

PIPING PLOVER ASSESSMENT

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ENDANGERED AND THREATENED SPECIES GROUP

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INTRODUCTION

Since 1968, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has aggressively pursued development and refinement of wildlife species assessments and implementation of cost-effective comprehensive programs that support selected goals and objectives for the next 15 years. Assessments are based upon available information and the judgments of professional wildlife biologists responsible for individual species or groups of species. Precise data may not always be available or are too limited for meaningful statistical analysis; however, many trends and indications are sometimes clear and deserve management consideration.

The assessment has been organized to group information in a user-meaningful way. The Natural History section discusses biological characteristics of the species that are important to its management. The Management section contains history of regulations and regulatory authority, past management, past goals and objectives, and current management. The Habitat and Population sections address historic, current, and projected conditions for the species. The Use and Demand section addresses past, current, and projected use and demand of the species and its habitat. A Summary and Conclusions sections summarizes the major points of the assessment.

NATURAL HISTORY

Description

The piping plover (*Charadrius melodus*), whose name describes its melodic call, is a small Nearctic shorebird approximately 17cm (7in) long with a wingspread of about 28 cm (15 in) (Palmer 1967). Breeding birds have white underparts and pale brown back and crown, white rump, and black upper tail with a white edge. In flight, each wing shows a single , white stripe with black highlights at the wrist and along the trailing edges. Breeding plumage includes a single black breastband, which is often incomplete and a black bar across the forehead. The black breastband and forehead bar are usually more pronounced in breeding males than females (Wilcox 1939). Legs and bill are orange in summer with a black tip on the bill. The demarcation between black and orange on the bill is generally more distinct in breeding males than females.

In winter, the birds lose the black bands, the legs fade from orange to pale yellow and the bill becomes mostly black. Palmer (1967) provides further details on the plumage and other characteristics of piping plovers.

Distribution

The piping plover is endemic to North America, where it breeds in 3 geographic regions. One population, estimated at 1,300 - 1,500 pairs, breeds on sandy beaches along the Atlantic Coast, from Newfoundland to South Carolina. A second population historically nested on sandy beaches throughout the Great Lakes, but has declined

dramatically to less than 20 pairs and now occurs at only a few sites. A third population of approximately 1,400 pairs breeds along major river systems and alkali lakes of the northern Great Plains.

Taxonomy

Piping plover subspeciation has been debated by taxonomists for a number of years. The most recent editions of the Checklist of North American Birds (American Ornithologists' Union 1957, 1983) recognize two subspecies of piping plover: *Charadrius melodus melodus* (Atlantic Coast) and *C. m. circuminctus* (inland birds). Designation of two subspecies is based largely on arguments by Moser (1942) that the extent of breast bands differs between inland and Atlantic Coast birds. Wilcox (1959), however, considered the subspecies *circuminctus* of dubious validity, noting that 18% of the birds he trapped on Long Island had complete breast bands. More recent electrophoretic analyses have not detected genetic differences among local or regional populations in Saskatchewan, Manitoba, North Dakota, Minnesota and New Brunswick (Haig and Oring 1988).

Reproduction and Recruitment

Piping plovers along the Atlantic Coast nest on coastal beaches above the high tide line, sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes. They may also nest on areas where suitable dredge spoil has been deposited. Nest sites are relatively flat with substrates ranging from fine sand to

mixtures of sand, shells, pebbles, or cobble. Nests occur most commonly at sites with little or no vegetation, but may be found in moderately-dense stands of beach grass (*Ammophila brevicata*).

Piping plovers return to breeding sites along the Atlantic Coast during mid-March to late April (Wilcox 1959, MacIvor 1990, Cairns 1977). In Maine, piping plovers arrive on the breeding grounds as early as late March and begin establishing territories during April (J. Jones, Maine Audubon Society, pers. com). Adult birds often return to beaches where they previously nested (Wilcox 1959, Haig 1985).

Some plovers may arrive on the breeding grounds already paired, but most apparently pair on the breeding grounds (Cairns 1977). Piping plovers are monogamous, but have been known to change mates between years (Wilcox 1959, Haig and Oring 1988, MacIvor 1990) and less frequently between nesting attempts in a given year (Haig 1992). Some individuals breed as early as one year of age (MacIvor 1990, Strauss 1990, Haig 1992), but the rate at which this occurs is unknown.

Upon arrival on the breeding grounds, males establish territories which they defend against other males. Their courtship is elaborate, consisting of elliptical and figure-8 flights performed over nesting territories. Courtship is also accompanied by much vocalization, scraping shallow depressions in the sand, tossing shell fragments, and displays (Cairns 1982).

Nests are shallow depressions or scrapes in the sand on the high beach and are frequently lined with bits of shell or pebbles (Wilcox 1959, Cairns 1982, MacIvor 1990, Strauss 1990). Clutch size for an initial nest attempt is usually four eggs, one of which is laid every other day. Eggs are light buff in color with fine, blackish-brown spots. Full-

time incubation usually begins with the completion of the clutch. Incubation averages 27-30+ days and is shared about equally by both sexes (Wilcox 1959, Cairns 1982). Incubation periods vary, and may be influenced by the length of time birds are kept off their nests by intruders (Wilcox 1939).

Piping plovers generally fledge only a single brood per season, but may renest several times if previous nests are lost, or infrequently, if a brood is lost within several days of hatching (Wrenn 1991, Goldin 1994, Rimmer 1994). One female on Cape Cod completed 5 nesting attempts, and laid a total of 19 eggs in a season (MacIvor 1990). Renests often occur at the same site, but movements between sites have been recorded (MacIvor 1990).

Adult piping plovers respond to potential predators (avian and mammalian) in their territories by displaying a variety of distraction behaviors, including squatting, false brooding, running, and injury feigning. Distraction displays may occur at any time during the breeding season, but are most frequent and intense around the time of hatching (Cairns 1982). Cairns (1982) reported that the average distance at which incubating plovers in Nova Scotia left the nest when approached was 43 m, but ranged from 5 - 85 m.

Peak nest initiation in Maine is mid-May to early June (J. Jones, Maine Audubon, pers.comm.). Although nests may be initiated as late as July 25, few nests hatch after July 15, and the latest recorded hatch is July 31 in Massachusetts (MacIvor 1990).

Eggs hatch within a few hours of each other. Hatching success (% of eggs laid which hatch) varies greatly between sites: 91% on Long Island between 1937 and 1938 (Wilcox 1959); 79% at Cadden Beach, Nova Scotia in 1975 and 72% in 1976 (Cairns

1977); 16-41% at study sites in Massachusetts during 1985-87 (MacIvor, et.al. 1987). Hatching success in Maine averaged 64% from 1993-99 (range 44 - 74%) (Maine Audubon, unpub. data).

