). Corps activities that impact the least tern and/or piping plover at specific sites require consultations with the U.S. Fish and Wildlife Service (USFWS), so the Corps continues to work closely with this agency in recovery efforts for inland populations of these species.

LEAST TERN (*Sterna antillarum*), INTERIOR POPULATION

Distribution. The least tern is a migratory species whose breeding range includes the Atlantic and Gulf Coasts, Mississippi River Basin, and California in the United States; the Greater and Lesser Antilles; and Mexico (USFWS 2000) (Figure 1). It winters in Central America and northern South America. Inland populations historically bred along the Mississippi, Missouri, Arkansas, Ohio, Red, and Rio Grande River systems and rivers of central Texas (Sidle and Harrison 1990). The current breeding range of the interior population is restricted to the less altered river segments, reservoirs, and refuges of these river systems.

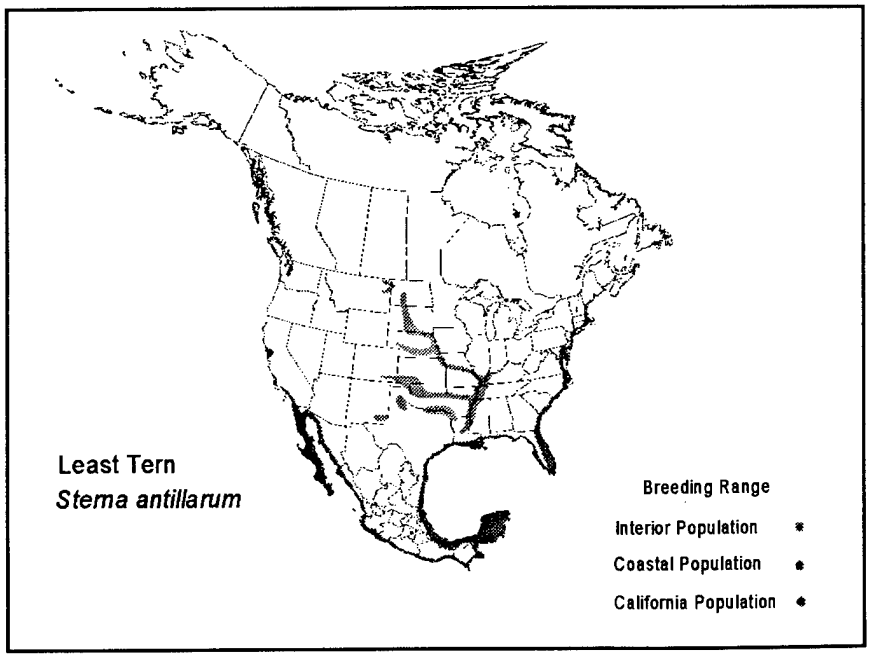


Figure 1. Range of the least tern in North America and Mexico

1 Personal Communication, 22 Mar 2000, Clyde Gates, U.S. Army Engineer District, Little Rock.

2 Personal Communication, 17 Mar 2000, John Rumancik, U.S. Army Engineer District, Memphis.

Status. The interior population of the least tern was listed as federally endangered in 1985 in states associated with the Mississippi, Missouri, and Rio Grande River systems (USFWS 1985). Although the interior least tern had been recognized as a subspecies (*S. a. athalassos*) in 1983 (American Ornithologists' Union 1983), it was not listed as endangered because of the taxonomic uncertainty of the subspecies in the United States (Sidle and Harrison 1990). The USFWS instead designated as endangered those populations of least terns occurring in interior North America (Table 1). This status applies to populations in Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana (Mississippi River and tributaries north of Baton Rouge), Mississippi (Mississippi River), Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Tennessee, and Texas (except within 50 miles of the coast) (USFWS 1985). The interior population is currently listed as endangered or protected in most states (Table 2). The interior population will be considered for Federal delisting when it reaches 7,000 individuals and is stable for 10 years, as verified by four censuses (Montana Fish, Wildlife & Parks 2000). The recovery goal of 7,000 birds was exceeded in 1995 as the result of large increases in least terns along a 560-mile (901-km) stretch of the Lower Mississippi River; however, numbers for most breeding areas farther inland have not reached recovery levels (Kirsch and Sidle 1999).

