Recovery Plan
For
Seabeach Amaranth
(Amaranthus pumilus)

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

RECOVERY PLAN

for

Seabeach amaranth (*Amaranthus pumilus*) Rafinesque

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Southeast Region
Atlanta, Georgia

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EXECUTIVE SUMMARY

Current Species Status: This species is listed as threatened. There are currently 55 populations remaining; the species has been eliminated from two-thirds of its historic range. Although some of the surviving populations are on public lands (national seashores and State parks), they are not completely protected from the threats that face almost all populations.

Habitat Requirements and Limiting Factors: This species is native to the barrier island beaches of the Atlantic Coast. An annual plant, this species appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner, allowing it to move around in the landscape, occupying suitable habitat as it becomes available. It often grows in the same areas selected for nesting by shorebirds such as plovers, terns, and skimmers. Threats include beach stabilization efforts (particularly the use of beach armoring, such as sea walls and riprap), intensive recreational use, and herbivory by webworms.

Recovery Objective: Delisting.

Recovery Criteria: Delisting will be considered when a minimum of 75 percent of the sites with suitable habitat within at least six of the nine historically occupied States are occupied by seabeach amaranth populations for 10 consecutive years.

Actions Needed:

1. Survey suitable habitat for additional populations.
2. Monitor and protect existing populations.
3. Conduct research on the biology of the species.
4. Establish new populations or rehabilitate marginal populations to the point where they are self-sustaining.
5. Investigate and conduct necessary management activities at all key sites.

Total Estimated Cost of Recovery ($000s): Because so little is known about this species at this time, it is impossible to determine costs beyond estimates for the first few years' work.

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1996	15.0	30.0	10.0	22.0	37.0	114.0
1997	15.0	30.0	10.0	20.0	33.0	108.0
1998	15.0	30.0	10.0	20.0	33.0	108.0
TOTAL	45.0	90.0	30.0	62.0	103.0	330.0

Date of Recovery: Impossible to determine at this time.

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PART I

INTRODUCTION

Seabeach amaranth (*Amaranthus pumilus*) is an annual plant native to the barrier island beaches of the Atlantic Coast. Because of its vulnerability to threats and the fact that it has already been eliminated from two-thirds of its historic range, the species was federally listed as threatened by the U.S. Fish and Wildlife Service (Service) on April 7, 1993 (Service 1993). Seabeach amaranth is listed as threatened by the State of North Carolina, as threatened and of national concern by the State of South Carolina, and is under consideration for addition to the New York State list (where it was rediscovered in 1990).

Current and Historical Distribution

Historically, seabeach amaranth occurred in 31 counties in nine States from Massachusetts to South Carolina. The species has now been completely eliminated from six of the States in its original range. As of 1990 (the last year a complete rangewide census was done), there were 55 remaining populations. Of these, 34 were in North Carolina, 8 were in South Carolina, and 13 were in New York. The status of the populations, by State and county, is shown in Table 1 from Weakley and Bucher (1992).

Description, Ecology, and Life History

Amaranthus pumilus, described by C. S. Rafinesque (1808) from material collected in New Jersey, is an annual plant in the amaranth family. Germination takes place over a relatively long period of time, generally beginning in April and continuing at least through July. Upon germinating, this plant initially forms a small unbranched sprig but soon begins to branch profusely into a clump, often reaching a foot in diameter and consisting of 5 to 20 branches. Occasionally a clump may get as large as a yard or more across, with a hundred or more branches. The stems are fleshy and pink-red or reddish, with small rounded leaves that are 1.3 to 2.5 centimeters in diameter. The leaves are clustered toward the tip of the stem, are normally a somewhat shiny, spinach-green color, and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous and are borne in clusters along the stems. Flowering begins as soon as plants have reached sufficient size, sometimes as early as June in the Carolinas but more typically commencing in July and continuing until their death in late fall or early winter. Seed production begins in July or August and reaches a peak in most years in September; it likewise continues until the plant dies.

Seeds are regularly produced by nearly all adult plants; fertility is assumed to be high (Baskin and Baskin 1994). For an annual species such as seabeach amaranth, the presence of plants in any given year is evidence of reproduction in the former year or of reproduction in earlier years and seed-banking. The relative roles of the fresh seed crop and banked seeds are unknown in seabeach amaranth. It is known, however, that century-old seeds of some species of amaranth are capable of successful germination and growth (David Brenner, University of Iowa, personal communication, 1990). Such controlled experiments, of course, have limited applicability to seed viability in the coastal environment, where salt, abrasion, temperature changes, and moisture changes are all factors likely to limit seed longevity.

Weather events (including rainfall, hurricanes, and temperature extremes) and predation by webworms have strong effects on the length of seabeach amaranth's reproductive season. In New York, recreational beach use and associated management practices, such as grooming and scraping, can also shorten the reproductive season (Cathy Brittingham, The Nature Conservancy, personal communication, 1995). As a result of one or more of these influences, the flowering and fruiting period for some populations can be terminated as early as June or July (flowering does not begin in New York until late July, so the season is even shorter) (Chris Mangels, botanical consultant, personal communication, 1996). Under favorable circumstances, however, the reproductive season may extend until January, or sometimes later in the South (Bucher and Weakley 1990, Weakley and Bucher 1992, Radford *et al.* 1968). Late-season plants (especially in December or January or following defoliation by webworms) may continue flowering and fruiting with few or no leaves, sometimes producing aberrant, dense, terminal inflorescences. The fleshy, reddish stem is apparently photosynthetic and, in combination with resources stored in the taproot, has some ability to continue to support the plant, produce flowers, and ripen seeds in the absence of leaves.

Based on morphology of the flower and inflorescence, seabeach amaranth is probably wind-pollinated. Most species of amaranth are wind-pollinated, though some visitation by bees has been seen in species other than *Amaranthus pumilus* (Brenner, personal communication, 1990). No evidence of visitation by insects was seen by Weakley and Bucher during the course of their surveys (1992). Mangels (personal communication, 1996), however, regularly observed flea beetles (*Phyllotreta chalybeipennis*) on the species in New York in 1991. The inconspicuous flowers, apparently lacking visual, chemical, or nectar attractants, are unlikely to be regularly visited by pollinating insects. Clustered, inconspicuous flowers with exerted stamens are often features of wind-pollinated taxa (Bucher and Weakley 1990). Based on observed seed production by a single individual isolated from other individuals of the species by 100 kilometers (the single plant in northern North Carolina), it is clear that seabeach amaranth is capable of self-pollination.

Seeds from this lone plant were not tested, but they appeared normal and fertile. Other examples of seed production by lone individuals were observed in South Carolina. Brenner (personal communication, 1989) reports that most species of *Amaranthus* are self-fertile, often showing extensive selfing (ca. 70 percent) even when grown in dense stands, a condition normally favoring out-crossing. Considering the generally very sparse populations of seabeach amaranth, it is likely that selfing plays a large, probably dominant, role in seed production. The ability to self is, of course, highly advantageous for a fugitive species, enabling the founding of (and subsequent reproduction by) a new colony via the dissemination of a single propagule. A high rate of selfing also has implications for within- and between-population genetic diversity.

Seed dispersal is one of the most important characteristics of the biology of an annual fugitive species like seabeach amaranth. Indeed, seabeach amaranth is a classic example of a fugitive species--"an inferior competitor which is always excluded locally under interspecific competition, but which persists in newly disturbed habitats by virtue of its high dispersal ability; a species of temporary habitats" (Lincoln *et al.* 1982). Seed dispersal of seabeach amaranth is apparently effected in a number of ways, including water dispersal (hydrochory) and wind dispersal (anemochory).

Seeds of seabeach amaranth are borne in usually indehiscent utricles. The seed does not fill the utricle, leaving a space filled with air. In addition, the utricle is fleshy in texture, as noted by various authors (Britton and Brown 1913, Fernald 1950, Gleason 1952, Gleason and Cronquist 1963). The fleshy tissue of the capsule is low in density. Informal experiments conducted by the authors showed that these utricles float easily on fresh or salt water and remain floating for at least a day in calm water. Seed-containing utricles also float effectively in agitated water, such as they would usually encounter under natural conditions. Though the utricle is normally indehiscent, it is not rare under field conditions to see it fragmenting, either before or after its detachment from the plant. Splitting or fragmentation of the utricle occurs under conditions of agitations (by wind), abrasion (by sand), or simple loss of integrity over time. Thus, seeds are rather commonly encountered dispersed from the utricle.

Additional experiments conducted by the senior authors showed that naked seeds, like those encased in utricles, are also capable of floating in fresh or salt water. Their smooth and glossy surfaces also appear to be somewhat "unwettable," possibly because of a waxy coating. This unwettable surface, combined with their lenticular shape, allows seeds to remain afloat on the surface tension of calm waters. Agitation of the water, however, results in their becoming wet. Low density still allows them to float just below the water surface, but once they become wet, most seeds sink over the course of a day as a result of absorbing water. Some seeds, however, remain floating after a day in water; the relative fertility of floating and sinking seeds is not known. Seeds retained in utricles are blown about rather easily in the windy conditions prevailing in the natural habitats. The partly air-filled utricle is easily caught by the wind and moved rapidly along the surface of the sand. It is not so light as to be easily picked up off the surface and carried aloft, though very strong winds could conceivably do so. When moved along the surface of the sand, utricles are liable to be deposited in depressions or in the lee behind plants, where wind speeds decrease. Under conditions of landward winds, utricles tend to collect at the foot of the foredune since wind velocities are not usually adequate to carry them up the dune slope. Under conditions of seaward winds, utricles in the lee of (seaward of) the foredune are sheltered and stay put, but utricles in more exposed situations are likely to be blown into the surf, from whence they can then be dispersed by water.