Chicks are precocial, remaining in the nest only until their down is dry. Wilcox (1959) remarked on the rapidity with which the chicks run and their ability to swim. Adults accompany young until they are fledged, and families usually remain in the general vicinity of the nest site (Wilcox 1959). Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Goldin 1990, MacIvor 1990, Howard et.al. 1993). First juvenile plumage replaces natal down after about 28 days and young are able to fly after 25-35 days (Wilcox 1939 and 1959, Cairns 1977, MacIvor, et.al. unpublished data). After fledging, adults and young are non-territorial and congregate at feeding areas prior to southward migration (Cairns 1977).

Fledging success (% of chicks hatched that reach the age of 25 days or flight) also varies widely, but tends to be higher than hatching success. Fledging success at study sites in Massachusetts ranged between 43 and 76% from 1985-1987 (MacIvor, et.al. 1987) and averaged 58% in Maine (range 50 - 68%) from 1993-99 (Maine Audubon, unpub. data). Productivity, measured as number of chicks fledged per breeding pair, also varies greatly between nesting sites. Maximum potential productivity is 4.0 chicks/pair, but is seldom achieved. Average 1988-1998 productivity for Atlantic Coast states ranged from 0.50 (North Carolina) to 1.88 (Maine) fledged/nesting pair (Table 1.).

Table 1. Summary of Piping Plover Productivity Estimates for the U.S. Atlantic Coast, 1988 - 1998.

STATE/REGION	CHICKS FLEDGED/PAIR											
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998 P	1988-1998 AVG ^Q
Maine	0.75	2.38	1.53	2.50	2.00	2.38	2.0	2.38	1.63	1.98	1.47 (60)	1.88(369/369)
New Hampshire	-	-	-	-	-	-	-	-	-	0.60	2.40 (5)	1.50 (10/10)
Massachusetts	1.29	1.59	1.38	1.72	2.03	1.92	1.80	1.62	1.36	1.32	1.50 (471)	1.57 (3135/3304)
Rhode Island	1.60	1.47	0.90	0.77	1.55	1.80	2.0	1.68	1.56	1.34	1.13 (46)	1.44 (356/362)
Connecticut	1.70	1.79	1.63	1.39	1.45	0.38	1.47	1.35	1.31	1.69	1.05 (21)	1.42 (338/338)
NEW ENGLAND	1.32	1.68	1.38	1.62	1.91	1.85	1.81	1.67	1.40	1.38	1.46 (603)	1.58 (4208/4383)
New York	1.24	1.02	0.80	1.09	0.98	1.24	1.34	0.97	1.14	1.36	1.09 (218)	1.13 (1479/2346)
New Jersey	0.94	1.12	0.93	0.98	1.07	0.93	1.16	0.98	1.00	0.39	1.09 (93)	0.96 (1322/1337)
NY-NJ REGION	1.03	1.09	0.88	1.04	1.03	1.08	1.25	0.97	1.07	1.02	1.09 (311)	1.05 (2801/3683)
Delaware	0	2.33	2.00	1.60	1.00	0.50	2.5	2.0	0.50	1.00	0.83 (6)	1.35 (46/46)
Maryland	0.52	0.90	0.78	0.41	1.00	1.79	2.41	1.73	1.49 ^r	1.02 ^s	1.30 (56)	1.30 (372/372)
Virginia	1.02	1.16	0.65	0.88	0.59	1.45	1.65	1.00	1.54	0.71	1.01 (84)	1.06 (646/1167)
North Carolina		0.59	0.43	0.07	0.42	0.74	0.36	0.45	0.86	0.23	0.61 (46)	0.50 (406/529)
SOUTHERN REGION	0.85	0.88	0.72	0.68	0.62	1.18	1.37	1.06	1.34 ^r	0.68	0.99 (192)	0.98 (1470/2114)
U.S. AVERAGE	1.11	1.28	1.06	1.22	1.35	1.47	1.56	1.35	1.30 ^r	1.16	1.27 (1106)	1.30 (8479/10180)
ATLANTIC CANADA	1.65	1.58	1.62	1.07	1.55	0.69	1.25	1.69	1.72	2.10	-	1.47 (878/2376)

^PParentheses indicate the number of pairs on which productivity is based. Number of pairs reflected in 1988-1995 data, by year, may be found on page 25 of the Revised Recovery Plan (USFWS 1996), while the number of pairs reflected in 1996 and 1997 productivity is provided in the respective Status Updates for those years (USFWS 1997, 1998).

^QParentheses denote number of pairs on which productivity is based/estimated number of pairs in the state or region between 1988 and 1998.

^rReflects correction in 1996 Maryland productivity from 1996 Status Update.

^sChicks surviving to 25 days projected from data collected through day 15 based on linear regression analysis. For further information see NPS and Maryland DNR (1997).

Population modeling by Melvin and Gibbs (1994) yielded an estimate of 1.24 chicks per pair needed to maintain a stationary population. However, modeled populations with this productivity rate remained relatively vulnerable to extinction (35% probability of extinction within 100 years for a population of 1,200 pairs). Modeling revealed that extinction probabilities are very sensitive to changes in productivity.

Survival and Longevity

Resightings of 103 adult plovers and 61 chicks color-banded on outer Cape Cod from 1985-1988 yielded estimates of survival of 0.74 for birds > 1 year old and 0.48 for chicks (U. S. Fish and Wildlife Service 1996). Loegering (1992) estimated survival rates of 0.67 - 0.72 for 53 adults and 0.41 for 29 chicks banded in Maryland from 1987-1989. R. Cross (Virginia Department of Game and Inland Fisheries, unpublished data) estimated annual survival rates of 0.75 and 0.83 for adults and 0.44 for chicks. Survival rates have not been determined in Maine. Population viability modeling (Melvin and Gibbs 1994) shows that extinction probabilities are sensitive to changes in survival rates.

Feeding

Prior to establishing and defending territories in early spring, and after the young fledge in July, local birds and migrants feed at areas not being defended by territorial pairs. Shortly after returning from migration, piping plovers defend portions of waterfront beach as feeding territories which are usually, but not always, contiguous with their nesting territories (Cairns 1977). Feeding areas include intertidal portions of

ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shore lines of coastal ponds and salt marshes (Gibbs 1986, Coutu et. al. 1990, Loegering 1992). Studies have shown that the relative importance of feeding habitat types may vary by site (Gibbs 1986, Loegering 1992, Elias-Gerken 1994) and by stage of the breeding cycle (Cross 1990). Feeding of adults and chicks may occur during all hours of the day and night (Burger 1994) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993). Plovers have been observed eating marine worms, fly larvae, beetles, crustaceans, mollusks and other invertebrates (Bent 1929, Cairns 1977). The relationships between availability and quality of feeding habitat and nest site selection are poorly understood.

