Management and Conservation Article

Expenditures and Effort Associated With Recovery of Breeding Atlantic Coast Piping Plovers

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ABSTRACT We calculated expenditures and hours of staff and volunteer time dedicated to monitoring and managing the United States breeding population of Atlantic Coast piping plovers (Charadrius melodus) in 1993 and 2002 and considered implications for recovery of this management-dependent species. In 2002, 73 federal, state, and local governmental agencies and private organizations played key roles in conservation efforts at 281 piping plover breeding sites. Total inflation-adjusted estimated expenditures increased by 51% between 1993 and 2002, from US$2.28 million to $3.44 million, but annual per-pair expenditures declined 4% from $2,459 to $2,350, and hours of paid-staff effort were similar (93 hr/pair in 1993, 95 hr in 2002). Expenditures for on-site monitoring and management were greater than for 6 other categories of expenses in both years and increased from 42% to 59% of total costs between 1993 and 2002. Staff time and expenditures were higher at sites where more labor-intensive efforts to protect plovers from recreation and other human use were necessitated by greater human accessibility. Total expenditures in 2002 were modest compared to those for some other threatened and endangered species and to costs of large beach-stabilization projects. Our results provide a baseline for estimating future costs of piping plover protection, including development and implementation of the long-term management agreements that will be required to remove this species from United States Endangered Species Act protection. Impediments to reducing costs for Atlantic Coast piping plovers are the species’ widespread distribution at low densities and the unrelenting threats posed by human activities and predators. Modest economies of scale may be achieved through arrangements for management and monitoring that span multiple landowners and include other at-risk beach species. (JOURNAL OF WILDLIFE MANAGEMENT 73(7):1099–1107; 2009)

DOI: 10.2193/2008-061

KEY WORDS Atlantic Coast, Charadrius melodus, endangered species, expenditures, piping plover, recovery.

Many threatened and endangered species will require long-term management commitments to counter persistent threats (Scott et al. 2005). Previous studies have assessed the relationship between recovery expenditures and trends in the status of species listed under the United States Endangered Species Act (ESA; Miller et al. 2002) and estimated long-term costs for management of endangered species affected by alien species and disruption of natural fire regimes (Wilcove and Chen 1998). The United States Fish and Wildlife Service (USFWS) endangered and threatened species expenditure reports (e.g., USFWS 2005a, b) reflect the sum of reasonably identifiable expenses reported by federal and state agencies. To our knowledge, however, attempts to comprehensively enumerate and describe factors affecting expenditures and hours of staff and volunteer time associated with recovery actions for an entire regional population of an endangered or threatened species and evaluate implications for long-term conservation have been minimal.

The piping plover (Charadrius melodus) is listed as threatened (Atlantic and Northern Great Plains populations) and endangered (Great Lakes breeding population) pursuant to the United States ESA (USFWS 1985). The Canadian Species at Risk Act recognizes 2 subspecies, C. m. melodus in Eastern Canada and C. m. circumcinctus in Ontario and Prairie Canada, and lists each as endangered (Department of Justice Canada 2002). Recovery efforts for piping plovers that breed on coastal beaches from Maine to North Carolina (USA) were initiated in the mid-1980s and gradually expanded and intensified under the auspices of 2 successive USFWS Atlantic Coast piping plover recovery plans (USFWS 1988a, 1996). Atlantic Coast piping plovers share wintering habitats along the southern Atlantic and Gulf coasts and Caribbean islands with conspecifics from breeding populations that are managed under separate ESA recovery plans (USFWS 1988a, 2003).

The United States Atlantic Coast piping plover recovery program is a collaborative effort of USFWS and state wildlife agencies; federal, state, municipal, and private landowners; nongovernmental organizations; academic institutions; and interested individuals. Much of the piping plover’s Atlantic Coast historic habitat has been destroyed or permanently degraded by development and artificial shoreline stabilization (USFWS 1996). Sparse distribution of these territorial breeders, diverse ownership of sites, and pervasive and persistent threats from human disturbance and predation pose formidable challenges to recovery cooperators (Melvin et al. 1991, USFWS 1996). The USFWS Northeast Region serves as a clearinghouse for information about piping plover conservation, provides technical assistance to cooperators, and synthesizes annual census data for piping plovers from the United States Atlantic Coast breeding range.