Naked seeds are also dispersed by wind, but to a much lesser degree than seeds retained in utricles. They behave like large, low-density sand grains. In general, they are not likely to be moved nearly as far from the parent plants as are seeds retained in utricles, tending to remain in the lee of the parent plant or to be moved to a nearby depression or the lee of a nearby plant. Many utricles remain attached to the plant and are never dispersed; such "planting" occurs primarily at the end of the season, upon the death of the plant. Seeds and fruits may often be observed to pile up around the bases of the parent plants, particularly larger individuals (Mangels, personal communication, 1996).

Since plants of seabeach amaranth act as sand binders, plants are often wholly or partially buried by winter sand movement. This phenomenon may well have an adaptive result and reflect a strategy similar to that of sea rocket (*Cakile edentula*), a close associate of seabeach amaranth, which disperses half its seeds via wind and water but retains half on the parent plant, where they are buried. In the dynamic foredune and island-end flat habitat occupied by these two annuals, such a strategy intuitively seems to make good sense. If conditions remain favorable at the site of the parent plant, the seed source for perpetuation of that population is guaranteed; if conditions are no longer suitable, seeds have also been dispersed via wind and water to colonize new sites. The relatively large size of seabeach amaranth seeds may play some role in their ability to survive long periods of immersion, presumably entailed in long-distance dispersal (Mangels, personal communication, 1996).

From fall through spring, short-distance dispersal (across overland distances of less than 100 meters) is easily seen in the field. It can be inferred from the behavior of utricles and seeds in water that longer-distance dispersal across an inlet to a new island is possible. Longer-distance dispersal probably takes place primarily during storm events such as fall hurricanes and winter northeasters. Some observers

(Mangels, personal communication, 1996) theorize that birds, such as savanna sparrows and shorebirds, may play a role in long-distance seed dispersal, although avian migratory direction and the fruiting season of seabeach amaranth would seemingly allow for southward transport only.

In some years there is substantial early mortality of young plants prior to reproduction. This can be caused by competition with other seabeach amaranth plants or other species, storm tides during the early growing season, or unfavorable weather conditions, such as drought. Once past this stage of germination and early growth, mortality is generally less, caused mainly by webworm predation. In some years substantial (or total) mortality is caused by early summer hurricanes. In some cases there is incidental mortality resulting from recreational use and associated management (grooming and scraping) of beaches; such mortality is locally severe in areas of heavy use, particularly in New York (Kevin DuBois, Service, personal communication, 1995).

During the prime fall reproductive seasons of 1987 and 1988, mortality in the Carolinas was primarily caused by webworm predation. In many populations this mortality was severe. In some years substantial (or total) mortality is caused by fall hurricanes. In late September 1989, for instance, Hurricane Hugo effectively ended the seabeach amaranth season from Cape Fear, North Carolina, south. On the other hand, populations of seabeach amaranth (absent for many decades from the north) reappeared in New York following Hugo, leading some to speculate that seeds might have been blown there from the Carolinas or long-buried seed banks might have been uncovered by the severe winds and tides associated with this hurricane. The effects of major hurricanes, such as Hurricane Hugo, on seabeach amaranth populations need to be investigated.

Seabeach amaranth shows good reproductive success in the years when no hurricanes occur. Large plants are estimated to produce several thousand fertile seeds over a fruiting season from July to January. By the standards of the amaranth genus, this is a very low fecundity, but seabeach amaranth has apparently evolved a strategy of producing relatively few large seeds. In years when hurricanes are responsible for the premature loss of reproductive plants, seed production is likely substantially lower. Peak seed production occurs in the late summer and fall, especially from August to October. Overall and peak seed production are closely correlated with overall and peak hurricane frequency. Hurricane flooding generally washes out and kills seabeach amaranth plants, terminating reproductive activity. Thus, the timing of a hurricane has critical impacts on the seed crop of a given year; an early hurricane could reduce the annual seed crops of several populations by over 90 percent. Depending on the hurricane's path and severity, such a reduction could occur throughout the remaining range of seabeach amaranth or in only a small portion of it. With a range much reduced from its historic size, seabeach amaranth is now much more vulnerable to the rangewide detrimental effects of a natural disaster like Hurricane Hugo.

Reproductive success is also affected by predation. Mangels (personal communication, 1996) reported herbivory by rabbits in New York. As mentioned, in 1987 reproductive success in the Carolinas was lowered by heavy predation by webworm caterpillars. In many populations, the majority of the plants were totally defoliated by September, at a time when they would have begun peak seed production. After being severely defoliated, plants withered and died, terminating their reproductive effort. Overall seed production may have been reduced by caterpillar predation by more than 50 percent in 1987. In 1988 webworm predation in the Carolinas was not quite as extensive and appeared to be somewhat more localized. Data from only two years do not allow an assessment of the dynamics and significance of webworm predation on reproduction and populations of seabeach amaranth, but it appears that this predation could be having a significant effect in North Carolina and South Carolina.

Seabeach amaranth is endemic to Atlantic Coast barrier beaches, where its primary habitat consists of overwash flats at accreting ends of islands, lower foredunes, and upper strands of noneroding beaches (landward of the wrackline). It occasionally establishes small temporary populations in other habitats, including sound-side beaches, blowouts in foredunes, interdunal areas, and on sand and shell material deposited for beach replenishment or as dredge spoil. Seabeach amaranth appears to be intolerant of competition and does not occur on well-vegetated sites. Mangels (personal communication, 1996) reported a particularly strong negative association with *Ammophila* spp. The plant acts as a sand binder, with a single large plant being capable of creating a dune up to 6 decimeters high, containing 2 to 3 cubic meters of sand (Weakley and Bucher 1992).

Seabeach amaranth's range correlates with a zone of low tidal amplitude. Its historic northern and southern range limits occur at about 5 or 6 feet mean tidal amplitude. In contrast to the biologically very important dividing line of Cape Cod, Massachusetts, the historic southern limit of seabeach amaranth in the vicinity of Charleston, South Carolina, is not biogeographically of special note; Cape Hatteras, North Carolina, is a more likely divide. From the viewpoint of a coastal geologist, however, the central South Carolina coast marks an important transition between the barrier islands (to the north) and the sea islands (to the south). As Godfrey (1977) states:

> from Cape Romain south, the relatively high "sea islands" are not subject to overwash flooding. Holocene beaches are "welded" to the front of these old land surfaces. The vegetation is a combination of mainland and dune species. In general, the dune strand is limited to the

> front of the islands and is dominated by sea oats, salt meadow cordgrass, croton, seashore elder, yucca and others. The beaches are typically narrow and slope down to the high water mark, as is characteristic of shorelines of low wave energy . . . . The Georgia Embayment [south of Cape Romain] is the most protected section of the coast except for the occasional direct hit by a hurricane . . . . Overwashes occur along this section infrequently and in only the lowest areas . . . .

One of the more striking features of the distribution of seabeach amaranth in the Carolinas is its near absence from the northern third of the North Carolina coast. From Cape Hatteras north, only two plants were found in each of the years 1987 and 1988. It is not currently known whether the virtual lack of amaranth in this area is related to natural or historic factors. A hypothesis emphasizing the importance of natural forces would note that the present North Carolina strongholds of seabeach amaranth appear, in general, to be the south-facing coast of Brunswick County, the south- and southeast-facing coasts of Carteret and Onslow Counties, and the south- and southeast-facing coasts of Dare and Hyde Counties. The east- or even northeast-facing coasts of Currituck, northern Dare, northern Carteret, and New Hanover Counties generally support smaller, more scattered populations of seabeach amaranth.

Dolan and Lins (1987) indicate that "the rate of shoreline erosion along the barrier islands of Virginia varies with the configuration of the shoreline. Erosion rates are highest where the shoreline faces northeast and lowest where it faces southeast." Greater erosion on east-facing beaches in the Carolinas may reduce seabeach amaranth habitat, compared to the south-facing beaches immediately west of each of the great capes (Hatteras, Lookout, and Fear). Long Island's (New York) Atlantic shore is also south-facing. Moreover, seabeach amaranth is (at least during periods of sea level rise) a species primarily of inlets, and Oregon Inlet is the only inlet from Cape Hatteras north to the North Carolina/Virginia line.

An alternate hypothesis notes that the stretch of North Carolina from which seabeach amaranth is absent corresponds almost exactly with the construction of a continuous barrier dune by the National Park Service, Civilian Conservation Corps, and Work Projects Administration from the 1930s to 1950s. Dolan and Lins (1987) state:

> Thirty years of artificial dune stabilization have altered the ecology and geology of the Outer Banks. A comparison of a cross section of Hatteras Island and Core Banks, representing the altered and natural states of barrier islands, shows how stabilization has changed the morphology and ecology of the beaches, dunes, and marshes. Viewed

> from the air, the most striking contrast between the natural and altered barrier islands, other than the artificial barrier dune, is a marked difference in beach width. The unaltered islands have beaches from 350 to 600 feet wide, whereas on Hatteras Island the beach has been reduced to 100 feet or less. The paradox suggests that manmade structures do not merely fail to protect beaches but actually work to destroy them.

We do not know whether seabeach amaranth was present here prior to artificial dune stabilization and was eliminated by its results. A species with a similar habitat, seabeach knotweed (*Polygonum glaucum*), was known from Chicamacomico, North Carolina, prior to the commencement of dune stabilization and has not been seen in recent years.