Migration

Migration patterns of Atlantic Coast piping plovers are poorly understood. Both spring and fall migration routes are believed to follow a narrow strip along the Atlantic Coast. Sightings away from the outer beaches, either inland or offshore, are rare. Northward migration occurs during February, March and early April. Southward migration peaks during late July and September, although transient birds may be sighted during October. Information on piping plover migration is contained in Bent (1929), Griscom and Snyder (1995), Cairns (1997), Raithel (1984), and Tull (1984).

Wintering

There is growing information on wintering distribution and ecology of Atlantic Coast piping plovers. Band recovery and sightings of color-banded birds suggest that most piping plovers which breed on the Atlantic Coast winter from North Carolina south

to Mexico and into the Bahamas and the West Indies. Few piping plovers banded on Atlantic Coast breeding sites have been sighted on the Gulf Coast (Haig and Oring 1988). The most comprehensive survey to date was the 1991 International Piping Plover Census, which tallied a total of 3,451 plovers, the largest number of birds ever accounted for during the winter period (Haig and Plissner 1993). While approximately 63% of the known adult plovers were observed during this survey, a large number were still unaccounted for. The barrier islands off Georgia and South Carolina seem to host the largest concentrations of wintering birds. The large proportion of birds found in Louisiana and Texas suggests the possibility that more birds from the Atlantic Coast breeding population may be wintering on the Gulf Coast than previously surmised.

MANAGEMENT

Regulatory Authority

The piping plover is protected from take and harassment by two Federal statutes: the Migratory Bird Treaty Act of 1918 and the Endangered Species Act of 1973. In 1986, the piping plover was listed as Endangered (Great Lakes population) and Threatened (Atlantic Coast and Great Plains populations) by the U.S. Fish and Wildlife Service, under provisions of the Endangered Species Act.

The U.S. Fish and Wildlife Service has not designated Critical Habitat for the Atlantic Coast population of piping plovers. Critical Habitat is legally defined in the Endangered Species Act as that portion of the environment that is considered essential for the continued existence of endangered or threatened species. Activities funded, authorized, or carried out by Federal agencies are prohibited in areas designated as Critical Habitat if those activities will adversely affect the species for which Critical Habitat was designated.

At the state level, Maine's Endangered Species Act of 1975 also protects the piping plover from take or harassment. The piping plover is classified as endangered by the Maine Department of Inland Fisheries and Wildlife. A 1988 amendment to the Maine Endangered Species Act authorizes the Maine Department of Inland Fisheries and Wildlife to designate Essential Habitat that is critical to the conservation of endangered and threatened species, and to promulgate and enforce guidelines for the protection of Essential Habitat. State agencies and municipal governments may not permit, license, fund, or carry out projects that significantly alter habitats identified as

essential or that violate protection guidelines. In 1994, Piping Plover and Least Tern Essential Habitat was designated for 9 nesting, feeding, and brood rearing areas.

Three additional areas were designated in 1998 (Table 2).

Since the listing of the piping plover as a federally threatened species, direct responsibility for authorization of capture, banding, construction of enclosures, or other activities controlled by the U.S. Endangered Species Act has been transferred from the U.S. Fish and Wildlife Service to state fish and wildlife agencies. Authorization can be granted through a letter to appropriate researchers or managers designating them agents of the state for purposes of conducting specific research or management actions. Actions requiring authorization include, but may not be limited to, capture, banding, installation of enclosures, and moving nests. Habitats of endangered and threatened species, including the piping plover, potentially receive regulatory oversight by the Maine Department of Environmental Protection (DEP) under Significant Wildlife Habitat provisions of the Natural Resources Protection Act (NRPA) of 1988. To date, Significant Wildlife Habitat for piping plovers has not been defined or designated by MDIFW and DEP. Also, Maine's Comprehensive Growth Management Act mandates MDIFW to provide information on rare species habitats to the Department of Economic and Community Development for use by towns for comprehensive planning purposes.

Past Goals and Objectives

Goals and objectives for managing piping plovers in Maine were established through recommendations made to MDIFW by a public Endangered Species Working Group. The goals and objectives were approved by MDIFW's Commissioner and

Table 2. Piping plover / least tern nesting, feeding and brood-rearing Essential Habitat in Maine.

Region	Essential Habitat	Site	Town Name(s)	7.5' Quad(s)	Ownership	Use by Piping Plovers (# pairs) 1981-1994	Use by Least Terns (# pairs) 1 981-1 994
A	PPLT 01	Ogunquit Beach	Ogunquit Wells	Wells York Beach	Private	1 pr. 1 986 -88	-
A	PPLT 02	Crescent Surf and Laudholm Beach	Kennebunk Wells	Wells	Private, Town	1-5 prs. 1981-94	1-65 prs. 1 981-93, 40 prs. 1994
A	PPLT 03	Goose Rocks Beach and Batson River	Kennebunkport	Biddeford	Private	0-2 prs. 1981-93, 4 prs. 1994	0-57 prs. 1977-93
A	PPLT 04	Pine Point and Western Beach	Scarborough	Prouts Neck	Private	1-3 prs. 1981, 1987, 1991, 1992, 1993, 5 prs. 1994	1 pr. 1 986, 8 pr. 1987
A	PPLT 05	Seawall, Popham and Hunnewell Beaches	Phippsburg	Small Point	Private, State, TNC	2-1 5 prs. 1 981 -93, 1 4 prs. 1994	4-72 prs. 1 977-93, 25 prs. 1 994
B	PPLT 06	Reid State Park	Georgetown	Boothbay Harbor	State, Private	1-3 prs. 1981-93, 4 prs. 1 994	0-32 prs. 1 981-93, 1 0 prs., 1 994
A	PPLT 07	Ram Island	Cape Elizabeth	Cape Elizabeth Prouts Neck	Private	1 pr. 1992-94	-
A	PPLT 08	Ocean Park	Old Orchard Beach Saco	Biddeford	Private	1 pr. 1993, 1994	-
A	PPLT 09	Higgins Beach	Cape Elizabeth Scarborough	Prouts Neck	Private	2 prs. 1993, 1 994	-
New Sites:							
A	PPLT 1 0	Wells Beach	Wells	Wells	Private	1 pr. 1994, 2 prs. 1 995, 5 prs. 1 996	3 prs. 1 981
A	PPLT 1 1	Fortunes Rocks Beach	Biddeford	Biddeford Pool	Private	1 pr. 1 995, 2 prs. 1 996	-
A	PPLT 1 2	Scarborough Beach	Scarborough	Prouts Neck	Private	1 pr. 1 995, 2 prs. 1 996	-

Total # New EHs = 9

Advisory Council on May 18, 1990. These goals and objectives are interim in nature and are milestones toward ultimate recovery goals, which have yet to be established for this species.