Recovery actions implemented on Atlantic Coast breeding grounds have included use of federal and state regulatory procedures to reduce and mitigate loss and degradation of habitat from human development and shoreline stabilization and intensive management to protect breeding birds, their eggs, and young from mammalian and avian predators and
from disturbance and direct mortality caused by human activities (Melvin et al. 1991, USFWS 1996). Many piping plover management activities are predicated on frequent monitoring of individual breeding pairs during territory establishment and courtship, nesting, and chick-rearing periods. For example, deployment of wire predator-exlosures to protect nests (Rimmer and Deblinger 1990, Melvin et al. 1992) depends on prompt detection of egg-laying. Minimizing the spatial extent and duration of restrictions on use of offroad vehicles is contingent on precise hatching-date predictions and daily verification of brood locations (USFWS 1996). Periodic adjustment of buffers established with warning signs and symbolic fencing to protect piping plover courtship habitat, nests, and incubation behavior requires regular observations of breeding activity. Almost all of these actions require continued implementation to counter threats that are present every year.

Twenty-one population censuses, based on multiple surveys of suitable breeding habitat each year, show substantial progress towards attainment of an abundance goal of 2,000 breeding pairs established in the USFWS Atlantic Coast piping plover recovery plan (USFWS 1996). Between 1986 and 2006, census totals increased from 790 pairs to 1,749 pairs. Productivity and population growth were positively and significantly correlated for each of 3 United States recovery units identified in the Atlantic Coast recovery plan (Hecht and Melvin 2009).

Recovery and removal of a threatened or endangered species from protections of the ESA requires not only targeted increases in abundance, distribution, and reproduction, but also amelioration of factors that led to listing of the species. Due to the pervasive and persistent nature of ongoing threats, one of the recovery criteria in the USFWS Atlantic Coast piping plover recovery plan requires long-term agreements among cooperating agencies, landowners, and conservation organizations to ensure protection and management sufficient to maintain target populations after delisting (USFWS 1996). The only previous study addressing the cost of piping plover conservation focused on management of one threat, predation, facing the Northern Great Plains population (Larson et al. 2003). We examined number and diversity of cooperating organizations and number of Atlantic Coast piping plover breeding sites in 2002. We characterized and compared expenditures and hours of paid staff and volunteer time dedicated to protecting breeding pairs in 1993 and 2002. We considered implications of recovery-program complexity and trends in expenditures for long-term agreements that must be established before this management-dependent species can be removed from ESA protection.

**STUDY AREA**

Our study area extended from Reid State Park, Maine, USA (43°46’N, 69°44’W) to Sunset Beach, North Carolina, USA (33°52’N, 78°30’W) and included every known breeding site in the United States portion of the piping plover’s Atlantic Coast breeding range in 1993 and 2002, except for one site in South Carolina where 1–3 pairs of breeding piping plovers were intermittently observed between 1986 and 1993. Our study area also incorporated sites where surveys were performed but no piping plover breeding activity was detected.