No vascular plants regularly occur at a lower topographic position on beaches than seabeach amaranth, though several others--most notably, saltwort (*Salsola australis*) and sea rocket (*Cakile edentula*)--often occur with seabeach amaranth at the lowest elevations that support vascular plants. Seabeach amaranth occupies elevations from 0.2 to 1.5 meters (8 inches to 5 feet) above mean high tide. In general, however, it is associated with a number of vascular plant species. The most constant associates, with which it almost always co-occurs in the Carolinas, are sea rocket (*Cakile edentula*) and seabeach sandmat or seabeach spurge (*Chamaesyce polygonifolia*). Other typical associates are beach elder (*Iva imbricata*), southern seabeach sandmat or southern seabeach spurge (*Chamaesyce bombensis*), Russian thistle (*Salsola australis*), cordgrass (*Spartina patens*), sea oats (*Uniola paniculata*), bitter panic (*Panicum amarum*), sea-purslane (*Sesuvium portulacastrum* and *S. maritimum*), seabeach orach (*Atriplex arenaria*), seablite (*Suaeda linearis*), beach pea (*Strophostyle helvola*), beach morning glory (*Ipomoea imperati*), hog spurge (*Croton punctatus*), sand grass (*Triplasis purpurea*), beach grass (*Ammophila breviligulata*), and beach knotweed (*Polygonum glaucum*). Common associates in New York are *sea rocket (Cakile edentula),* seabeach spurge (*Chamaesyce polygonifolia),* seabeach orach (*Atriplex arenaria, A. Patula),* Russian thistle (*Salsola kali),* sea purselane (*Honkenya peploides),* beach wormwood (*Artemisia stellariana),* beach grass (*Ammophila breviligulata),* seabeach knotweed (*Polygonum glaucum),* narrowleaf goosefoot (*Chenopodium berlandieri* var. *macrocalycium),* beach pea (*Lathyrus japonicus)* and seabeach sandwort (*Arenaria peploides)* (Brittingham, personal communication, 1995; Steve Young, New York Department of Environmental Conservation, personal communication, 1996; Mangels, personal communication, 1996).

However, where these species become well-established and form a perennial-dominated and stabilized low dune, seabeach amaranth is quickly out-competed. In the extremely porous sand of this beach habitat, water and certain cations are probably the critical limiting factors, and the extensive root systems of perennial species monopolize these resources. Thus, although these perennials are frequent associates of seabeach amaranth, they also indicate a successional trend toward a habitat unsuitable for this pioneer annual. The successional trend toward stabilization is, of course, often halted or reversed by natural disturbance in the dynamic conditions of barrier islands.

Seabeach amaranth usually is found growing on a nearly pure silica sand substrate, occasionally with shell fragments mixed in. This habitat is mapped by the U.S. Natural Resources Conservation Service (formerly the U.S. Soil Conservation Service) either as Beach-Foredune Association or Beach (occasionally flooded) (Bucher and Weakley 1990). In the wetland classification of Cowardin *et al.* (1979), the usual habitat of seabeach amaranth is (rather surprisingly) considered a marine wetland. Cowardin *et al.* (1979) state that "the Marine System consists of the open ocean overlying the continental shelf and its associated high-energy coastline . . . . The Marine System extends from the outer edge of the continental shelf shoreward to including the splash zone from breaking waves." At most sites, this definition includes all of the upper beach to the crest of the foredune. Since the extreme high water of spring tides is an important depositor of the seeds of seabeach amaranth, its growth zone would clearly fall within this category. The full classification is Marine System, Intertidal Subsystem, Unconsolidated Shore Class. In the rare situations where seabeach amaranth occurs behind the foredune (such as in interdunal areas and overwash fans), the habitat would likely not be considered a wetland (Cowardin *et al.* 1979).

The habitat of seabeach amaranth is sparsely vegetated with annual herbs (forbs) and, less commonly, perennial herbs (mostly grasses) and scattered shrubs. Christensen (1988) states that "strand vegetation consists of an assemblage of short-lived plants whose spatial distribution shifts from season to season and year to year. Many of these species are salt-tolerant and have life-history characteristics that allow them to invade suitable habitat when it becomes available." This natural community or vegetation type is classified by Schafale and Weakley (1990) as Upper Beach, although seabeach amaranth is sometimes found on sand spits 50 meters or more from the base of the nearest foredune (Mangels, personal communication, 1996).

Seabeach amaranth appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner. This allows it to move around in the landscape, as a fugitive species, to occupy suitable habitat as it becomes available.

Populations of seabeach amaranth, like the habitat upon which it grows, are highly dynamic, with numbers of plants often fluctuating dramatically from one year to the next. The plants generally occur in a sparse to very sparse distribution pattern. The plants are often widely scattered, especially on upper beaches where the average density can be as low as one plant per kilometer. Because amaranth usually occurs in a zone about 10 meters wide (somewhat wider in New York [Brittingham, personal communication, 1995]), this translates to a density of one plant per hectare. A more typical beach density would be 10 plants per 100 meters of linear beach (100 plants per hectare), and occasionally, on accreting beaches, dense populations of 100 plants per 100 meters of linear beach (1,000 plants per hectare) can be found. Island-end flats generally have higher densities than beaches. The overall range of densities is about the same as on upper beaches (1 to 1,000 plants per hectare), but higher densities are encountered more often. Density is presumed to be determined by a complex set of factors, including previous year's seed set, seed bank, pattern of deposition of seeds by wind and water, weather conditions (especially rainfall) determining germination and survival of seedlings, predation by webworms, disturbance by human use, storms, and hurricanes.

Implications for the Barrier Beach Ecosystem

This plant shares its beach habitat with a number of other rare species, both plant and animal. Seabeach knotweed (*Polygonum glaucum*), the purslanes (*Sesuvium portulacastrum* and *S. maritumum*), and seabeach morning-glory (*Ipomoea imperati*) are all considered rare within the Carolinas. Salt meadow grass (*Diplachne maritima*) and seabeach knotweed are considered rare in New York. A number of gulls, terns, skimmers, sandpipers, oystercatchers, and plovers also use this habitat for resting, roosting, or nesting. Included in this group are the State- and/or federally listed piping plover (*Charadrius melodus*), least tern (*Sterna antillarum*), Wilson's plover (*Charadrius wilsonia*), black skimmer (*Rhynchops niger*), and Caspian tern (*Sterna caspia*). The endangered roseate tern (*Sterna dougallii dougallii*) also occurs in some of the same places. Some of the largest seabeach amaranth populations are associated with nesting sites of the least tern, Caspian tern, piping plover, or Wilson's plover. In the Carolinas, sea turtles also nest in this habitat; loggerheads (*Caretta caretta*) are the most common, but on rare occasions, green sea turtles (*Chelonia mydas*) also nest here. Both turtles are federally and State-listed as threatened. In New York, the endangered northeastern beach tiger beetle once occupied seabeach amaranth habitat (Brittingham, personal communication, 1995).

These species, unlike many endangered species, are not narrow endemics. Such pervasive declines in a cluster of wide-ranging species occupying the same habitat is an obvious indication of an entire ecosystem in serious trouble. Seabeach amaranth has a particularly close tie with piping plovers, very frequently occupying the same sites. Habitat management for one benefits the other, and no action taken to manage for one has harmed the other.

Habitat loss and degradation due to shoreline development and beach stabilization and intensive use by off-road vehicles during reproductive seasons has contributed to the decline of each of these listed species. As the Piping Plover Recovery Plan (Service 1996) states:

> If the precarious status of these species is a symptom of an embattled ecosystem, then remedial efforts aimed at the restoration of the natural processes that maintain this system, rather than single-species "fixes," are likely to have the greatest long-term benefits. Important components of ecologically sound barrier beach management include perpetuation of natural dynamic coastal formation processes; management of human recreation to prevent or minimize adverse impacts on dune formation, vegetation, and the invertebrate and vertebrate fauna; and efforts to counter the effects of human-induced changes in the types, distribution, numbers, and activity patterns of predators.

Although management of the ecosystem as a whole is always the preferable approach and is the ultimate recommendation of this plan, as well as of the recovery plans for the other federally listed species, in some cases single-species management actions are necessary and appropriate. Such actions include the protection of individual nests of sea turtles and shorebirds from predators whose populations are introduced or unnaturally inflated because of human actions (introduction of house cats and other feral animals, removal of top predators from the ecosystem, and refuse on the beach that attracts scavengers to the area). The proposed reintroduction of seabeach amaranth to habitat from which it has disappeared all along the Atlantic Coast is another such species-specific action that is being recommended. Since seabeach amaranth is a good barometer of a healthy, functioning barrier beach ecosystem, its successful reintroduction and persistence in the landscape will be an indication of successful protection and management of the system as a whole. Since it is a sand binder and dune builder, it will, in turn, protect the beach ecosystem where it thrives.

Threats and Population Limiting Factors

Seabeach amaranth has been and continues to be threatened by destruction or adverse alteration of its habitat. The species has been eliminated from approximately two-thirds of its historic range, primarily as a result of beach stabilization efforts and storm-related erosion. Beach erosion and most attempts to curtail it represent severe threats to seabeach amaranth. This plant is never found where the foredune is scarped by undermining water at high (or storm) tides. Seabeach amaranth grows above the high tide line and is intolerant of even occasional flooding during its growing season. It does not, however, grow more than a meter or so above the beach elevation on the foredune and is not often found anywhere behind the foredune (except in overwash areas). It is, therefore, dependent on a terrestrial, upper beach habitat that is not flooded during the growing season from May into the fall. This zone is absent on barrier islands that are experiencing significant rates of beach erosion. If data and hypotheses suggesting future increases in sea level are correct, beach erosion will accelerate and put further pressure on seabeach amaranth, especially on the barrier beaches that can no longer respond naturally to such change because of beach armoring and other hard stabilization structures.