Goal: Increase the piping plover population, and the number and quality of nesting sites in Maine.

Population Objective: Increase the number of nesting pairs of piping plovers to at least 20 distributed at all available breeding sites in at least 3 of the prior 5 years by 1995.

Nesting Habitat Objective: Increase the number of active nesting sites to at least 7 in at least 3 of the prior 5 years by 1995.

Productivity Objective: Increase the average annual productivity to at least 1.5 fledged chicks per nesting female per year at all sites with a statewide average of at least 2.0 fledged chicks per nesting female by 1995.

Past and Current Management

Recovery efforts on behalf of the piping plover in Maine and elsewhere along the Atlantic Coast are coordinated by the U.S. Fish and Wildlife Service, and by the U.S. Atlantic Coast Piping Plover Recovery Plan (Dyer et.al. 1988). In 1996, this recovery

plan was revised and new recovery objectives were established (U.S. Fish and Wildlife Service 1996).

Active monitoring and management of breeding piping plovers in Maine has been done primarily by biologists with the Maine Audubon Society since 1981. However, as the population has grown significantly in the late 1990's, Wells Estuarine Reserve, Wells volunteers, Rachel Carson National Wildlife Refuge and the U. S. Fish and Wildlife Service have all contributed to management. Significant financial support for these activities has come from the Maine Department of Inland Fisheries and Wildlife, the U.S. Fish and Wildlife Service, Maine Audubon Society, Outdoor Heritage Fund, and The Nature Conservancy (TNC). Management activities include population surveys, monitoring of reproductive success and limiting factors, protecting nests with warning signs and fencing, public education, reducing sources of predation, and working with landowners. In 1986, TNC began active management of plovers at Seawall beach. In 1996, Audubon and TNC began to jointly hire biologists to monitor and manage all sites.

In 1988, management included, for the first time, use of wire exclosures to prevent nest predation by mammalian and avian predators. In 1996, MDIFW and Audubon biologists began using electric fencing to deter predators at some plover sites. In 1997, interpretive signs designed by MDIFW were installed at all piping plover nesting areas. In 1996, in cooperation with Maine Department of Conservation, MDIFW began experimental predator control at Reid State Park, and several red foxes were removed in late winter. Night observations at plover and least tern nesting sites were conducted in 1999 and 2000 to deter predators. It is likely that the nesting population of

pipng plovers in Maine would be substantially smaller if these intensive management actions were not taken.

Beginning in 1995, all landowners in the vicinity of plover nests were contacted by Audubon and provided with a fact sheet and newsletter about plover conservation. At mid-nesting and post-nesting, each landowner is contacted again with a letter of thanks and a newsletter. Information packets are distributed to beach-front rental units. Training sessions are held by Audubon each spring for volunteer beach monitors. Public speaking engagements are regularly held with beach associations. Meetings are held with town managers prior to, and during, the nesting season (Jones et. al. 1997).

In 1999, MDIFW and USFWS worked with residents in the town of Wells to develop a beach management plan for Wells and Drakes Island beach in lieu of designating Essential Habitat. The plan, first of its kind in Maine, outlines recommendations for beach management to avoid incidental take of plovers, protocols for municipal activities on the beach (beach cleaning, garbage removal, and beach nourishment), and provides for local volunteers to assist with plover management.

Blodget and Melvin (1996) provide an overview of piping plover management in the Northeast. More details on piping plover management in Maine are outlined in the Piping Plover Management System.

HABITAT ASSESSMENT

Atlantic Coast Habitat

The trend in habitat for piping plovers along the Atlantic Coast during the past 100 years has been one of loss. Habitat has been physically lost due to building on, and stabilizing of, beaches and dunes. Habitat has become functionally unavailable to plovers because of disturbances and direct mortality caused by human recreational use of beaches (Wilcox 1959, Raithel 1984, Dyer et al., 1988).

Maine Habitat

The trend in breeding habitat for piping plovers in Maine has also been one of loss. Although not documented, historic nesting at Moody Beach, Wells Beach, Old Orchard Beach, Pine Point, and Biddeford Pool probably collectively supported >50 nesting pairs of piping plovers. Plovers no longer nest at many of these sites, probably because the habitat has been so severely degraded by construction of houses and seawalls on the dunes and berms of these beaches and because of associated human disturbance.

Over the past 25 years, physical loss of habitat has continued, but at a slower rate than has functional losses. Functional loss of habitat has likely increased during this period as result of increasing recreational use of beaches by people and pets.

Past Habitat

Sandy beaches and dune systems in Maine are restricted almost exclusively to the southern one-third of the coast. East of the mouth of the Kennebec River, the coastline is primarily rocky, and beaches tend to be small, narrow, and composed largely of rocks and cobble.

Of an estimated 31 miles of suitable piping plover nesting habitat that likely existed in Maine prior to European settlement, only 8+ miles are currently used (Table 3). Many miles of historic habitat are now unsuitable because of physical alteration from seawalls, jetties, piers, boardwalks, homes, commercial buildings, parking lots, and use of snow fences to stabilize or construct dunes. Much of the habitat that is suitable has become functionally unavailable to breeding plovers because of disturbance and direct mortality to eggs and chicks caused by increasing use of beaches by people and pets over the past 50 years. At most beaches in Maine where piping plovers still nest, the carrying capacity of the existing habitat has been significantly reduced by intensive human recreational use.

If one imagines how all of the sandy beaches that now exist in Maine probably looked prior to European settlement, i.e., unaltered and undisturbed natural habitats, then it is not unreasonable to suppose that historically there was sufficient habitat in the state to support 100-200 pairs of piping plovers (Table 3). This estimate is based on the assumptions that 31 miles of suitable nesting habitat existed historically in Maine, and this habitat supported 3-7 nesting pairs of plovers per mile of beach.

Table 3. Estimates of historic and current piping plover nesting habitat in Maine.