Habitat. Major habitats used for nesting and foraging are riverine sandbars and gravel pits, river channel environments, and lake and reservoir shorelines (Sidle and Harrison 1990). Meandering rivers on broad flat floodplains offer the most suitable habitats for inland populations of least terns. Typical nesting habitat consists of unvegetated or sparsely vegetated sand and gravel bars within a wide unobstructed river channel. Nesting areas are usually located on higher elevations away from the water's edge, and nests are placed on open sandy areas, gravelly patches, or exposed flats. An important feature of nesting habitat is the presence of large amounts of driftwood (sticks, twigs, bark), since nests are usually placed near pieces of wood and debris (Smith and Renken 1991). In the absence of suitable riverine habitat, least terns will nest on artificial sites such as dike fields, sand and gravel pits, ash disposal areas of power plants, and reservoir shorelines (Mitchell 1998).[1] Primary foraging habitat consists of the shallow water of rivers, streams, lakes, and ponds with an abundance of small fishes (Bull and Farrand 1990). However, least terns nesting on sand islands in the lower Mississippi River will forage in adjacent waters exhibiting a wide range of depths (e.g., the main channel, side channels, sloughs, and tributaries) in response to variations in hydrologic cycles on the river (Renken and Dugger 1996).

Behavior. The least tern migrates along the Pacific, Atlantic, and Gulf Coasts and major river drainages in the United States to coastal habitats along Baja, California, southern Mexico, Central America, and South America (Thompson et al. 1997). Migratory routes have not been clearly defined; therefore, it is not known whether interior populations have different migration routes from coastal populations (Sidle and Harrison 1990). Interior least terns arrive at breeding grounds from late April to early June and remain for 4 to 5 months (Mitchell 1998). Birds tend to return to the vicinity of their hatching or former breeding sites (Smith and Renken 1990). The majority of juvenile least terns leave colonies within 3 weeks of fledging (Thompson and Slack 1984), and both adults and juveniles have usually departed by early September (Hardy 1957).

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1 Whenever cited, this document contains multiple references to the information provided.

Reproduction. Interior least terns are monogamous, nesting in colonies on islands, sandbars, beaches, salt flats, and man-made structures. Colonies may range in size from a few pairs to more than 2,000 pairs but are usually composed of 25 to 500 pairs of terns (Thompson et al. 1997). Courtship occurs at or near the nest site (Tomkins 1959) and includes nest scraping, postures, vocalizations, an aerial display referred to as the fish flight, and copulation (Hardy 1957). The nest is a scrape, or shallow depression, that holds two or three speckled or streaked olive-buff eggs (Mitchell 1998). The reproductive cycle requires approximately 50 days. Egg laying begins by late May; incubation is shared by both parents and lasts for 20 to 25 days. The precocial chicks hatch within one day of each other and are brooded for a week. Fledging occurs at three weeks, but parental care continues until juveniles leave the colony. Least terns commonly renest up to three times following nest or chick loss (Thompson et al. 1997). Renesting may occur as late as August in the lower Mississippi River Valley (Landin et al. 1985). Annual reproductive success varies greatly depending upon the site and seasonal environmental conditions, but the long life span (up to 25 years) of least terns may partly compensate for years of low reproductive success (Mitchell 1998). Interior populations should remain stable if the annual fledging rate is maintained at 0.5 fledgling per pair, the minimum value thought necessary for population maintenance (Smith and Renken 1993).