This amaranth has certainly survived other episodes of sea level rise, which have occurred naturally and episodically in the past. Seabeach amaranth is not likely to be a young or recently evolved species, considering its isolation within the genus (having no apparently close relatives) and its possession of numerous adaptations to the peculiar environment in which it grows. Pleistocene temperature fluctuations and variations in glaciation have resulted in major changes in geologically recent times in the position of the Carolina coast. Dolan and Lins (1987) state, "when the last period of glaciation (the Wisconsin) came to an end between 12,000 and 14,000 years ago, the sea level was some 350 feet lower than it is today, and the shorelines of the Atlantic and the Gulf coasts were from 20 to 75 miles seaward of their positions now." A landward retreat of 20 to 75 miles (105,600 to 396,000 feet) over a period of 12,000 to 14,000 years indicates an average annual retreat of 7 to 33 feet. Dolan and Lins (1987) also estimate that currently "the overall shoreline-erosion rate along the Mid-Atlantic coast is from 1.5 to 4.5 feet per year."

Natural episodes of barrier island retreat have accommodated fugitive species such as seabeach amaranth. Even a rapid retreat is unlikely to have severely detrimental effects for seabeach amaranth, for in a natural landscape of barrier island retreat there are localized areas where islands are accreting, especially in the vicinity of inlets. Inlets are never naturally stable and are always in flux. Dolan and Lins (1987) further state:

> Overwash and inlet formation are common along the Atlantic coast, particularly south of Cape Cod (the historic northern limit of seabeach amaranth). Temporary inlets are formed during storms when the narrower reaches of islands are overwashed and breached, creating openings to the lagoons and bays behind the beaches . . . . Overwash is commoner along the mid-Atlantic coast than along the other sections. The mid-Atlantic section is close to the track that most of the winter northeasters follow as they move offshore, and the tide range is small. As a result high storm surges are frequent.

At island ends, inlet migration generally means that land is accreting on one side of the inlet and eroding on the other. On the eroding side of the inlet, habitat for seabeach amaranth is usually small or absent. Accreting sides of inlets are, along with accreting capes, the most favorable habitat for the plant.

Since most of the beaches in the Carolinas are eroding, upper beach habitat for seabeach amaranth is generally poor. The near absence of seabeach amaranth from North Carolina north of Cape Hatteras is related to this fact. North of Cape Hatteras there are 165 kilometers of beach (nearly all of it strongly eroding) with only a single inlet (Oregon Inlet). In both 1987 and 1988, only two individuals were found in this stretch, and one of those was found in a casual or adventive site on a sound-side beach back of Avon. Seabeach amaranth once occupied numerous beaches from Nantucket south to the North Carolina/Virginia border. Based on the results of the status survey by Bucher and Weakley (1990, Weakley and Bucher 1992), it appears likely that its range will soon be further curtailed at the north; the small populations known north of Cape Hatteras, North Carolina, are very tenuous and threatened.

Local exceptions to beach erosion can be found in the Carolinas, such as in Brunswick County, North Carolina, on the west end of Holden Beach, where beach accretion has led to a thriving population on the upper beach. Brunswick County has been a stronghold for seabeach amaranth throughout the 1980s, with populations (some of them large) on nearly every barrier island. Reasons for the health of these populations are the localized accretion of beaches, frequency of inlets, and absence of erosion-control structures. Unlike most of North Carolina, however, Brunswick County's south-facing beaches were substantially eroded by Hurricane Hugo. In September of 1989, Hurricane Hugo struck the Atlantic Coast near Charleston, South Carolina, causing extensive flooding and erosion north to Cape Fear, North Carolina, with less severe effects extending northward throughout the range of seabeach amaranth. This was followed by several severe northeasters in the winter of 1989-1990 and by Hurricane Bertha in the late summer of 1990. These last storms, although not as significant as Hurricane Hugo, caused substantial erosion of many barrier islands in the heart of seabeach amaranth's remaining range. The 1990 surveys revealed that the effects of these climatic events were substantial. Thirteen populations of the species reappeared on Long Island, New York, many in places that had been surveyed repeatedly in the past (Mangels 1991). It is not known whether these populations represented the long-distance dispersal of seeds (perhaps by ocean currents), short-distance dispersal from previously undiscovered populations on Long Island, or exposure of local seed banks.

In the Carolinas, populations were severely reduced. In South Carolina, where the effects of Hurricane Hugo and subsequent dune reconstruction were extensive, seabeach amaranth numbers went from 1,800 in 1988 to 188 in 1990, a reduction of

90 percent. Even with the addition of the New York populations, rangewide totals were reduced 76 percent from 1988. Ironically, although storms and the related erosion of beaches threaten seabeach amaranth because of its currently restricted range and reduced populations, attempts to stabilize beaches against these natural geophysical processes, as noted earlier, are often more destructive to the species and to the beaches themselves in the long run.

Engineered approaches to halting beach erosion are usually divided into two general categories--hard and soft (Dolan and Lins 1987). Hard structures are constructed of stone, concrete, steel, or wood and include such structures as sea walls, bulkheads, revetments, groins, terminal groins, and breakwaters. Soft approaches involve the addition of sand to beaches to replace sand lost by erosion (Dolan and Lins 1987). The two approaches can be combined, such as a dual strategy of groin construction and beach replenishment. A third approach, which might be termed "semisoft," has also been widely used--the stabilization or "building" of dunes by the placement of sand fences or planting of vegetation (such as sprigging of beach grass).

Attempts to halt beach erosion in the Carolinas and New York through beach hardening (sea walls, jetties, groins, bulkheads, etc.) appear invariably to destroy habitat for seabeach amaranth. Simply put, any stabilization of the shoreline is detrimental to a pioneer, upper beach annual, whose niche or "life strategy" is the colonization of unstable, unvegetated, or new land and which is unable to compete with perennial grasses. Different types of structures will be discussed in separate categories since their detrimental effects are different.

Bulkheads or sea walls are structures made of wood, concrete, or metal (built at the foot of and parallel to the foredune) designed to halt erosion of the dune. They are usually built to protect buildings and roadways threatened by the landward retreat of the shoreline. Revetments are similar but are constructed of large stones or bags filled with concrete, and they generally have a sloping face.

During status surveys conducted from 1987 to 1990, seabeach amaranth was not found on shorelines where bulkheads, sea walls, or riprap zones had been constructed. Construction of these structures occurs in the primary habitat of seabeach amaranth, and water and wind erosion lower the profile of the beach seaward of the armoring. The upper beach habitat required by seabeach amaranth (above inundation by tidal action) ceases to exist as the beach is steadily eroded. Bucher and Weakley (1990) reported having never seen seabeach amaranth on a beach with a sea wall; it can be found, however, on nearly every beach between Cape Hatteras, North Carolina, and Cape Romain, South Carolina, that lacks a sea wall.

Groins are concrete or riprap structures built out into the surf zone or beyond, perpendicular to the shoreline, and designed to catch the lateral flow of sand and deposit it on the updrift side of the groin. On some beaches in South Carolina, New York, and New Jersey, a series of groins has been placed at regular and close intervals along the length of the island. If placed at the end of an island, they are termed terminal groins and are sometimes built singly (on one side of the inlet) or in pairs (on both sides of the inlet). Groins have mixed effects on seabeach amaranth. Immediately upstream from a groin, accretion sometimes provides or maintains, at least temporarily, habitat for seabeach amaranth; immediately downstream, erosion usually destroys seabeach amaranth habitat. However, in 1991 Long Island's (New York) largest population occurred along a groin field. One subpopulation within the larger one, found in a highly eroded area immediately downslope of the last groin in the field, grew vigorously in the early part of the season but succumbed to overwash in late summer (Mangels, personal communication, 1996). In the long run, groins (if they are successful) stabilize upstream beach, allowing succession to perennials, rendering even the upstream side only marginally suitable for seabeach amaranth.

Another beach-hardening structure, the breakwater, generally consists of a riprap barrier placed offshore and parallel to the beach, intended to intercept and break the erosive force of waves. Bucher and Weakley (1990) knew of no examples in the Carolinas. Dubois (personal communication, 1995) knew of one example, used off the north shore of Long Island, that was unsuccessful and several others in New Jersey.

Widespread use of sea walls, jetties, and other hard stabilization structures in New Jersey, New York, and other northern States is associated with the extirpation of seabeach amaranth in those States. The continued presence of seabeach amaranth in North Carolina and in the parts of South Carolina and New York that lack sea walls is probably not accidental or coincidental.

Sand fences (sometimes termed snow fences) have been widely used on unarmored East Coast beaches to stabilize dunes. In many cases they have been placed in stretches of coastline that were naturally unstable and subject to overwash in order to protect buildings and roads. Seabeach amaranth is rarely encountered in areas that have sand fences. In the few places where Bucher and Weakley (1990, Weakley and Bucher 1992) saw seabeach amaranth associated with sand fences, plants occurred only as rare, scattered individuals or short-lived populations. It appears that the dune stabilization and vertical sand accretion caused by sand fences are detrimental to seabeach amaranth and contradictory to its life history or life strategy.

The effects on seabeach amaranth of stabilization of dunes by planting vegetation (such as sprigging of beach-grass) are similar to those of the placement of sand fences. Seabeach amaranth rarely persists where vegetative stabilization has taken place.

Ironically, beach erosion and lowering of barrier islands have, in some cases, been accelerated by man's structures built far from the ocean. Damming of large brown-water rivers upstream reduces the sediment load carried by the rivers to the coastal environment. There is evidence in several cases that this has reduced the coastal sediment budget, leading to increased erosion rates. Construction of the Santee Dam on the Santee River in South Carolina, impounding Lake Marion, has probably caused the increased erosion of islands in the vicinity of the mouth of the Santee (Phil Wilkinson, South Carolina Department of Natural Resources, personal communication, 1990), though the Cooper River rediversion may halt or reverse these effects. All of the islands in the vicinity of the Santee's mouth are currently marginal habitat for seabeach amaranth, and the species has been extirpated from a number of islands by the frequency of overwash.