**METHODS**

Using state reports to the USFWS, we tallied the total number of tabulated sites that supported breeding pairs in 2002, as well as the proportion of each state’s population that nested at sites with ≤5 breeding pairs. We counted the number of cooperators, defined as governmental agencies, nongovernmental organizations, or private landowners that 1) paid full- or part-time staff to monitor or protect piping plovers, or 2) contributed funds, equipment, or supplies to on-site protection efforts in 2002. We solicited and compiled data on expenditures and person-hours devoted by all cooperators to monitoring and protecting piping plovers at all United States Atlantic Coast breeding sites by federal, state, and local governmental agencies and private organizations. We gathered this information in 1993 to inform revision of the USFWS Atlantic Coast piping plover recovery plan. We repeated this exercise in 2002 to detect differences in expenditures and effort for a more established recovery program and a breeding population that had increased >60%. We requested estimates for hours of time expended by paid staff and volunteers for 3 categories of activities: 1) on-site monitoring and management (e.g., locating breeding adults and monitoring fates of nests and chicks, construction and maintenance of fencing and warning signs around breeding habitat, predation management, patrolling and law enforcement); 2) reporting (including data compilation) and management planning; and 3) off-site public information and education. Cooperators also provided estimates of dollars paid for staff time in each of these 3 categories and for 4 other expenditure categories: 1) administration (e.g., hiring, payroll preparation, telephones); 2) transportation (mileage or other costs, both land and boat); 3) materials and equipment; and 4) miscellaneous ‘other’ site-specific expenditures (e.g., contracts for research and predator management, meals and housing for interns and volunteers). We furnished definitions of activities and expenditures to be included in each category and a spreadsheet for entering responses to state and USFWS coordinators, who compiled and quality-controlled information provided by all other cooperators in their states. Where piping plover conservation efforts were intertwined with conservation of other beach-dwelling species (e.g., least terns [Sternula antillarum], seabeach amaranth [Amaranthus pumilus]), added expenditures specific to protecting the other species were excluded.

State and federal coordinators accounted for as many expenditures as possible while avoiding double-reporting. We requested explanations for estimates that appeared to be far above or below those associated with similar management practices elsewhere, and cooperators adjusted estimates found to be incomplete or to include extraneous expenditures. Most responses reflected detailed accounting of time.
and expenditures. In a few cases, where records were incomplete, we carefully reconstructed best estimates via discussions with cooperators. Expenditures reflected only direct costs of conservation activities and did not include any positive or negative impacts on local or regional economies that might have occurred due to piping plover conservation efforts. We adjusted expenditures in 1993 for inflation (24.5%) between 1993 and 2002 using the consumer-price-index inflation calculator (U.S. Department of Labor 2006). We derived per-pair expenditures by dividing total expenditures in a state or expense category by the corresponding number of breeding pairs.

RESULTS

In 2002, 73 federal, state, and local governmental agencies and private conservation and land-management organizations played key roles in implementation of United States Atlantic Coast piping plover conservation efforts (Table 1). Federal cooperators included 7 National Park Service units, 11 national wildlife refuges managed by the USFWS, the United States Coast Guard, the United States Animal and Plant Health Inspection Service (United States Department of Agriculture), and 6 United States Army Corps of Engineers (USACE) districts. State wildlife agencies assumed the primary role in coordinating recovery efforts in 8 of 11 states and were active participants in the other three. State park lands supported breeding piping plovers in 10 states. Many cooperators were active at multiple sites; for example, a New York (USA) county parks agency monitored and managed plovers at 14 sites, and a nongovernmental organization provided monitoring and protection at >40 sites in Massachusetts, USA. In addition, many other public and private landowners authorized plover protection efforts on their properties and limited certain uses (e.g., dog-walking, off-road vehicle use) during the breeding season. For example, in Maine, USA, 104 private landowners granted permission for some form of monitoring or protection of piping plovers on their properties in 2002.

Breeding pairs were reported at 281 sites in Atlantic Coast states in 2002; 30% of breeding pairs occurred at 208 sites with 1–5 pairs (Table 1). In addition to the active sites, surveys were performed at 177 sandy coastal beaches and spits where no breeding was detected in 2002.