Beach Name	Town	Historic habitat (miles of beach)	Currently Used habitat (miles of beach)	Maximum no. of plover nests observed 1981 - 98
Long Beach	York	0.57	-	-
Short Sands	York	0.19	-	-
Ogunquit Beach	Ogunquit	1.33	1.14	6
Moody Beach	Wells	1.14	-	-
Wells Beach	Wells	1.23	0.57	4
Drakes Island	Wells	0.57	0.19	1
Laudholm	Wells	0.57	0.19	2
Crescent Surf	Wells	0.57	0.28	5
Parsons	Wells	0.76	-	-
Kennebunk Beach	Kennebunk	0.38	-	-
Gooch's Beach	Kennebunk	0.57	-	-
Goose Rocks Beach	Kennebunkport	1.89	0.47	7
New Burn Cove	Kennebunkport	0.19	-	-
Horseshoe Cove	Kennebunkport	0.38	-	-
Fortune's Rock	Biddeford	1.99	0.38	3
Ferry Beach	Old Orchard Beach	2.37	-	-
Hills Beach	Biddeford	1.80	-	-
Ocean Park/Old Orchard Beach	Old Orchard Beach	2.94	0.19	1
Pine Point	Scarborough	1.33	0.57	3
Western	Scarborough	0.76	0.38	3
Scarborough Beach	Scarborough	1.42	0.38	3
Higgins Beach	Scarborough	0.57	0.09	5
Ram Island Area	Cape Elizabeth	0.28	-	-
Richmond Island Harbor Area	Cape Elizabeth	0.57	0.38	2
Crescent Beach	Cape Elizabeth	0.76	0.76	1
Morse Mt. / Sewall Beach	Phippsburg	1.52	1.52	9
Hunnewell Beach	Phippsburg	1.14	0.38	6
Popham Beach	Phippsburg	0.76	-	-
Popham Beach State Park	Phippsburg	1.14	0.38	8
Reid State Park - 1/2 mile	Georgetown	0.38	0.19	7
Reid State Park - mile	Georgetown	0.76	0.28	-
TOTAL		30.83	8.72	76

Current Habitat

It is difficult to determine the current potential carrying capacity of Maine beaches. Piping plovers are territorial nesters, but observed nesting densities in the Northeast are highly variable. In New York, Elias-Gerken (1994) noted densities of 0.2-2.1 pairs per kilometer of beach, but nests can be spaced much closer. Recent data from New England show that significant increases in breeding density can occur without declines in productivity. For example, in 1993, Seawall/Popham/Hunnewell Beaches supported 15 pairs with average productivity of 1.7 chicks/pair, where only 2 were recently recorded in 1981 (Jones et. al. 1996). Because plovers may be becoming more tolerant of human activity and adapting to nesting in developed habitats, a reliable habitat model for piping plovers has not been developed.

Habitat in Maine has supported as many as 60 pairs of piping plovers in 1996 and 1998. The carrying capacity of the habitat to support piping plovers fluctuates annually with dynamic coastal processes. Carrying capacity is further influenced by human activities such as shoreline development and associated disturbances such that estimates of carrying capacity are subject to annual and long-term changes. Carrying capacity is also influenced by the degree and efficacy of management. Finally, birds may be able to nest at higher densities as habitat diminishes. Currently, we believe that plover carrying capacity is limited by nest site availability and not food. However, beach sweeping and nourishment projects may cause local declines in food availability that could affect productivity or survival of young. For these reasons, estimates of carrying capacity, especially on a local basis, may be subject to change over time and may require periodic revision to reflect changes in habitat conditions and bird behavior.

Under optimum conditions, there currently exists sufficient habitat to physically support approximately 75 pairs of piping plovers in Maine (Table 3). However, because of disturbance and direct mortality caused by people and pets, existing habitat is functionally only able to support 30-60 pairs with intensive management.

Habitat Projection

During the next 15 years, if current levels of management are maintained, there will likely continue to be habitat that is physically and functionally available habitat for 30-60 pairs of plovers. However, if management programs are reduced or eliminated, the functional carrying capacity may decline to 0-15 pairs. Future carrying capacity will also depend on the ability of natural resources protection statutes, especially Essential Habitat and NRPA (Sand Dune Regulations), to control coastal development and associated human disturbance.

POPULATION ASSESSMENT

Past Populations - Atlantic Coast

Historical population trends for the Atlantic Coast population of piping plovers have been reconstructed from scattered, largely qualitative, records. Nineteenth century naturalists, such as Audubon and Wilson, described the piping plover as common summer residents on the beaches of the Atlantic Coast (Haig and Oring 1987). By the beginning of the 20th century, uncontrolled shooting, primarily for the millinery trade, and egg collecting had greatly reduced the population, and in some areas along the Atlantic Coast, the plover was close to extirpation. Following passage of the Migratory Bird Treaty Act in 1918, and changes in the fashion industry, plover numbers recovered and the species was again considered common (Bent 1929, Wilcox 1939, Griscom and Snyder 1955, H.S. Hathaway, Audubon Society of Rhode Island, unpub. notes).

Rhode Island piping plover numbers reached a 20th century peak following the 1938 hurricane, which flattened dunes and destroyed shoreline developments (Raithel 1984). However, plover numbers in Rhode Island declined after World War II, as habitat was lost to dune stabilization efforts and summer home construction. The population partially recovered following another severe hurricane in 1954 before beginning the steady decline which continues today.

Wilcox (1959) documented major fluctuations in Piping Plover numbers on Long Island which he correlated with habitat changes. An increase from 20 pairs before the hurricane in 1938 to 64 pairs in 1941 attests to the plover's ability to rapidly colonize

newly available habitat. The population then declined as habitat was lost to dune stabilization, summer homes, and road construction.

Reports of local or statewide declines along the Atlantic Coast in the last 30 years are numerous and are summarized by Cairns and McLaren (1980) and by Haig and Oring (1985). While Wilcox (1939) reported 500 pairs of plovers on Long Island, a 1985 survey recorded only 114 pairs (Peterson et.al. 1985). Numbers of pairs of breeding piping plovers declined 50-100% at 7 Massachusetts sites between the early 1970s and 1984 (S. Melvin, Massachusetts Natural Heritage Program, unpub. data).

Available data suggest that the most recent Atlantic Coast-wide population decline has been in the late 1940's or early 1950's (Haig and Oring 1985). Since 1972, the National Audubon Society's "Blue List" of birds with declining status has included the piping plover as a bird in potential danger. Johnsgard (1981) described the piping plover as "... declining throughout its range and in rather serious trouble." The Canadian Committee on the Status of Endangered Wildlife in Canada designated the piping plover as "Threatened" in 1978, and elevated the plover's status to "Endangered" in 1985.