Human recreational use of the beach habitats favored by seabeach amaranth is, of course, extensive, and sometimes intensive, especially on Long Island, New York. From the point of view of seabeach amaranth, this use can be divided simply into two categories--vehicular and pedestrian.

Many beaches in the Carolinas and New York allow off-road-vehicle (ORV) traffic, at least during some seasons. On some beaches, traffic is relatively light, whereas on others it can approach traffic jam proportions. In general, ORV traffic occurring during seabeach amaranth's dormant season could potentially have some negative impacts, including the pulverization of seeds. At levels of ORV use generally found on Carolina beaches, there is little evidence of highly detrimental effects, unless it results in massive physical erosion or degradation of the site, such as can be seen at the northern end of Carolina Beach. In some cases, off-season ORV traffic may even provide some benefits for seabeach amaranth. This appears to be true at Cape Hatteras, where a large sand flat would probably proceed through succession into dominance by perennial grasses and shrubs except for heavy winter truck traffic by fishermen. In spring and summer much of the area is fenced off from traffic by the National Park Service in order to protect nesting habitat for least terns, piping plovers, and other shorebirds. Following nesting, in early fall, fencing is removed to allow truck traffic. Physical disturbance by trucks helps prevent the widespread establishment of perennials, which would render the area unsuitable as a nesting ground for birds and as unsuitable habitat for seabeach amaranth.

While seabeach amaranth populations are somewhat tolerant of ORV use from **December until May**, the brittle, fleshy stems are easily broken, and growing plants (**May to December**) do not generally survive a single pass by a truck tire. Thus, even minor beach traffic directly across the plants during the growing season is detrimental, causing mortality and reduced seed production. In the Carolinas, traffic has been successfully routed around these sensitive areas, and most ORV drivers have been respectful of the public land that has been roped off for nesting birds or seabeach amaranth. The seabeach amaranth and nesting shorebirds often occur together in the Carolinas, even outside roped-off areas. On New York's heavily used beaches, however, the interiors of shorebird exclosures are often the only places where seabeach amaranth is found, strongly suggesting that heavy ORV traffic and beach grooming are rendering most of the beaches unsuitable there (DuBois, personal communication, 1995).

Growing-season traffic is allowed at a variety of beaches in North Carolina, including the north end of Carolina Beach and the entire length of Currituck Banks (where the beach is the only land access to several developments near the North Carolina/Virginia line). In New York, where beaches are eroded and narrow, conflicts arise between human access and conservation efforts because there is not enough room left for vehicles to get around sensitive areas (DuBois, personal communication, 1995).

Pedestrian traffic during the dormant season (December to May) is unlikely to have any significant effects in the Carolinas. Even during the growing season pedestrian traffic there generally has little effect on populations of seabeach amaranth. Many beaches with daily use by thousands of sunbathers, joggers, and other recreation enthusiasts have substantial and apparently healthy populations of seabeach amaranth. The main exceptions appear to be in the vicinity of high-rise hotels or condominiums, where beach usage is concentrated and portions of seabeach amaranth populations are sometimes eliminated or reduced by repeated trampling. The general compatibility of human pedestrian recreation enthusiasts and seabeach amaranth lies in their preferences for different parts of the beach. Joggers inevitably prefer packed sand and stay seaward of seabeach amaranth. The great majority of sunbathers prefer to be close to the water and away from beach vegetation, so they generally choose sites seaward of those favored by seabeach amaranth. Island-end flats, the sites most favored by seabeach amaranth, are generally not found desirable by beach-goers, except as a destination to be reached on a long stroll. On the rare beaches where proximity to hotels or condominiums brings heavier use to island-end flats, Bucher and Weakley (1990) saw further evidence of humans avoiding seabeach amaranth habitat. Frequently a low ridge of loose sand, often much favored by seabeach amaranth, parallels the shoreline as it hooks back toward the inlet; joggers, strollers, and birdwatchers stay on the packed sand in front of this ridge, while sunbathers occupy locations in front of or behind it. Unlike in much of the Carolinas, New York's beaches are narrower, and beach goers are forced into areas they would not normally select for walking, jogging, etc. (DuBois, personal communication, 1995).

While pedestrian traffic appears to be a minor problem for seabeach amaranth in the Carolinas, it is probable that the heavier traffic borne by northern beaches near major population centers may have been partially responsible for the extirpation of seabeach amaranth in those regions. Beach grooming is more common on northern beaches and may also have contributed to the loss of those populations (Robert Zaremba, The Nature Conservancy, personal communication, 1996). Motorized beach rakes, which remove trash and vegetation from bathing beaches, do not allow seabeach amaranth to colonize long stretches of northern beach (Young, personal communication, 1996). Only on beaches where the greatest human usage in the Carolinas (such as Wrightsville Beach or North Topsail Beach) are conditions crowded enough to force beach users to choose less optimal recreational sites (more optimal seabeach amaranth sites). The breadth of the beach can, however, minimize the impacts.

Beach replenishment projects and the placement of dredge spoil from maintaining the Atlantic Intracoastal Waterway and various inlet channels have impacts on seabeach amaranth and are not advocated for Federal land where private property is not threatened and where the preservation of natural coastal processes is a prime goal. More study is needed before the overall impacts can be accurately assessed. Since dredging normally takes place in winter in the Carolinas, when seabeach amaranth exists primarily as seeds, the impacts on individual plants are likely to be minor there. In New York, however, dredging is done in the fall, and impacts may be more serious (Brittingham, personal communication, 1996). Deeply burying seeds, at any season, could have serious effects on populations. The severity of the effects depends on the nature of seabeach amaranth's seed bank and the importance of long distance and water dispersal of seeds. These topics need further study.

On the other hand, beach replenishment rebuilds habitat for seabeach amaranth and can have long-term benefits. For instance, Wrightsville Beach was probably the first location in North Carolina where seabeach amaranth was collected, in 1888. It was collected several times later, such as in 1931. A beach replenishment project was begun on Wrightsville Beach in 1965 by the U.S. Army Corps of Engineers (Corps). A jetty was constructed on the south end of Wrightsville Beach in 1966, and the beach was "rebuilt" with sand (all placement of sand was on the north and central portions of the island) (Tom Jarrett, Corps, Wilmington District, personal communication, 1989). Additional renourishment was undertaken in 1970, but then a lapse of 10 years occurred and severe erosion took place. The full length of the beach was surveyed on a regular basis during 1978 to 1980; no seabeach amaranth was found. In 1980 and 1981, a total of 1.7 million cubic yards of sand was placed on the beach. Eighty-five seabeach amaranth plants were found on the north end in 1985 and twelve plants were found on the south end. A further renourishment of 900,000 cubic yards was placed in 1986. That same year, 611 plants were found on the north end (the south end was not surveyed). In 1987, the censuses recorded 431 individuals on the north end and 69 on the south, and in 1988, the north end had 2,521, and the south had 414. Overall, Wrightsville Beach is now one of the largest and least variable populations of seabeach amaranth known. It has apparently reestablished itself (whether from a seedbank or from colonization is not known) on this renourished beach. It is interesting that on the south end, which accreted because of the jetty, a population has also become reestablished, though consistently smaller than on the renourished north end.

At Atlantic Beach, dredge spoil placement has also apparently aided in the reestablishment of a population of seabeach amaranth. A very large renourishment project at Carolina Beach, North Carolina, however, has failed to help seabeach amaranth. A few plants are present, but it is one of the poorest populations in the State, despite repeated renourishment since the 1960s. Reasons include the use of a 2,000-foot-long rock wall and heavy ORV use during the growing season.

Fragmentation of habitat in the Northeast may have led to regional extirpation, resulting from the separation of suitable habitat areas from one another by too great a distance to allow recolonization following natural catastrophes. Though apparently suitable habitat is present in a number of northern States, formerly part of seabeach amaranth's range, it is now found only on Long Island in New York (Clemants and Mangels 1990).

It is instructive to review what can be learned of the history of seabeach amaranth in New Jersey, where the species was first discovered by Rafinesque in 1803 or 1804. It was repeatedly noted, written about, and collected over the next 110 years. It is apparent that it was not especially rare, though probably not an abundant or conspicuous part of the flora. In 1889, Britton, in a catalogue of plants of New Jersey, described seabeach amaranth as being "frequent . . . on sandy sea-beaches" (Britton 1889). Twenty-two years later, in 1911, Stone listed it as "apparently local and not common" on "sands of the sea beaches" (Stone 1911). He went on to list eight locations, many of them collected by Bayard Long at about that time, so it is apparent that though seabeach amaranth was "apparently local and not common," it was still encountered at a number of locations. The last record of seabeach amaranth from New Jersey was two years later, in 1913. Over a period of less than 30 years, seabeach amaranth had gone from "frequent" to "not common" to "extirpated."

What had occurred during this time to render New Jersey uninhabitable for seabeach amaranth? It appears that hard stabilization of the shoreline with bulkheads and sea walls began in the latter part of the nineteenth century. Pilkey and Wright (in prep.) tell the story of Sea Bright. The first documented bulkheading is shown in a picture from 1886, followed by a "large rubble wall lining a portion of the north end beach" in 1903. By 1931, the length of the shore was "protected" by a rubble wall 5.2 meters (17 feet) high. Though this particular beach is not known to have supported seabeach amaranth, similar fortification was occurring at other locations along the New Jersey coast. Pilkey and Wright (in prep.) found in their study of North Carolina, South Carolina, and New Jersey, that:

> . . . not surprisingly, New Jersey is the State with the highest degree of stabilization. As measured by the amount of shoreline in the totally stabilized category (90 to 100 percent walled), New Jersey, America's oldest developed shoreline, is 43 percent hard-stabilized. South Carolina, which has a mostly post-World War II history of shore-front development and few restrictions on sea wall construction has a developed shoreline, 18 percent of which falls into the 90 to 100 percent walled category. North Carolina has actively discouraged sea wall construction in recent years and only 3 percent of the State's developed shoreline is stabilized with hard structures . . . . The above percentages do not include the mileage of publicly owned stretches of shoreline such as National Seashores, State Parks, military bases, etc.