Paid staff time for on-site monitoring and management of United States Atlantic Coast piping plovers nearly doubled between 1993 and 2002, from approximately 66,350 hours to 120,328 hours (Fig. 1a), but hours expended per pair of plovers increased only 12% from 76 hours to 85 hours (Fig. 1b). Although overall staff time spent on data compilation, report preparation, and planning was similar in 1993 (15,230 hr) and 2002 (14,190 hr; Fig. 1a), effort per pair dropped 41%, from 17 hours to 10 hours (Fig. 1b). Combined time expended per pair by paid staff for on-site monitoring and management, data compilation, reporting, and planning was similar in 1993 (93 hr) and 2002 (95 hr; Table 2). Time donated by volunteers for on-site monitoring and management declined 30% from 31,310 hours (36 hr/pair) in 1993 to 21,808 hours (15 hr/pair) in 2002 (Fig. 1a, b).

Total estimated expenditures for protecting breeding piping plovers on the United States Atlantic Coast increased by 51% between 1993 and 2002, from US$2.28 million ($1.83 million before adjustment for inflation) to $3.44 million (Fig. 2a). Expenditures per pair (excluding off-site information and education and regional expenditures), however, were similar in 1993 ($2,459, in 2002 dollars) and 2002 ($2,350; Fig. 2b). Expenditures for on-site monitoring and management were greater than for any other category in both years, and increased from 42% to 59% of total costs between 1993 and 2002 (Fig. 2a). Per-pair expenditures for on-site management and administrative expenses (e.g., hiring, payrolling, telephones) increased 32% and 7%, respectively, but per-pair expenditures in all other categories declined, including data compilation, report preparation, and planning (~30%); materials and equipment (~30%); transportation (~42%); and ‘other’ site-specific expenditures (~55%; Fig. 2b). Regional coordination expenditures that could not be assigned to any particular state or site decreased 57%, whereas expenditures for off-site information and education activities increased 39% (Fig. 2a).

### Table 1. Number of nonfederal cooperators, total number of sites occupied by United States Atlantic Coast breeding piping plovers, number of sites with ≤5 pairs, and percent breeding pairs at sites with ≤5 pairs, 2002.

<table>
<thead>
<tr>
<th>State</th>
<th>No. nonfederal cooperators*</th>
<th>No. occupied breeding sites</th>
<th>% breeding pairs at sites with ≤5 pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>State agency</td>
<td>Local government</td>
<td>Private</td>
</tr>
<tr>
<td>ME</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>NH</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MA</td>
<td>2</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>RI</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>CT</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>NY</td>
<td>2</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>NJ</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>DE</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MD</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VA</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>NC</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>All states</td>
<td>19</td>
<td>24</td>
<td>25</td>
</tr>
</tbody>
</table>

* State and local government agencies, nongovernmental organizations, or private landowners that 1) paid full- or part-time staff to monitor or protect piping plovers, or 2) contributed funds, equipment, or supplies to on-site protection efforts.
Per-pair expenditures decreased in the 7 states with the largest proportional increases in number of breeding pairs but increased in the only state where number of pairs declined (NC) and in the 2 states with the smallest proportional increases in numbers of pairs (NJ and VA). The highest per-pair expenditures occurred in Delaware in 1993 in support of efforts to prevent extirpation of that state’s breeding population, which had declined to only 2 pairs. In 2002, when 6 pairs nested in Delaware, per-pair costs and hours (staff and volunteers combined) decreased 71% and 78%, respectively. The reverse trend in North Carolina, where per-pair expenditures increased from $1,405 in 1993 to $7,879 in 2002, partly reflects a decline from 53 to 23 pairs but was also due to an overall 143% increase in that state’s expenditures as managers intensified piping plover recovery efforts.

Figure 1. Hours expended on United States Atlantic Coast piping plover conservation, 1993 and 2002, (a) total and (b) per pair.
Table 2. Time and expenditures for conservation efforts for breeding United States Atlantic Coast piping plovers by state and on National Park Service lands and National Wildlife Refuges, 1993 and 2002.