Reproductive success at a breeding site can be severely impacted by predation in any given year (Thompson et al. 1997). Primary mammalian predators are the red fox (*Vulpes vulpes*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), feral hog (*Sus scrofa*), domestic cat (*Felis catus*), and dog (*Canis familiaris*). Avian predators include crows (*Corvus* spp.), gulls (*Larus* spp.), great blue heron (*Ardea herodias*), black-crowned night heron (*Nycticorax nycticorax*), ruddy turnstone (*Arenaria interpres*), sanderling (*Calidris alba*), great horned owl (*Bubo virginianus*), peregrine falcon (*Falco peregrinus*), American kestrel (*F. sparverius*), northern harrier (*Circus cyaneus*), and loggerhead shrike (*Lanius ludovicianus*). Egg and chick predation occurs on the ground, whereas most adult predation occurs when parents leave the nest site or attempt to mob predators (Burger 1989).

Food habits. Least terns feed on a wide variety of small fishes found in shallow water. The most important fishes are topminnows (*Fundulus* spp.), shiners (*Notropis* spp.), stonerollers (*Campostoma* spp.), minnows (*Pimephales* spp.), mosquitofish (*Gambusia* spp.), bass (*Morone* spp.), shad (*Dorosoma* spp.), sunfish (*Lepomis* spp.), carpsuckers (*Carpiodes* spp.), and *Blonesox* spp. (Mitchell 1998). The red shiner (*Notropis lutrensis*), common carp (*Cyprinus carpio*), plains minnow (*Hybognathus placitus*), and channel catfish (*Ictalurus punctatus*) are also consumed by least terns nesting on Oklahoma salt flats (Schweitzer and Leslie 1996). Least terns nesting in riverine habitats usually forage within 100 ft (30 m) (Faanes 1983) to 820 ft (250 m) (Jernigan et al. 1978) of the colony, whereas those nesting on artificial sites away from the water (e.g., ash disposal sites or gravel pits) may fly 2 to 4 miles (3 to 6.5 km) to feed (Talent and Hill 1985). Least terns search for prey while flying low above the water's surface and plunge into the water to capture detected prey (Eriksson 1985). They eat the fish while flying or carry it to the nest to feed their mate and chicks (Atwood and Kelly 1984).

Impacts. Although natural flooding greatly impacts least terns nesting in the Mississippi Valley, the decline in interior populations has been attributed to habitat alteration and destruction. Channelization, irrigation, and reservoir construction have contributed to the elimination of much sandbar

nesting habitat in the Missouri, Arkansas, and Red River systems (Mitchell 1998). Dike construction along the LMR has created many sandbars on which nesting colonies are located (Landin et al. 1985, Rumancik 1989), but dike fields at other nesting sites have accreted sediment that creates a linkage to the shore, thus reducing prime nesting habitat (Smith and Stucky 1988). However, data collected by the Corps (USACE 1999) over a 15-year period along the LMR indicates that an abundance of nesting habitat is available to least terns along the river.

Changes in river flow to accommodate reservoir functions, such as barge traffic and hydroelectric power generation, create problems for nesting terns (Smith and Stucky 1988). Changes in seasonal riverflow patterns may reduce the available nesting habitat, especially when high flow periods extend into the normal nesting period (Schwalbach, Vandel, and Higgins 1988). Least terns must move further inland to nest on poorer quality sites (e.g., vegetated areas), thus reducing reproductive success. Human disturbance of nesting areas also reduces reproductive success, thus contributing to population decline (Smith and Renken 1990). Many of the larger rivers in the central United States have become centers for recreational activities, especially those with sandbars large enough to serve as beaches. Artificial nesting sites, such as sand and gravel pits, are also subjected to a high level of human disturbance.