It is perhaps not surprising that seabeach amaranth's present stronghold is North Carolina, its status in South Carolina is somewhat tenuous, and it was extirpated from New Jersey during the period when sea walls were being constructed.

Seabeach amaranth appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner. This allows it to move around in the landscape, as a fugitive species, to occupy suitable habitat as it becomes available. In New Jersey and in most of New York, it apparently succumbed to the fortification and modification of a portion only of the coastline. Rendering 50 percent or 75 percent of a coastline permanently unsuitable may doom seabeach amaranth, because any given area will become unsuitable at some time because of natural forces. If a seed source is no longer available in the vicinity (from adjacent populations or a long-lived seed bank) and if long-distance dispersal does not occur, seabeach amaranth will be unable to reestablish itself when the area is once again suitable. In this way, it can be progressively eliminated, even from generally favorable stretches of habitat surrounded by permanently unfavorable areas.

Habitat loss and degradation are, by far, the greatest threats to the continued existence of seabeach amaranth. However, on a more local scale, predation (herbivory) by webworms (the caterpillars of small moths) is a major source of mortality and lowered fecundity in the Carolinas. Caterpillars were collected from several amaranth populations and were sent or delivered to insect or pest specialists. Moth species are difficult to identify based on larval characters, so several attempts were made to raise caterpillars to maturity in order to make a positive identification from the mature moths, but the caterpillars never reached metamorphosis. In the Carolinas, there have been four identifications for caterpillars collected on seabeach amaranth--beet webworm (*Loxostege similialis*), garden webworm (*Achyra rantalis*), southern beet webworm (*Herpetogramma bipunctalis*), and Hawaiian beet webworm (*Spoladea recurvalis*) (Ken Ahlstrom, North Carolina Department of Agriculture, personal communication, 1990; David Stephan, North Carolina State University, personal communication, 1990). All four species are believed to be native in the southeastern United States. *Loxostege* and *Achyra* are known from the entire historic range of seabeach amaranth, *Spoladea* extends north to New York, and *Herpetegramma* extends north to New Jersey (Ahlstrom, personal communication, 1990). In New York, an infestation of the caterpillars of *Estigmene acraea*, a general foliage feeder, was observed in 1994. The leaves of many plants at Jones Beach Island East were totally consumed by caterpillars that year. No caterpillars were observed in 1995 (Young, personal communication, 1996).

Potential webworm herbivory would seem to be greater in the South, so it seems unlikely that herbivory is the cause of the extirpation of seabeach amaranth in the North. Not only are there more potential species of webworm in the South, but also they are likely to produce more broods over the course of a longer warm season. The beet webworm is a general foliage feeder, known to feed on alfalfa, beans, beets, clover, cowpeas, lamb's-quarters, peas, amaranths, and ragweed. Garden webworms are reported to feed on alfalfa, beans, beets, clover, corn, peas, cotton, strawberries, and many other plants (Stehr 1987, Covell 1984). Southern beet webworms are known to feed on amaranths, beets, and many other plants (Ahlstrom, personal communication, 1990). Hawaiian beet webworms have been reported on beets, Swiss chard, spinach, amaranths, and lamb's-quarters (Stehr 1987, Covell 1984). Evidence of webworm herbivory, even in very small, isolated populations of seabeach amaranth, supports an identity as a general foliage feeder not specific to amaranths. All four of these webworm species are generalists; they can find other host plants, such as *Strophostyles*, *Chenopodium ambrosioides*, and others, on barrier islands. The size of a population of seabeach amaranth and its proximity to the mainland are poor predictors of the absence or presence of webworms, a pattern that would be expected of a generalist herbivore or pest. Webworms appear to have strong effects on seabeach amaranth. Most populations experienced moderate to severe herbivory by webworms in both 1987 and 1988. Herbivory is, however, difficult to assess by a single visit in a year and difficult to compare from year to year when single visits may occur as much as a month apart.

Determination of the relative importance of the various webworm species, the pattern of their predation, and their other hosts are important questions regarding seabeach amaranth's biology and prognosis for survival. Even though the five webworms so far identified on seabeach amaranth are all native species, their use of barrier island habitats has probably been altered by changes in the coastal plain landscape (i.e., extensive agricultural use), the development of barrier islands, and the introduction of weedy plants that can also serve as host plants. All five webworms are "weedy" species, probably much more abundant now than they were in pre-Columbian times. For this reason, the level of predation that seabeach amaranth is experiencing is likely unnatural. Considering the extreme habitat alterations that seabeach amaranth is experiencing, particularly in the northern part of its historic range, it is likely that webworm herbivory is a contributing, rather than a leading, factor in its decline. The combination of extensive habitat alteration and chronic severe herbivory could be a deadly one for seabeach amaranth, however.

If it is decided that control measures against webworms are needed, BT (*Bacillus thuringensis*) is likely to be the best alternative. It affects only lepidopterans, and if used in the beach habitat of seabeach amaranth, it is not likely to have serious deleterious impacts on rare lepidopteran species.

Conservation Efforts

Seabeach amaranth cannot be protected through what has become the most conventional approach to preserving rare plant species--purchasing habitat for important populations and managing the land as a preserve for the continued well-being of the species. As a species dependent on a dynamic landscape, its condition is an indicator of one aspect of the health of the landscape. Where the landscape has been too strongly modified, seabeach amaranth has disappeared. Because of its dependence on landscape-scale processes and its growth in a habitat in which Federal agencies have strong roles, Federal designation as a threatened species may help to ensure its continued existence. State and local actions protecting individual amaranth populations from destruction can help but are not sufficient. Seabeach amaranth no longer exists in six of the original nine States in which it occurred. It appears to be vulnerable in South Carolina, with only a few populations of over a hundred plants. New York, as of 1995, was down to six populations, with one of these containing only a single plant (DuBois, personal communication, 1995) and only two containing more than 100 plants. (Brittingham and Young, personal communications, 1996).

Although North Carolina offers some formal protection to the species by virtue of its listing as threatened under the Plant Protection and Conservation Act of 1979, this protection is largely limited to the regulation of collecting and trade. This leaves unaddressed the main problems for this species--habitat loss and modification and predation by webworms. Although South Carolina also recognizes the species as threatened and of national concern, this is simply a nominate designation that does not confer legal protection. In New York the species is proposed for listing as endangered, but a moratorium on new rulemakings has prevented the species from being officially added to that State's endangered species list. In any case, State-listed species in New York are protected only from taking on State-owned lands. State legislation offers essentially no protection to the habitat of seabeach amaranth in any of the three States where it remains.

The Endangered Species Act of 1973, as amended (Act), requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species. If a Federal action may affect a listed species, the responsible Federal agency must enter into formal consultation with the Service. In the process of consultation, the two agencies attempt to work out a compromise where the agency's proposed action can be carried out without jeopardizing the continued existence of the species. In addition, the Act confers certain trade protection for threatened plants. These trade restrictions, in part, make it illegal for any person subject to the jurisdiction of the United States to import or export, transport in interstate or foreign commerce in the course of a commercial activity, sell or offer for sale this species in interstate or foreign commerce, or to remove and reduce to possession the species from areas under Federal jurisdiction. Seeds from cultivated specimens of threatened plants are exempt from these prohibitions provided that a statement of "cultivated origin" appears on their containers.

In addition, for endangered plants, the 1988 amendments (Pub. L. 100-478) to the Act prohibit the malicious damage or destruction on Federal lands and the removal, cutting, digging up, or damaging or destroying of endangered plants in knowing violation of any State law or regulation, including State criminal trespass law. Section 4(d) of the Act allows for the provision of such protection to threatened species through regulations. This protection may apply to threatened plants once revised regulations are promulgated.

Certain exceptions apply to agents of the Service and State conservation agencies. The Act and 50 CFR 17.72 also provide for the issuance of permits to carry out otherwise prohibited activities involving threatened species under certain circumstances. Recognition through Federal listing also encourages and results in conservation actions by Federal, State, and private agencies; groups; and individuals. The Act also provides for possible land acquisition and cooperation with the States through a grant-in-aid program and requires Federal agencies to carry out recovery actions for all listed species.

Habitat of seabeach amaranth, whether or not it is on public property, is regulated by various State and Federal agencies. For instance, construction of buildings in the dynamic beach areas where seabeach amaranth grows is forbidden by North Carolina's Coastal Areas Management Act. Construction of sea walls and revetments is also disallowed in North Carolina, and South Carolina has made recent attempts to increase the regulation of coastal development and beach hardening. Coastal development and the installation of shoreline stabilization structures are regulated by New York State's Tidal Wetlands Law. However, proposed changes may weaken the protection these regulations currently offer (DuBois, personal communication, 1995).