<table>
<thead>
<tr>
<th>State or agency</th>
<th>No. of pairs</th>
<th>Hr/pair</th>
<th>Volunteers</th>
<th>Expenditures/pair (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1993</td>
<td>2002</td>
<td>Paid staff</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>32</td>
<td>65</td>
<td>127</td>
<td>68</td>
</tr>
<tr>
<td>NH</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>MA</td>
<td>289</td>
<td>538</td>
<td>94</td>
<td>83</td>
</tr>
<tr>
<td>RI</td>
<td>31</td>
<td>58</td>
<td>204</td>
<td>96</td>
</tr>
<tr>
<td>CT</td>
<td>24</td>
<td>31</td>
<td>87</td>
<td>54</td>
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<tr>
<td>NY</td>
<td>193</td>
<td>369</td>
<td>101</td>
<td>107</td>
</tr>
<tr>
<td>NJ</td>
<td>127</td>
<td>138</td>
<td>61</td>
<td>137</td>
</tr>
<tr>
<td>DE</td>
<td>2</td>
<td>6</td>
<td>975</td>
<td>214</td>
</tr>
<tr>
<td>MD</td>
<td>19</td>
<td>60</td>
<td>386</td>
<td>103</td>
</tr>
<tr>
<td>VA</td>
<td>106</td>
<td>120</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>NC</td>
<td>53</td>
<td>23</td>
<td>16</td>
<td>318</td>
</tr>
<tr>
<td>All states</td>
<td>876</td>
<td>1,415</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>National Park Service</td>
<td>168</td>
<td>231</td>
<td>128</td>
<td>142</td>
</tr>
<tr>
<td>National Wildlife Refuges</td>
<td>100</td>
<td>158</td>
<td>72</td>
<td>74</td>
</tr>
</tbody>
</table>

- Includes on-site monitoring and management, data compilation, report preparation, and planning.
- Includes only on-site monitoring and management.
- Includes on-site monitoring and management, data compilation, report preparation, and planning by paid staff, administrative costs (e.g., hiring, payrolling, telephone), transportation, materials and supplies, and miscellaneous other site-specific expenditures (e.g., meals and housing for volunteers, contracts for predator management services). We adjusted expenditures in 1993 for inflation (24.5%) between 1993 and 2002.
- ND = no data reported for volunteers in ME, but annual report acknowledges volunteer efforts.
- Cape Cod National Seashore (MA); Fire Island National Seashore (NY); Breezy Point Unit, Gateway National Recreation Area (NY); Sandy Hook Unit, Gateway National Recreation Area (NJ); Assateague Island National Seashore (MD); Cape Hatteras National Seashore (NC); and Cape Lookout National Seashore (NC).
- Does not include expenditures for university research projects with multiyear and off-site benefits at 3 National Park Service units.
- Included in both 1993 and 2002: Parker River (MA), Monomoy (MA), Long Island (NY), Edwin B. Forbythe (NJ), Chincoteague (VA), Eastern Shore of Virginia (VA). Included only in 1993: Trustom Pond (RI), Ninigret (RI), Back Bay (VA), Currant (NC). Included only in 2002: Rachel Carson (ME), Cape May (NJ); Pea Island (NC). Omissions are due to lack of breeding activity or nonexistence of refuge, except for Trustom Pond, Ninigret, and Stewart B. McKinney where 2002 expenditures were not separable from those incurred in protection efforts involving substantial amount of nonfederal land.

Expenditures and staff time associated with recovery efforts were generally higher at sites where more labor-intensive efforts to protect piping plover adults, eggs, and chicks from recreation and other human use were necessary. For example, in both 1993 and 2002, per-pair spending at 7 National Park Service units, where public use was allowed but intensively managed, was more than double expenditures at National Wildlife Refuges that prohibited or severely restricted public access to beaches during the piping plover breeding season (Table 2). Economies of scale did not account for this difference, because National Park Service units averaged 24 pairs in 1993 and 33 pairs in 2002, whereas 10 National Wildlife Refuges averaged 10 pairs in 1993 and 9 refuges averaged 18 pairs in 2002. In Virginia, where all nesting sites were either on National Wildlife Refuges or on offshore islands where boat-only access limited recreational use (Boettcher et al. 2007), staff-time per pair was only 42% of the United States Atlantic Coast average in 1993 and 57% of the average in 2002.