All states and provinces along the Atlantic Coast now census piping plovers annually. The total number of breeding pairs reported increased from 790 pairs in 1986 to approximately 1,377 pairs in 1998, an increase of 71% (Table 4). Population increases have been unevenly distributed within the birds' range, with the New England recovery unit (CT to ME) increasing from 184 to 632 pairs (240%), the New York-New Jersey recovery unit increasing from 208 to 338 pairs (62%) and the southern recovery unit increasing from 158 to 207 pairs (31%). The population estimate in Atlantic

Table 4. Summary of Atlantic Coast Piping Plover Population Estimates, 1986 to 1998.

STATE/REGION	PAIRS													
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	
Maine	15	12	20	16	17	18	24	32	35	40	60	47	60	
New Hampshire	-	-	-	-	-	-	-	-	-	-	-	-	5	5
Massachusetts	139	126	134	137	139	160	213	289	352	441	454	490	495	
Rhode Island	10	17	19	19	28	26	20	31	32	40	50	51	46	
Connecticut	20	24	27	34	43	36	40	24	30	31	26	26	21	
NEW ENGLAND	184	179	200	206	227	240	297	376	449	552	590	619	627	
New York	106 ^a	135 ^a	172 ^a	191	197	191	187	193	209	249	256	256	245	
New Jersey	102 ^b	93 ^b	105 ^b	128	126	126	134	127	124	132	127	115	93	
NY-NJ REGION	208	228	277	319	323	317	321	320	333	381	383	371	338	
Delaware	8	7	3	3	6	5	2	2	4	5	6	4	6	
Maryland	17	23	25	20	14	17	24	19	32	44	61 ^c	60	56	
Virginia	100	100	103	121	125	131	97	106	96	118	87	88	95	
North Carolina	30 ^c	30 ^c	40 ^c	55	55	40	49	53	54	50	35	52	46	
South Carolina	3	-	-	-	1	1	-	1	-	-	0	-	-	
SOUTHERN REGION	158	160	171	199	201	194	172	181	186	217	189 ^e	204	203	
U.S. TOTAL	550	567	648	724	751	751	790	877	968	1,150	1,162 ^e	1,194	1,168	
ATLANTIC CANADA	240	223	238	233	229	236	236 ^d	236 ^d	182	199	186	197 ^f	204	
ATLANTIC COAST	790	790	886	957	980	987	1,026	1,113	1,150	1,349	1,348 ^e	1,391	1,372	

^aThe recovery team believes that this estimate reflects incomplete survey effort. See discussion on page 22 of the Revised Atlantic Coast Piping Plover Recovery Plan (USFWS 1996).

^bThe New Jersey plover coordinator conjectures that one quarter to one third of the apparent population increase between 1986 and 1989 is due to increased survey effort.

^cThe recovery team believes that the apparent 1986-1989 increase in the North Carolina population is due to intensified survey effort. See discussion on page 22 of the recovery plan (USFWS 1996). No actual surveys were made in 1987; estimate is that from 1986.

^d1991 estimate.

^eReflects correction in 1996 Maryland population from 60 pairs reported in 1996 Status Update to 61 pairs.

^fAssumes that the number of pairs in Newfoundland in 1997 was 11 pairs, the same as 1996; Newfoundland reported 35 adults in 1997, up from 27 in 1996, but provided no 1997 estimate for breeding pairs.

Canada declined from 240 to 204 pairs (-18%). Recent declines in Atlantic Canada and the southern part of the range are of particular concern because of the small numbers of birds, only about 200 pairs, remaining in these large geographic areas.

Past Populations - Maine

Piping plovers have never been common in Maine, given the relative dearth of sandy beaches and dune areas in the state. However, it is also likely that prior to European settlement, the species was more abundant in Maine than at present. Severe declines in the Atlantic Coast population during the late 19th and early 20th centuries were mirrored in Maine. By 1882, the piping plover had been reduced to a rare summer resident in Maine (Brown 1882), and in 1908, Knight (1908) suggested it might have been extirpated as a breeding bird from the state. By the 1940s, the population had rebounded, and Palmer (1949) described the piping plover as common on sandy beaches from Kittery in York county to Cape Elizabeth in Cumberland county, and on beaches in Phippsburg and Georgetown, and rarely eastward. Of interest, Knight (1908) also made vague reference to piping plovers breeding on islands (possibly Roque Island) in Washington county. Island nesting has not been documented since.

During the period 1932-1976, piping plovers were reported nesting at only 8 sites in Maine (Dorr 1976) (Table 4), although it is likely that they nested at several additional sites in York or Sagadahoc counties during that period. A survey in 1976 located an estimated 20-28 pairs at 6 sites (Dorr 1976). Twenty-one different sites have been used for nesting in Maine from 1981-1998.

Current Population

Maine's population of piping plovers has been monitored annually since 1981 by Maine Audubon Society and other groups. During this period, the number of pairs reported has ranged from seven pairs at four sites in 1983 to 60 pairs at 19 sites in 1996 and 1998 (Table 5). Twenty-one different nesting sites have been used during this period. The population trend since the early 1990's has been one of increase because of intensive management. In 1989 (at the time of writing of the first piping plover assessment), only 16 pairs of piping plovers nested at 7 locations in Maine. Only 2 sites supported more than 2 pairs. In contrast, from 1995 - 1998, 40-60 pairs nested at 21 different sites. High productivity, coupled with high adult survival, has resulted in dramatic population increases. From 1989-1995, the New England population increased from 206-632 pairs. Maine's population has not only increased during this period, but expanded to include nesting at 13 new sites including Drakes Island (Wells), Landholm Beach (Wells), Fortunes Rocks Beach (Biddeford), Goosefare Brook (Saco), Old Orchard Beach (Old Orchard), Western Beach (Scarborough) Scarborough Beach (Scarborough), Higgins Beach (Scarborough), Ram Island (Cape Elizabeth), Crescent Beach State Park (Cape Elizabeth), Ferry Beach (Saco), Moody Beach (Wells) and Indian Point Beach (Georgetown). Wells Beach (Wells) and Batson River (Kennebunkport), which had not been used since the early 1980s, were reoccupied in the 1990s.

The productivity of piping plovers in Maine (measured as number of chicks fledged per nest) has ranged from a low of 0.90 chicks per pair in 1981 to a high of 2.38 chicks per pair in 1989 and 1993 (Table 6). Statewide productivity since 1981 has been

Table 5. Historic records of Piping Plover nesting areas in Maine, 1932-76.