Management. The recovery plan placed strong emphasis on predator management during the nesting season (Sidle and Harrison 1990). Suggested management measures for mammalian predators include trapping and removal of identified predators and erection of electric fences around nesting areas. Electric fences have been used to protect coastal populations of the least tern (Minsky 1980, Massey and Atwood 1982), and solar-powered electric fences have been built around nesting areas of inland populations in Oklahoma (Koenen, Utych, and Leslie 1996). A strobe light system has been used to reduce nocturnal predation by owls and night herons in Indiana (Johnson and Castrale 1993). Public use within nesting areas should be restricted and enforced during the breeding season, as disturbance caused by foot traffic and recreational vehicles can destroy eggs and chicks or inhibit territory establishment, feeding behavior, incubation, or courtship (Mitchell 1998). Since strict enforcement may be impractical, a public relations effort should be conducted to reach potential visitors to an active nesting area. The use of volunteer "tern wardens" (McCulloch 1982) or hired guards at times of anticipated excessive human activity in the area (Jackson and Jackson 1985, Burger 1989), local media coverage (Mayer 1993), and one-on-one contact with sportsmen have greatly enhanced efforts to protect restricted areas of nesting habitat. The recovery plan (Sidle and Harrison 1990) suggested managing riverflow regimes to protect and provide sandbar nesting habitat, but this may not be feasible for small areas. Methods that may be used to create or enhance habitat for interior least terns include the following: (a) creation of islands; (b) deposition of sand, gravel, and/or debris; (c) construction of nesting rafts; (d) eradication of rank vegetation on potential nest sites; (e) prescribed burning of vegetation; and (f) erection of sand drift fences (Mitchell 1998). Decoys may be used to attract least terns to abandoned or unoccupied colony sites if there is sufficient space for pioneering pairs (Kotliar and Burger 1984).

PIPING PLOVER (*Charadrius melodus*)

Distribution. The northern Great Plains breeding population of the piping plover extends from the alkali wetlands of southeastern Alberta through the Northern Great Plains across southern Saskatchewan and Manitoba, into southwestern Ontario and northwestern Minnesota (Haig 1992,

DeGraaf and Rappole1995) (Figure 2). Interior breeding range reaches south along river systems, particularly those associated with the Missouri River, in the prairie region of the United States, including northeastern Colorado, northwestern Oklahoma, northeastern Montana, North Dakota, South Dakota, Nebraska, and Iowa (Haig 1992). A breeding population also exists on the Great Lakes, but only on Lakes Michigan and Superior in northern Michigan and Wisconsin. The Atlantic Coast breeding population extends from New Brunswick, Prince Edward Island, Nova Scotia, Quebec and southern Maine south to Maryland, Virginia, and North Carolina (Haig 1992). Wintering range is not fully known, but most piping plovers appear to winter along beaches from Florida to northern Mexico (Nicholls and Baldassarre 1990a). Individuals have been reported sporadically along the Mexican coast to the northern Yucatan Peninsula, and in the Bahamas, Barbados, Bermuda, Cuba, Jamaica, Puerto Rico, Virgin Islands and the West Indies (Haig and Oring 1985). Some populations winter along the Atlantic coast from Virginia to the Florida Keys (Haig 1992).