**DISCUSSION**

Stable per-pair recovery expenditures for United States Atlantic Coast piping plovers between 1993 and 2002 reflect the labor-intensive nature of protecting a management-dependent, sparsely distributed, wide-ranging species. Increased expenditures for monitoring and management and paid staff hours were at least partly the result of a shift by many cooperators from recruiting, training, and scheduling volunteers to using modestly paid, full-time interns and seasonal technicians. Similarly, the sharp decline in the category of “other” site-specific costs between 1993 and 2002 may have accounted for some of the concurrent increase in on-site management costs. Examples include $96,985 (in 2002 dollars) for predator management contracts reported by Gateway National Recreation Area in the “other” expenses category in 1993 and none in 2002 when predator management was conducted by National Park Service staff. In 2002, direct-hire seasonal monitors supplanted monitoring provided by contracted research projects at 3 National Seashores (categorized as “other” expenses) in 1993. Declines in per-pair time and expenditures devoted to data compilation, reporting, and planning were likely due to increased efficiency of experienced staff using established data recording procedures and report formats, economies of scale as annual reports addressed more pairs at most sites, and a declining need to modify management plans prepared in earlier years. More veteran managers and state coordinators working with well-established management protocols also required less assistance and oversight in 2002 compared to 1993, thus lowering regional coordination costs (A. Hecht, USFWS, personal observation). However, regional coordination costs may spike upward in some future years, for example, when ESA-mandated status reviews are scheduled.
Landowner choices regarding management options, exemplified by differences between National Park Service units and National Wildlife Refuges in allowing public access to beaches during the piping plover breeding season, exerted a strong influence on expenses. The recovery plan for the Atlantic Coast population (USFWS 1996) presents alternative strategies for managing off-road vehicle use to avoid killing or injuring piping plovers, their eggs, or chicks.

Figure 2. Dollars expended on United States Atlantic Coast piping plover conservation, 1993 and 2002, (a) total and (b) per pair. Expenditures in 1993 are adjusted for inflation (24.5%) between 1993 and 2002.
Some alternatives require little monitoring and, hence, lower costs (for example, complete closure to vehicles for the entire nesting season), but many beach managers have elected options with more labor-intensive monitoring requirements that allow them to minimize the extent and duration of vehicle closures. Per-pair expense of deploying predator-exclosures (wire cages placed around nests) declines little as number of pairs on a site increases, because this technique requires intensive monitoring of each pair to detect nest initiation. After the enclosure has been installed, the pair must be monitored at least every other day to assure prompt identification of track patterns indicative of frequent or prolonged predator visits likely to result in nest abandonment or depredation of incubating adult plovers (USFWS 1996). However, potential public controversy has deterred some landowners from adopting lethal predator removal, despite fixed costs per site and potentially larger benefits of reducing predation on both eggs and precocial chicks.

Declines in per-pair expenditures in the states with the largest plover population increases may have reflected some economies of scale. In the northern part of the piping plover’s United States Atlantic Coast range (i.e., New England states), the greatest progress has been made toward abundance objectives specified in the recovery plan, and many management protocols are well-established and accepted. Management efforts to maintain productivity and abundance in New England in 2002 resulted in per-pair spending that ranged from $786 in Connecticut to $1,709 in Rhode Island. By contrast, per-pair expenditures in New York and New Jersey of $3,582 and $3,137, respectively, were associated with protecting piping plovers on a high proportion of sites where beaches were artificially stabilized through beach nourishment, jetties, and groins (USFWS 2005c, USACE 2006) and where numerous houses, roads, and parking lots are situated close to the primary dune with multiple entry points allowing easy beach access by many people.