Site	Town	Known Active Years	Source of Data
Ogunquit Beach		1946, '76	1
	Ogunquit		
Webhannet River		1969, '71, '75, '76	2, 3, 4
	Wells		
Drake's Island		1932, '52, '67, '71	3, 4, 5, 7, 8
	Wells		
Biddeford Pool		1,958	6
	Biddeford		
Pine Point		1932, '52, '76	4, 7, 8
	Scarborough		
Western Beach		1,976	4
	Scarborough		
Small Point		1932, '52, '76	4, 7, 8
	Phippsburg		
Popham Beach		1932, '52, '73, '76	4, 7, 8
	Phippsburg		

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6. Stackpole, R and Emery, R. 1958. Records of New England Birds, XIV:2
7. Gross, A.O. 1952. Piping Plover Forming Flocks for Early Southern Migration. Maine Coast Fisherman, Vol. 7, September.
8. Gross (1952) makes a general comment on the presence of nesting Piping Plovers at Wells, Pine Point, Small Point and Popham Beach between 1932 and 1952. Current Population

Table 6. Number of nesting piping plover pairs and fledglings in Maine 1981 - 1999.

	OGUNQUIT	MOODY	WELLS	DRAKES ISLAND	LAUD- HOLM FARM	CRESCENT SURF	BATSON RIVER	GOOSE ROCKS	FORTUNES ROCK	FERRY	OCEAN PARK	OLD ORCHARD	PINE POINT	WESTERN	SCAR- BOROUGH	HIGGINS	RAM ISLAND	CRESCENT BEACH STATE PARK	SEAWALL	POPIAM	HUNNEWELL	REID STATE PARK	INDIAN POINT	TOTAL
1981	0	0	1(0)	-	-	4(9)	0(0)	1(0)			-		1(0)	-		-	-	-	2(0)	0(0)	-	1(0)		10(9)
1982	0	0	0	-	-	3(10)	0	0			-		1(0)	-		-	-	-	5(8)	3(0)	-	1(0)		10(18)
1983	0	0	0	-	-	1(0)	0	0			-		0	-		-	-	-	3(4)	1(0)	-	1(3)		6(7)
1984	0	0	0	-	-	0	0	0			-		0	-		-	-	-	6(14)	1(2)	-	2(5)		9(21)
1985	1(3)	0	0	-	-	1(0)	1(2)	1(3)			-		0	-		-	-	-	9(14)	0	-	2(6)		15(28)
1986	1(1)	0	0	-	0	1(0)	0	1(4)			-		0	0		-	0	-	9(24)	0	0	3(2)		15(31)
1987	[1(0)]	0	0	-	0	1(0)	0	1(4)			-		1(0)	0		-	0	-	8(17)	0	0	1(0)		12(21)
1988	[1(0)]	0	0	-	0	1(2)	0	2(3)			-		0	0		-	0	-	7(3)	1(3)	6(2)	3(0)		20(15)
1989	0	0	0	-	0	2(3)	0	2(8)			-		0	0		-	0	-	7(11)	3(11)	1(3)	1(2)		16(38)
1990	0	0	0	-	0	3(4)	0	2(4)			-		0	0		-	0	-	6(8)	3(2)	1(4)	2(4)		17(26)
1991	0	0	0	-	1(3)	3(9)	0	1(3)			-		1(0)	-		-	-	-	4(12)	4(6)	2(6)	2(6)		18(45)
1992	0	0	0	-	1(0)	4(16)	0	2(3)			-		0	1(2)		-	-	-	7(13)	5(10)	2(0)	2(5)		24(49)
1993	0	0	0	-	1(4)	4(16)	0	2(7)			1(2)		0	3(9)		2(2)	1(3)	-	6(10)	8(18)	1(0)	3(5)		32(76)
1994	0	0	0	-	1(3)	4(11)	0	4(10)			1(3)	0	2(1)	3(8)		2(2)	1(1)	-	5(6)	7(19)	1(0)	4(6)		35(70)
1995	2(5)	0	2(5)	-	1(2)*	4(9)	0	6(15)	1(2)		1(0)	0	[1(0)]	3(10)	1(3)	2(4)*	2(5)	-	6(12)	4(12)	0	5(11)		40(95)
1996	5(10)	0	4(12)	1(0)	1(4)	5(15)	1(3)	6(8)	2(3)*		1(2)	1(3)	3(0)	3(4)	2(0)	5(13)	1(3)	-	7(6)	5(10)*	0	7(2)		60(98)
1997	3(8)	0	4(11)	-	1(2)	4(13)	1(3)	6(13)	2(4)		1(0)	2(0)	1(0)	[1(0)]	2(1)	4(13)	1(4)	-	5(9)	6(11)	-	4(1)	[1(0)]	47(93)
1998	6(16)	0	4(5)	1(0)	2(3)	3(6)	1(0)	7(14)	3(10)		1(1)	0(0)	1(0)	1(2)	3(2)	4(3)	2(4)	1(1)	9(10)	5(6)	2(2)	4(3)	0	60(88)
1999	6(5)	1(2)	6(9)	0	4(11)	4(4)	0(0)	6(12)	4(7)	1(1)	0(0)	0(0)	0(0)	0(0)	2(4)	3(10)	3(6)	1(1)	8(10)	2(3)	3(3)	2(3)	0	56(91)

[] = failed early in season, not counted in total

* = additional nests present but failed, see methods

among the highest documented in any Atlantic Coast state or province. Maine productivity has exceeded 1.7 chicks per pair in 11 of the past 19 years. The trend in productivity has been generally one of increase since 1981.

Piping plovers in Maine are contiguous with nesting populations to the south, but likely disjunct from populations in Atlantic Canada. Nearest nesting sites to the south are at Seabrook Beach, New Hampshire. To the north, the nearest nesting locations are 240 miles (386 km) away in Nova Scotia.

It is likely that interchange occurs between plovers nesting in Maine and much of the Atlantic Coast population. Studies in Massachusetts have documented site fidelity in nesting plovers of only 65-70% for adults and <10% for juveniles (MacIvor et.al. unpub. data). Nesting locations of color-marked individuals have been as much as 200 km apart in successive years. In addition, the Atlantic Canadian population passes through Maine twice annually, during spring and fall migration. Thus, it is likely that genetic interchange occurs between plovers originating from southern New England, Maine, and possibly the Canadian Maritimes.

Population Projections

At the time of writing the first Maine Piping Plover Assessment (1989), it was believed that Maine's plover population would never exceed 30-40 pairs. Although populations as high as 60 pairs have been recorded (1996 and 1998), it is doubtful that Maine's population will ever exceed 100 pairs. An avian population of less than 100 breeding pairs falls short of estimates of minimum viable population and effective

population size necessary for short-term and long-term survival of animal populations (Frankel and Soule 1981, Soule 1987).

Down-listing to “threatened” status in Maine would be warranted when all of the following criteria are met:

- 1) statewide annual population of > 100 nesting pairs for 5 consecutive years;
- 2) nesting pairs distributed over 20 sites;
- 3) mean annual productivity of 1.7 chicks fledged per pair for 5 consecutive years; and
- 4) the Atlantic Coast population has attained Federal recovery objectives.