Ownership and legal rights of private owners, recreation enthusiasts, and public agencies in beach and barrier island areas (seabeach amaranth habitat) has been confusing and controversial. "For legal purposes, the 'beach' is often divided into four geographic parts. The upland is the area landward of the vegetation line. The area between the high tide line and the vegetation line is the dry sand beach. It is inundated only during storms and extraordinary tides. The wet sand is the area between the mean low and high tide lines, also called the foreshore or tideland. Seaward of the mean low tide line is the seabed part of the beach. In North Carolina, the State owns the seabed and wet sand beach, and private parties can own the dry sand beach and uplands. However, the public probably has a legal right to use the dry sand area for walking, fishing, shell collecting, and typical beach recreation activities" (Schwab 1989). In New York, the State generally owns the bottomland below the apparent low water line, but in some cases municipal (and other) ownership extends below the mean high tide line (Dubois, personal communication, 1995). In South Carolina, the land below mean high tide belongs to the State, with higher ground being privately owned. Depending on the interpretation of the "vegetation line," seabeach amaranth occurs either on the "upland" or the "dry sand beach." Both of these areas can be privately owned in all three states where the plant remains, with public use rights more clearly established for the dry sand beach. On certain developed beaches, seabeach amaranth populations may be distributed among hundreds of owners, with each "frontline lot" owner possessing a short segment of the population.

A number of populations (and some of the largest) of seabeach amaranth occur on public property designated for conservation purposes, but this does not guarantee proper management for seabeach amaranth, however. Among public conservation agencies with ownership of amaranth populations are the Service (Cape Romain and Currituck National Wildlife Refuges); National Park Service (Cape Hatteras National Seashore, Cape Lookout National Seashore, Fire Island National Seashore, and Gateway-Breezy Point National Recreation Area); North Carolina Division of Parks and Recreation (Fort Macon State Park and Hammocks Beach State Park); South Carolina Department of Parks, Recreation, and Tourism (Huntington Beach

State Park and Myrtle Beach State Park); New York State Parks (Jones Beach, Robert Moses, and Gilgo Beach State Parks); Suffolk County (New York) Parks (Smith Point and Cupsogue); New York City Parks (Averne-by-the-Sea); Town of Brookhaven (New York) (Cedar Beach); and the North Carolina Coastal Reserves, managed by the Division of Coastal Management (including Masonboro Island Coastal Reserve, Rachael Carson Coastal Reserve, and Zekes Island Coastal Reserve). Conflicting land management goals sometimes lead to problems for seabeach amaranth. Growing season ORV use is a problem in some areas, where the managing agency either does not rope off sensitive areas or where ORV drivers do not respect such designations and there is insufficient enforcement, or where the narrowness of the beach (New York) forces drivers into seabeach amaranth habitat. Recreational use by pedestrians does not appear to have significant negative impacts on the surviving seabeach amaranth populations in the Carolinas. However, pedestrian use of New York beaches is more intense and does pose a problem there. Beach grooming is not carried out to any extent in the Carolinas, but it is a common practice in New York, where it poses a serious threat to existing populations and may be preventing seabeach amaranth from colonizing suitable beaches. Beach scraping (the practice of scraping off as much as 6 inches of sand from the top of the beach and stockpiling it for construction or augmentation of dunes) also threatens the species in New York (DuBois, personal communication, 1996).

The national seashores, in keeping with the requirements of the Act, protect amaranth by excluding ORVs from areas where amaranth plants are growing. Many State parks are doing the same. Efforts to provide protection for nesting shorebirds have also provided protection for seabeach amaranth, since they occupy the same habitat.

The Maryland Natural Heritage Program, with partial funding from the Service, is undertaking a project to reestablish populations along the mid-Atlantic Coast, probably on Assateague Island. Isozyme analyses will be conducted first to look for genetic differences between the northern and southern populations (Wayne Tyndall, Maryland Natural Heritage Program, personal communication, 1995). If the populations in New York and the Carolinas are found to have strong genetic differences but no problems with inbreeding depression, the donor population will presumably be the closest one to the reintroduction site that is producing plenty of seeds. Seabeach amaranth was the subject of a recent graduate research project by Tom Hancock, University of North Carolina at Wilmington (Paul Hosier, University of North Carolina at Wilmington, personal communication, 1995). Included in this study were germination trials and some direct seeding experiments, as well as other investigations into the species' life history. The New York populations are being monitored; a more systematic and comprehensive monitoring effort is needed in the Carolinas. In New York, the

13 known seabeach amaranth sites are annually surveyed and protected with temporary barriers by The Nature Conservancy, working in conjunction with the New York Department of Environmental Conservation (Brittingham, personal communication, 1995).

Some of the most significant activities potentially affecting seabeach amaranth survival and recovery are Federal actions:

1. **Construction of sea walls, revetments, groins, and jetties and the artificial closure of beaches and inlets.** The most severe threat to the continued survival of seabeach amaranth (and the likely cause of its extirpation in most of its historic range) is the construction of hard structures to try to prevent the landward migration of barrier islands. Such structures have historically been constructed largely or entirely with Federal funding, and usually by the Corps. In recent decades more emphasis has been placed on beach nourishment or replenishment, which is more compatible with seabeach amaranth and has had demonstrably positive effects on several populations, even though, in the long run, this is still interfering with natural coastal geophysical processes. Barrier islands from South Carolina to Massachusetts will certainly continue to migrate, as they always have, and Federal agencies will certainly react to the associated erosion. Some possible actions could exterminate seabeach amaranth within a short period of time (perhaps a decade), other possible actions might have little effect on its status, and still others could lead to its recovery and reestablishment in portions of its former range.

2. **Dredging activities (placement of dredge spoil) and beach replenishment projects.** These two actions are discussed together, though they are often separate activities. As discussed throughout this report, the habitat of seabeach amaranth is upper beaches and island-end flats on either side of inlets. Beach replenishment projects and spoil disposal from inlet dredging have impacts on seabeach amaranth. Relatively simple studies could help determine how to minimize negative impacts and maximize positive impacts. Any modifications of current policies designed to enhance the status of seabeach amaranth are not likely to be significant in terms of cost or difficulty of carrying out the project in the Carolinas. In New York, the situation could be different (Brittingham, personal communication, 1995). At present, it appears that the winter placement of dredge spoil (December to April) is most compatible with seabeach amaranth, but further studies and experimentation are needed to determine the best seasons and techniques for disposal of dredge spoil in seabeach amaranth habitat. The Wilmington, North Carolina, and Charleston, South Carolina, Corps

districts have undertaken long-term monitoring studies to investigate the effects of disposal and beach nourishment on the species (Bill Adams, Corps, Wilmington District; Jim Woody, Corps, Charleston District; personal communications, 1995).

3. **North Carolina's Coastal Area Management Act.** Federal and State regulation of development in coastal areas has undoubtedly helped prevent the extinction of seabeach amaranth by prohibiting construction in the unstable areas which form the best habitat for the species. Changes in policy could have positive or negative impacts on seabeach amaranth. In North Carolina, an interagency committee composed of the Service, the National Park Service, Corps, National Marine Fisheries Service, Federal Highway Administration, and North Carolina Department of Transportation is investigating transportation alternatives, such as replacing existing stretches of coastal island highways with causeways or other alternatives that would not be displaced by storm overwash and would allow the natural geophysical processes to operate. Alternatives of this type could lessen highway maintenance costs while benefiting seabeach amaranth and other species that depend on the overwash habitats (Ries Collier, Cape Hatteras National Seashore, personal communication, 1995).

Strategy for Recovery

The following conditions are believed to be necessary for the continued survival of seabeach amaranth in the wild:

1. **Continued presence of the habitat described as suitable, under A, Recovery Objective.** Critical to the continued existence of this habitat is the absence of hard stabilization structures. Recent efforts to weaken so-called "anti-hardening" statutes in the Carolinas and changes to New York State's tidal wetlands laws are of great concern. Important components of the natural physical environment are:

   (a) sandy substrate;
   (b) coastal environment (nutrient supply from salt spray);
   (c) minimal competition from other beach annuals or widely scattered perennials; and,
   (d) unstabilized dunes, upper beach, and overwash flats.

2. **Protection from the excessive loss of plants from ORV traffic and excessive pedestrian traffic during seabeach amaranth's growing season.** While seabeach amaranth populations are somewhat tolerant of ORV use during the dormant season (from December until May) the brittle, fleshy stems are easily broken. Thus, even minor beach traffic directly over the plants during the growing season is detrimental.

3. **Protection from excessive herbivory by webworms and other herbivory/predators that are found to be a problem.** Further study is needed to determine if webworm predation is chronic and severe. Serious mortality of plants from webworms was documented in 1987, yet seabeach amaranth had a good year in 1988. A steady loss of seed production, however, might have effects that would not be immediately apparent and make the species more vulnerable to extinction.

4. **Protection of long "multi-inlet" stretches of coastline from hard stabilization and artificial closures of beaches and inlets.** Preference of beach replenishment as a means of dealing with erosion where private property or public safety is threatened. Even with apparently suitable habitat present on a few islands in New Jersey and Massachusetts, seabeach amaranth has failed to survive there. The overall coastline landscape has apparently been altered to a degree that does not allow seabeach amaranth to exercise its fugitive life strategy. Protection should be focused on the factors described in item 1.

PART II

RECOVERY

A. Recovery Objective

Seabeach amaranth (*Amaranthus pumilus*) will be considered for delisting when the species exists again in at least six of the States within its historic range (Delaware, Massachusetts, Maryland, North Carolina, New Jersey, New York, Rhode Island, South Carolina, and Virginia) and when a minimum of 75 percent of the sites with suitable habitat within each State are occupied by amaranth populations for 10 consecutive years. Sites are defined in accordance with Weakley and Bucher (1992); e.g., spits and island ends (two to three potential sites on islands longer than 5 kilometers), one large site on islands shorter than this (or more potential sites where suitable habitat is separated by substantial areas of strongly unsuitable habitat). Suitable habitat is defined as overwash flats at accreting spits or ends of barrier islands and the lower foredunes and upper strands of noneroding beaches (including sound-side beaches, in New York). Numbers of plants within these populations will fluctuate, and locations of sites with suitable habitat will vary from one year to the next, depending on storms and other coastal dynamics. Mechanisms must be in place to protect the plants from destructive habitat alterations (particularly construction of sea walls and other forms of beach armoring), destruction or decimation by ORVs or other beach uses (this can take the form of differential traffic-routing away from occupied areas, with sufficient enforcement), and protection of populations from debilitating webworm predation. This recovery objective is considered an interim goal because of the need for more specific data on the ecological requirements of the species for long-term survival. The recovery objective for seabeach amaranth will be reassessed at least annually in light of any new information which becomes available.