Widespread distribution of Atlantic Coast piping plovers at low densities presents a major obstacle to efficient management. Because nearly one-third of the population breeds at sites with \( \leq 5 \) pairs, reducing management efforts for these small aggregations would impede recovery of the population. Piping plovers often persist in attempts to nest at sites with poor breeding success, so reduced protection efforts at smaller sites could create population sinks that would unfairly increase the burden on landowners and beach-users elsewhere to compensate with increased productivity achieved through more intensive management. Furthermore, lowering expectations for protection of sites with few pairs creates a disincentive for landowners to increase their populations.

One solution to providing cost-effective monitoring and management for small sites is cooperation among a variety of public and private entities that provide staff to protect piping plovers on multiple sites with diverse ownerships in many parts of the piping plover’s United States Atlantic Coast range. Cross-landowner management allows more efficient use of skilled staff, vehicles, and equipment and better supervision than could be furnished by each landowner independently. To date, however, such arrangements rarely span state lines.

Cost–benefit comparisons among alternative management approaches would be useful but may be confounded by site-specific and temporal variability in predation pressure, weather, changes in habitat configuration due to dynamic coastal formation processes, and efficacy of management techniques. For example, simulation modeling to identify optimal strategies for managing predation threats to piping plovers on the Northern Great Plains (Larson et al. 2003) assumed continuation of observed increased productivity at nests protected with wire predator-exclosures (Rimmer and Deblinger 1990, Melvin et al. 1992, Larson et al. 2002). In recent years, however, episodes of systematic harassment and predation at exclosures, elevated rates of nest abandonment, and incidents of adult mortalities associated with exclosed nests on the Atlantic Coast (USFWS 1996; S. M. Melvin and C. S. Mostello, Massachusetts Division of Fisheries and Wildlife, unpublished reports) and elsewhere (Murphy et al. 2003) have decreased effectiveness of predator-exclosures, with corresponding effects on cost–benefit ratios.

Higher per-pair staff hours were devoted to conservation of 272 breeding pairs of piping plovers in the Canadian breeding range of the Atlantic Coast population (between NF and NS) in 2002 than in the United States portion of the range. The Canadian Wildlife Service reported 25.5 salaried person-years by federal, provincial, and private contributors on behalf of eastern Canada piping plovers in 2002 (Recovery of Nationally Endangered Wildlife [RENEW] 2003). Assuming 1,900 hours/person-year, 178 staff hours were expended per pair in eastern Canada in 2002, nearly double the 95 hours/pair expended in the United States. However, in 2003, per-pair salaried staff time reported for eastern Canada piping plovers declined to 95 hours (RENEW 2004).

Total expenditures of $3.44 million by federal, state, and local governments as well as private cooperators in 2002 were modest compared with costs of monitoring and protecting some other threatened and endangered species. For the fiscal year ending 30 September 2002, federal and state expenditures alone included >$27 million for the threatened bull trout (Salvelinus confluentus), >$8 million each for the threatened desert tortoise (Gopherus agassizii) and endangered West Indian manatee (Trichechus manatus), $7 million for the endangered southwestern willow flycatcher (Empidonax traillii extimus), and >$6 million for the threatened bald eagle (Haliaeetus leucocephalus). Federal and state agencies spent >$833 million on behalf of endangered and threatened populations of steelhead (Onchorhyncus mykiss), chinook salmon (O. tschawytscha), coho salmon (O. kisutch), sockeye salmon (O. nerka), and chum salmon (O. keta) in fiscal year 2002 (USFWS 2005a). Wilcove and Chen (1998) estimated $32–42 million/year (in $1997) as the cost of active management needed to counter threats from alien species or disruption of natural fire regimes in currently occupied habitats of United States endangered species.
Expenditures for United States Atlantic Coast piping plover protection are also modest when compared with costs of some other beach-management activities. For example, funding commitments to support management of piping plovers following artificial beach nourishment are often negotiated during ESA consultations between the USACE and the USFWS. Initial construction costs for 28.6 km of the Sandy Hook to Barnegat Inlet, New Jersey beach-erosion control project, including sand placement, modification of groins, and outfall pipe extensions, totaled >$119 million between 1994 and 2001. The first renourishment contract covered approximately 8.9 km of shoreline at a cost of $14 million in 2002 (L. M. Bocamazo, USACE, personal communication). Contributions by the USACE to Conserve Wildlife Foundation of New Jersey for management of piping plovers (8 pairs) and least terns in the overall project area were $29,211 in 2002 (not including USFWS overhead, which was eliminated in subsequent yr). Piping plover management contributions have been made annually, whereas renourishment has occurred less often, approximately every third year in some portion of the project area.