It is unlikely that even an extremely effective program of management and protection will result in population increases sufficient to warrant complete de-listing of piping plovers in Maine. This population is severely habitat limited. It is physically limited by the small number and restricted distribution of sandy beaches and dunes in the state, and it is functionally limited by intense coastal recreation and development. Thus, it is likely piping plovers in Maine will continue to be listed as endangered for the foreseeable future and will require intensive management to maintain an nesting population in the state. However small, progress toward population increases in Maine are an important contribution toward the recovery of the Atlantic Coast population.

The revised recovery goals for the Atlantic Coast population (U.S. Fish and Wildlife Service 1996) are:

- 1) increase and maintain for 5 years a total of 2,000 breeding pairs, distributed among four recovery units:

Atlantic Canada	400 pairs
New England	625 pairs
New York/New Jersey	575 pairs
Southern(DE, MD, VA, NC)	400 pairs

2) verify the adequacy of a 2,000 pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term (i.e. scientifically demonstrate that a population this size can avoid inbreeding problems over time).

3) achieve five-year average productivity of 1.5 chicks fledged per pair in each of the four recovery units.

4) institute long-term agreements among cooperating agencies, landowners, and conservation organizations that will ensure protection and management sufficient to maintain the population targets and average productivity for each recovery unit.

5) Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

Limiting Factors

Habitat availability, human disturbance, direct mortality caused by humans and their pets, and predation are the most important factors limiting the abundance and distribution of breeding piping plovers in Maine. Sandy beaches and low, sloping dunes suitable for nesting are uncommon in Maine, and often have been so altered by construction and stabilization activities that they are unacceptable to plovers.

Many sections of beaches in Maine that are physically suitable for breeding plovers are functionally unavailable to the birds because of human recreational activities and predators. Disturbance may cause plovers to leave the nest, exposing eggs to the summer sun or predation. Excessive disturbance eventually may cause abandonment. Foot or vehicular traffic on beaches can crush eggs or young, or prevent young from feeding.

At sites where piping plovers do nest in Maine, predation on eggs or chicks by red fox (*Vulpes vulpes*) , striped skunk (*Mephitis mephitis*) , raccoon (*Procyon lotor*), American crow (*Corvus brachyrhynchos*), and gulls (*Larus spp.*) may seriously limit reproductive success in some years. Free-roaming dogs and cats that chase adults and chicks, kill chicks, and eat eggs are a serious problem at several sites.

USE AND DEMAND ASSESSMENT

The demand for flora and fauna, especially those listed as threatened or endangered, is unequivocally mandated in the preamble to the Maine Endangered Species Act of 1975:

“The Legislature finds that various species of fish or wildlife have been and are in danger of being rendered extinct within the State of Maine, and that these species are of esthetic, ecological, educational, historical, recreational, and scientific value to the people of the State. Legislature, therefore, declares that it is the policy of the State to conserve, by according such protection as is necessary to maintain and enhance their numbers, all species of fish or wildlife found in the State, as well as the ecosystems upon which they depend.”

As such, MDIFW is committed to preserving the biological diversity of all wildlife in the state and is entrusted with the preservation of Maine’s natural heritage for future generations. This responsibility is manifested by an increasing commitment to management and research programs that protect and enhance endangered and threatened species of all taxa.

The protection and ecological understanding of highly visible species, such as the piping plover, are vital to proper ecosystem management and to the preservation of Maine’s natural heritage. Piping plovers contribute to the biological diversity of our state, and their presence adds to the ecological value of Maine’s beach and saltmarsh

ecosystem. Hundreds of thousands of recreational beach users encounter piping plovers and associated recovery efforts during their annual visits to some of Maine's most popular beaches. These highly visible recovery programs provide an opportunity to educate the public and provide an example of how endangered species and traditional public land uses can coexist with proper management.

A recent study of the economic values of Maine's wildlife resources (Boyle et al. 1990) provides insights into the nonconsumptive use and demand for wildlife. An estimated 91% of the state's adult population participate in nonconsumptive use of wildlife. Fifty-five percent of households in Maine actively attract wildlife to their homes or camps, and 35% made trips annually to view wildlife. Eighty percent believe the opportunity to view wildlife in Maine is very important, and 49% indicate the presence of wildlife influenced where they chose to live.

This high public demand for nonconsumptive use of wildlife is of considerable value to Maine's economy (Boyle et al. 1990). In 1988, expenditure to attract and observe wildlife totaled \$50.3 million (this figure represents a minimum expenditure for Maine residents and does not include expenditures of nonresidents). This aggregate surplus value of 10 federally-listed endangered species in Maine was valued at \$5.1 million. Thus, a very conservative estimate of the nonconsumptive value of wildlife in Maine was \$55.4 million annually and was comparable to the economic contribution of resident hunting.

As the popularity of photography and nature study appreciation, and awareness of the diversity of Maine's wildlife resources grows, the demand for observational and photographic use of rare species, such as the piping plover, will increase. Moderate

increases in recreational activity in nesting beaches could adversely affect piping plover behavior and nesting success. As interest in piping plovers intensifies, there will likely be increased public demand for interpretive and educational materials to explain recovery programs and habitat protection.

Increasing numbers of citizens desire preservation of the greatest diversity of species possible, at state, national, and global levels (Kellert 1980). These desires are based on increasing public perception of scientific, utilitarian, and cultural values of biological diversity, as well as ethical arguments for preserving plant and animal species that are endangered by the actions of human society. At the state level, public support for the preservation of biodiversity in Maine is growing and is reflected in strong state legislation to protect endangered and threatened wildlife and their habitats.

SUMMARY AND CONCLUSIONS

Piping plovers are rare in Maine, and have probably always been uncommon because of limited sandy beach and dune habitat. Because this species is so habitat restricted in Maine, intensive management is expected to result in only moderate increases in population abundance and distribution.

Much of Maine's piping plover habitat has become physically or functionally unavailable to the birds because of habitat alteration and disturbance. Estimated physical and functional carrying capacity of existing habitat in Maine is 40-70 pairs. The population can be expected to be maintained at carrying capacity only if current management actions are continued or intensified and further habitat is not lost. High levels of productivity and/or ingress of individuals from elsewhere along the Atlantic Coast will likely be necessary to prevent the extirpation of this small breeding population. It is unlikely that Maine's piping plover populations can be recovered sufficiently to warrant state de-listing, although recent population increases and productivity are contributing to the recovery of the Atlantic Coast population and federal recovery objectives.

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