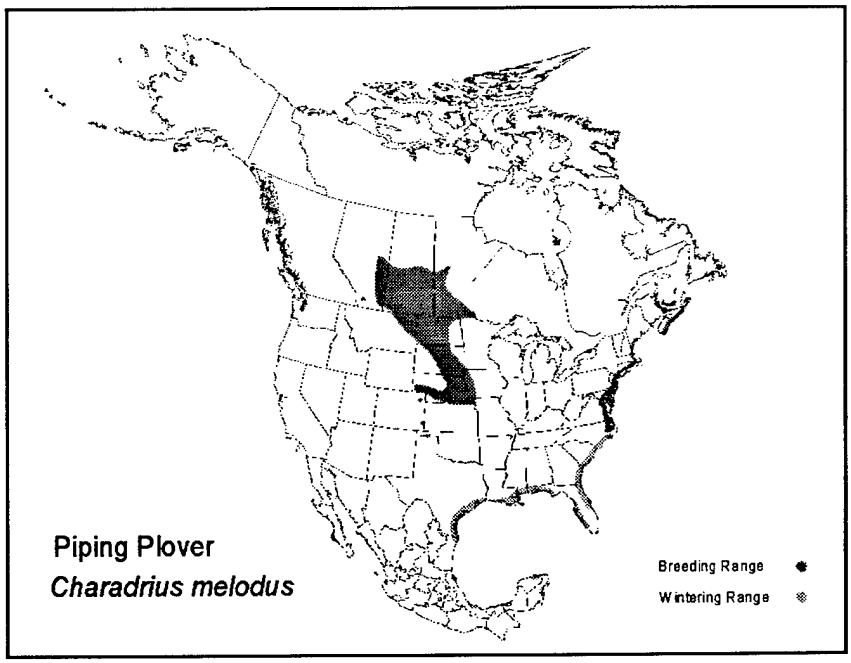

Figure 2. Range of the piping plover in North America and Mexico

Status. The piping plover was listed in 1986 under the Endangered Species Act (1973) as endangered in the Great Lakes population. Populations breeding along the Atlantic Coast and in the Northern Great Plains were listed as threatened (USFWS 1996) (Table 1). At the time of listing, only 800 pairs were known to exist in the three major populations combined. With increased survey efforts and implementation of recovery plans, the number of detected breeding pairs increased to 1,350 by 1995 in the conterminous United States. Between 1986 and 1995, the Atlantic Coast population increased by over 400 pairs, and total population in the United States and Canada in 1996 was estimated at 5,913 pairs: 2,581 on the Atlantic Coast, 3,284 in the Northern Great Plains (U.S. and Canada), and 48 in the Great Lakes (Plissner and Haig 2000). Currently, two recovery plans are in effect; one for the Great Lakes/Northern Great Plains populations and one for the Atlantic Coast population (USFWS 1988, 1996). Similar plans have been implemented for populations in Canada (Canadian Wildlife Service 1989). The recovery goal for the Northern Great Plains population is to achieve 2,550 pairs (Haig and Oring 1988a), but under reproductive

parameters known in the early 1990s, the populations are expected to decline by 7 percent (Ryan, Root, and Mayer 1993). Census data for the United States and Canadian Great Plains between 1991-96 showed that the population declined by 5 percent. Despite projected declines, populations during this period increased by 31 percent along the Atlantic Coast and 20 percent in the Great Lakes region. In 1994, the Piping Plover Recovery Team recommended that the status of the Northern Great Plains population be changed from threatened to endangered (Sidle and Faanes 2000), but that change has not yet been officially proposed.

Habitat. During the breeding season, interior piping plovers will nest in alkali lakes and ponds using exposed salt-encrusted areas of sand, gravel, or mud with little or no vegetative growth (Haig 1992, USFWS 1996). Although unstable due to unpredictable floods and droughts, alkali lakes support between two-thirds and three-fourths of the interior population (Murphy et al. 2000). Sand and gravel beaches on rivers, as well as natural or dredged islands and sandbars are used in riverine settings. Nesting areas along the Atlantic coast are sparsely vegetated, sandy beaches that are adjacent to sand dunes. Nests are almost always near a shoreline or water's edge where foraging occurs. Along interior and coastal beaches or shorelines, these plovers often nest in association with the least tern (*Sterna antillarum*), common tern (*S. hirundo*), or arctic tern (*S. paradisaea*) (Haig 1992). In the Great Plains, individuals nest in exposed, sparsely vegetated areas on the shores of lakes and rivers, often adjacent to pastures and rangelands, and are frequently observed with killdeer (*Charadrius vociferus*), spotted sandpipers (*Actitis macularia*), and American avocets (*Recurvirostra americana*) (Haig 1992). During migration and wintering seasons, piping plovers continue to depend on beach and alkali mudflats and spend winters mainly along the Gulf of Mexico and Atlantic coasts (Nicholls and Baldassarre 1990a). During the winter, these birds are often associated with similar species including sanderlings (*Calidris alba*), least sandpipers (*C. minutilla*), western sandpipers (*C. mauri*), semipalmated plovers (*Charadrius semipalmatus*), and snowy plovers (*Charadrius alexandrinus*) (Nicholls and Baldassarre 1990b, Haig 1992).