Other at-risk beach-dwelling species have been indirect beneficiaries of piping plover monitoring and protection efforts. Examples include seashore amaranth, a federally threatened plant; northeastern beach tiger beetle (Cicindela dorsalis dorsalis), a federally threatened insect; and several species of beach-nesting birds of management concern, including the least tern, black skimmer (Rynchops niger), and American oystercatcher (Haematopus palliatus). Predator removal and seasonal restrictions on off-road vehicles, for example, benefit other beach-nesting birds. On many New York beaches, especially those that allow public use of off-road vehicles, most seashore amaranth seedlings that reach detectable sizes are located on sections of beach fenced to protect piping plover courtship and nesting activities and habitat from human recreational activities (S. Young, New York Natural Heritage Program, unpublished report).

Atlantic Coast piping plovers illustrate challenges associated with recovering a management-dependent species that is widely distributed but occurs at low densities in habitats that are, and will undoubtedly continue to be, heavily impacted by human activities. Some critics of the ESA disparage the small number of species that have been removed from the endangered and threatened species lists (Mann and Plummer 1995, Eilperin 2004, Stokstad 2005). Restoring populations to the point that they require no further management intervention is a laudable goal and one that biologists should strive to attain to the maximum possible extent. However, many threatened and endangered species, including Atlantic Coast piping plovers, face unrelenting threats due in large part to dense and increasing human populations, associated development, and other activities. Long-term persistence of such species will likely be dependent on the ability of wildlife managers to effectively address these threats, whether under the auspices of the ESA or through other federal, state, or local regulatory and nonregulatory mechanisms.

MANAGEMENT IMPLICATIONS

Our results characterize expenditures in time and money that have resulted, to date, in a successful recovery program for a widely distributed population of a threatened species of shorebird. Our results provide a baseline for estimating future costs of piping plover protection efforts, including implementation of long-term management agreements that will be required to remove Atlantic Coast piping plovers from direct ESA protections. Our results only reflect costs associated with recovery efforts on the breeding grounds, and a similar assessment of conservation efforts on the piping plover’s migration and wintering grounds may be warranted.

The greatest impediments to reducing management costs for breeding Atlantic Coast piping plovers are the species’ widespread distribution at low densities and the unrelenting threats posed by human recreation, coastal development, shoreline stabilization projects, and predators. It is likely that managers will continue to have the option of choosing less labor-intensive, and therefore less expensive, management and monitoring, in exchange for greater restrictions on some types of recreational use. Modest economies of scale in monitoring and protection may also be achieved through cooperative management arrangements that span multiple landowners and by further combining protection efforts for piping plovers with those for other at-risk beach species.

ACKNOWLEDGMENTS

We summarized information provided by dozens of biologists and beach managers. We can never thank them enough. We especially acknowledge the following 1993 and 2002 state and federal coordinators: M. McCollough, J. Jones, A. Briggaman, C. Raithel, J. Victoria, R. Miller, D. Rosenblatt, C. D. Jenkins, T. Pover, L. Gelvin-Innvaer, H. Niederriter, L. Maclvor, D. Brinker, J. Kumer, K. Terwilliger, R. Boettcher, D. Allen, S. Cameron, D. Avrin, N. Schlott, S. von Oettingen, J. Nicholls, D. Peters, D. Rabon, and A. Scherer. We also thank T. Pover, S. von Oettingen, and 2 anonymous reviewers for comments on earlier drafts of our manuscript.

LITERATURE CITED