Behavior. Spring migration occurs from early February through May, and fall migration occurs from mid-summer (July) through mid-November. Detections of this species during migration are uncommon, and most individuals probably migrate nonstop to the wintering areas (Haig 1992). The species migrates in groups of three to six individuals and rarely in groups of ten or more. Major stopover sites in Bolivar Flats and San Luis Pass, TX; Cape May, NJ; and Wallops Island, VA, may have flocks of more than 100 individuals. During the spring, peak migration occurs in March and birds reach breeding areas in Manitoba and North Dakota by April. Males and females usually arrive together on the breeding areas. On the Atlantic coast, peak migration occurs in late March and early April. Individuals begin fall migration as early as late June or July, especially in years when breeding is disrupted by adverse weather conditions. After breeding, females generally leave the grounds first, followed by unpaired males, males with fledglings, and juveniles (Haig 1992).

Reproduction. Male piping plovers begin establishing and defending territories in April (USFWS 1996; Patterson, Fraser, and Roggenbuck 1991). Typical aggressive displays between competing males include long sprint-like runs up to 300 ft (100 m), aerial leaps and hovering, and continuous vocalizations (Cairns 1982). Males also perform elaborate courtship displays that include advertising their territory to females with dizzying flights, and pre-copulatory actions such as the nest-scraping display, tilt display, and the tossing of shell fragments (USFWS 1996, Haig 1992). The piping plover is generally monogamous but may shift mates after a nest failure (Haig

and Oring 1988a). Although most individuals breed after 2 years of age, some have been observed nesting in their first year. Nesting densities range from 0.2 to 2.1 pairs per 0.6 mile (1 km). The nest of the piping plover is usually a shallow depression scraped into the loose substrate that can take less than a minute to make; yet birds may take 5 to 10 days to settle into one scrape (Haig 1992). Common nest substrates include sand, gravel, and shells. Birds usually fledge one brood per year, but may make several nesting attempts per season after successive failures. In rare circumstances, pairs may fledge more than one brood (MacIvor 1990, Haig 1992). Peak nesting generally occurs from early April through early June, but birds may begin nesting in early April or late July. Clutch size is around four eggs and incubation generally takes from 25 to 28 days (Haig 1992, USFWS 1996). Young are precocial and depart from the nest after a few hours, but adults will continue to brood young up to 21 days beyond hatching. Young attain flight ability and independence from parental care after approximately 28 to 32 days. Annual reproductive success depends on the area but tends to range between 0.3 and 2.1 chicks fledged per pair per year (Haig 1992). Success rate is lower in the Great Plains; these populations may not be breeding sufficiently to offset mortality (Haig and Oring 1988b).

Food Habits. Piping plovers feed in the intertidal portions of beaches, mudflats, sandflats, and shorelines of coastal ponds, rivers, alkali lakes, and salt marshes (USFWS 1996). During the day, birds often forage within 15 ft (5 m) of a shoreline, but may move farther inland during the evening (Haig 1992). Foraging habitat varies with time of season and the age, sex, and breeding stage of the individuals. Diet consists mainly of freshwater, marine, and terrestrial invertebrates. Marine worms, Dipteran larvae, beetles and other insects, crustaceans, and molluscs form the bulk of the bird's diet (Haig 1992, USFWS 1996). During the winter, birds focus foraging activities in coastal mudflats or sandflats exposed during low tide. Foraging activity occurs alone or in small flocks and continues through daylight hours into the night (Haig 1992).

Impacts. During the late 19th century and extending into the early part of the 20th century, market hunting of migratory birds, including piping plovers, constituted the greatest threat to viable populations. Hunting ceased to be a factor after the passage of the Migratory Bird Treaty Act (1918) (USFWS 1996). Since the 1940s, the major factors involved in the decline of this species have been habitat loss through urbanization and continued disturbance of nesting areas by human activities. By the early 1970s, prime breeding areas along the Atlantic coast were over 40 percent urbanized. Breeding birds are known to avoid parking lots and concrete walkways, hence the construction of such features may severely degrade potential nesting habitat. Habitats are also degraded by beach stabilization efforts that involve dredging breachways, building breakwaters and planting dune areas. Urban development along coastal areas has created a demand for construction of artificial dunes, yet these areas are often poor habitat for breeding piping plovers and may lower suitability of existing habitats. Protection of public beaches by the use of jetties and other structures may accelerate erosion of nesting habitat farther down the coast. Loss of habitat may be offset on the accreting side of the jetties; however, these areas also create habitat for plant succession, suggesting that suitability for breeding piping plovers may be short-lived without management (USFWS 1996).

Inland populations, especially along rivers, have lost habitat through reservoir construction, dredging practices that increase water flow and erode beach habitat, and untimely water releases from locks and dams that flood nesting areas during peak breeding periods (Sidle and Faanes 2000,

Swaringen 2000). Natural breeding habitat for piping plovers along the Missouri River is estimated to have decreased 80 percent since the 1950s due to construction of dams and dredging operations (Swaringen 2000). Along the Platte River in Nebraska, populations have steadily decreased due to habitat alterations, including water drawdowns that permit encroaching vegetation to become established on once-productive shorelines and sandbars (Sidle and Faanes 2000). Populations breeding along shores of alkali lakes in the Great Plains are subject to droughts and floods that occur regularly, such that these populations show great year-to-year variability in reproductive success. During good years, however, reproductive success on alkali lakes is often higher than on any other part of the species range. With continued degradation of nesting habitat along rivers and other interior areas, successful breeding on alkali lakes has become more important in maintaining viable inland populations on the Northern Great Plains (Murphy et al. 2000).

Harassment of birds by people, pets, and vehicles may disrupt breeding activities and lower nest success, particularly in the Great Lakes and Atlantic Coast populations (McIvor 1990, Haig 1992). Predation has a major negative impact on nesting success on all breeding areas. Predominate predators include the red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), Norway rat (*Rattus norvegicus*), opossum (*Didelphis virginiana*), American crow (*Corvus brachyrhynchos*), common raven (*Corvus corax*), gulls (*Larus spp.*), common grackle (*Quiscalus quiscula*), American kestrel (*Falco sparverius*), domestic cat (*Felis catus*), and dog (*Canis familiaris*) (USFWS 1996). Coastal areas subjected to intense storms and hurricanes that remove vegetation and create new inlets and pools may actually increase nesting densities of piping plovers during subsequent years (Wilcox 1959).

Management. Protection of sandy beaches and mudflats from urbanization and human disturbances is a primary feature of successful management for piping plovers. Both coastal and inland populations often use ephemeral, sparsely vegetated areas that change with the course of succession and other environmental forces, such that habitat use by these plovers is constantly changing from year to year. Conservation efforts currently focus on identifying new and current nesting areas, monitoring success of active nests, creating barriers from disturbance for existing breeding sites, vegetation and water control, and the use of predator exclusion devices on nest sites (Haig 1992, Dooling 1997). Populations are closely monitored through an international effort including 26 states, 3 Canadian provinces, and 7 countries (USFWS 1996). In the northern Great Plains region, partnerships between the Corps, Bureau of Land Management, and the USFWS have accomplished tasks formulated by the recovery plans, including breeding surveys, monitoring and assessing reproductive success, predator control using predator exclusion devices, minimizing human disturbance, managing water levels, and developing overall river management plans, particularly along the Missouri River. These Federal agencies are also assisted by state game and fish departments and The Nature Conservancy.

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