B. Narrative Outline

1. **Protect existing populations and essential habitat**. Based on the last complete rangewide census, only 55 populations of seabeach amaranth survive, all within the States of North Carolina, South Carolina, and New York.

   1.1 **Develop interim research and management plans in conjunction with landowners and managers**. Much remains to be learned about the specific management necessary to ensure the long-term survival of this species. Therefore, immediate emphasis will be on protection, particularly of the sites that have consistently supported large and vigorous populations over many years' time. Because the nature of this species' habitat involves constant shifting and changing of the land, sites which support good populations one year may not be suitable habitat the next year. Therefore, protection should focus on suitable habitat, with emphasis placed on those land areas where suitable habitat is consistently created in the same vicinity, season after season (such as Cape Point, Cape Hatteras National Seashore, North Carolina). Habitat use models should be developed to predict the location of future populations. This would give land managers the ability to recommend which sections of beach, based on physical characteristics, should be protected and managed to recover this species in a given year. The model would be based on the dynamic geophysical processes of barrier beaches, as well as vegetative characteristics of these habitats.

   1.2 **Search for additional populations**. Because this annual species changes locations from one growing season to the next, searches for new populations and newly created habitat are essential to monitoring the species' status and determining protection priorities within a given year.

   1.3 **Determine habitat protection priorities**. Because of the relatively small number of surviving populations and the pervasive and imperfectly understood threats to the species' survival, it is essential to protect as many areas of suitable habitat as possible. However, efforts should be concentrated first on the sites in protective ownership, or where current private landowners are cooperative, and where the largest and most vigorous populations have existed in recent years.

2. **Determine and implement the management necessary for long-term reproduction, establishment, maintenance, and vigor.** Protection of existing populations and suitable habitat are the obvious first steps in ensuring survival. For an annual species with a fugitive lifestyle, this is not an easy or small-scale task. Protection of long reaches of shoreline, involving multiple ownerships, is necessary for the long-term survival of this species. Methods for accomplishing this will have to be worked out as part of the recovery process, in conjunction with landowners and managers and municipalities. If protective action must be taken when erosion threatens beach-front property or public safety, beach replenishment and nourishment should be favored over sea walls and jetties (and, preferably, should be carried out in the nongrowing season of December through April).

   By comparison, the physical protection of existing populations is more straightforward. ORV traffic can often be easily routed around the areas where plants are growing, just as is done to protect nesting shorebirds. Pedestrian traffic is usually not a problem for the species (except on some New York beaches), but in the unusual situations where it is, symbolic fencing and interpretive signs can be used to persuade people not to trample the plants. Enforcement of these protective measures may be critical in some areas. Protection of the populations from webworm predation may involve the use of chemical or biological controls such as BT. In small populations, control of this predator can be easily and safely accomplished by simply picking off the caterpillars before they metamorphose.

   2.1 **Conduct long-term demographic studies.** Long-term demographic studies should be conducted. Populations should be surveyed annually, preferably twice in the first few years, once early in the season and again after seed set has occurred. This information is important since plants can sometimes germinate in large numbers in atypical habitat (such as on dredge spoil); counts done just after germination would convey a false impression of the relative importance of this habitat to the species. Plants in this situation often do not survive to reproduce; for an annual plant such as seabeach amaranth, this means that such a population, even though thousands of plants may germinate initially, is of no value to the long-term survival of the species. Systematic, annual surveys provide valuable information on how much fluctuation populations within a given area can undergo and still thrive over the long term. They also allow the observers to identify the important stretches of coastline that produce suitable habitat for this species, year after year, where the largest and most stable populations are usually found. When plants are mature, it is generally quite easy to separate and count individuals, even though this can be tedious in large populations. In addition to counting the number of individuals, the census should document the percentage of plants that produce seeds, as well as the extent of the area occupied by the population ("17 plants spread across 5 square meters," or "500 plants scattered along 2 kilometers of beach from the northernmost point of the island," etc.). Evidence of webworm or other herbivory should also be documented.

Research is needed on seed dispersal, as well as on the existence and possible long-term survival of seed banks.

2.2 **Determine the effects of past and ongoing habitat disturbance.** Much is known already about the destructive effects of beach armoring on this species. However, the coastal environment is complex, and the long-term effects on seabeach amaranth of disrupting the natural sand movement patterns are not completely understood. Establishment of a long-term amaranth population monitoring program, along with concurrent documentation of coastal projects and observed impacts, may be the most effective means of assessing the effects of disturbance.

2.3 **Develop techniques and reestablish populations in suitable habitat within the species' historic range**. Techniques for seed collection and storage have been developed for this species (Brenner, personal communication, 1993). Techniques for germination, propagation, and transplantation need to be refined and implemented, and the technology should be made available to interested parties. This information will need to be developed in conjunction with knowledgeable individuals in greenhouse or nursery facilities. Transplant sites in native habitat must be closely monitored to determine success and to adjust methods of reestablishment. Transplant sites will be chosen based on the probability that suitable habitat will remain within seed-dispersing range over the long term. Also, information on seed banks in wild populations must be obtained to determine whether, and under what conditions, decimated colonies can recover naturally.

3. **Develop a cultivated source of plants and provide for long-term seed storage**. There are at present no known cultivated sources of this species. Since the species is an annual, it might be more advisable to concentrate

on perfecting techniques for long-term seed storage in cooperation with botanical gardens, nurseries, and other appropriate facilities. The Center for Plant Conservation is already in the process of collecting, storing, and maintaining this taxon as part of its National Collection of Endangered Plants, but more collections will need to be made in order to obtain a genetically representative sample (Anukriti Sud, Missouri Botanical Garden, personal communication, 1995). The participating institution responsible for this taxon is the North Carolina Botanical Garden in Chapel Hill, North Carolina. Genetic analysis should be conducted so that different genotypes are protected and preserved for appropriate transplantation back into the wild (this is currently underway in Maryland [Tyndall, personal communication, 1995]).

4. **Enforce laws protecting the species and/or its habitat**. The Act regulates trade and prohibits the taking of seabeach amaranth from Federal land without a permit. Section 7 of the Act provides additional protection of the habitat from impacts related to federally funded or authorized projects. The State of North Carolina prohibits the taking of the species without a permit and the landowner's written permission and regulates trade in the species (North Carolina General Statute 19-B, 202.12-202.19). Although South Carolina recognizes seabeach amaranth as threatened and of national concern (South Carolina Committee on Rare, Threatened, and Endangered Plants), this State offers no official protection. In New York, the species is being proposed for listing as endangered. State law prohibits the taking of listed plants from State land without a permit. New York, like the other two States where the species currently survives, offers essentially no habitat protection, except for indirect protection provided through the State's Tidal Wetlands Act.

5. **Develop materials to inform the public about the status of the species and the recovery plan objectives**. Public support for the conservation of seabeach amaranth could play an important part in encouraging landowner/manager assistance and conservation efforts. Informational materials should not identify the plant's locations so as not to increase the threat of taking.

    5.1 **Prepare and distribute news releases and informational brochures.** News releases concerning the status and significance of the species and recovery efforts should be prepared and distributed to major newspapers in the range of the species, as well as to smaller newspapers in the vicinity of the species' habitat. Publicity should not specify locations of plants. It should be emphasized that the protection of seabeach amaranth also contributes to the protection of a healthy and accreting beach ecosystem for the enjoyment of people.

A seabeach amaranth fact sheet has been developed by the Service's New York Field Office.

5.2 **Prepare articles for popular and scientific publications**. The need to protect the species in its native habitat and cooperation among local, State, and Federal organizations and individuals should be stressed. Scientific publications should emphasize additional research that is needed and solicit research assistance from colleges and universities that may have conducted studies on closely related species. Cooperation should be sought from botanical societies, native plant groups, and other professional and avocational organizations.

6. **Annually assess the success of the recovery efforts for the species.** Review of new information, evaluation of ongoing actions, and redirection, if necessary, is essential for assuring that full recovery is achieved as quickly and efficiently as possible.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

COE - U.S. Army Corps of Engineers
ES - Ecological Services, U.S. Fish and Wildlife Service
FWS - U.S. Fish and Wildlife Service
LE - Law Enforcement Division, U.S. Fish and Wildlife Service
NPS - National Park Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
R5 - Region 5 (Northeast Region), U.S. Fish and Wildlife Service
SCA - State Conservation Agencies - State plant conservation agencies in North Carolina--the Plant Conservation Program (North Carolina Department of Agriculture) and the Natural Heritage Program (North Carolina Department of Environment, Health, and Natural Resources)

SEABEACH AMARANTH IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000s) FY1	Cost Estimates ($000s) FY2	Cost Estimates ($000s) FY3	Comments
1	1.1	Develop interim research and management plans in conjunction with landowners and managers.	Ongoing	R4 and R5/ES	NPS, SCA, COE	20.0	20.0	20.0	
1	2.1	Conduct long-term demographic studies.	Ongoing	R4 and R5/ES	NPS, SCA, COE	25.0	25.0	25.0	
1	4	Enforce laws protecting the species and/or its habitat.	Ongoing	R4 and R5/ES	NPS, SCA, COE	5.0	5.0	5.0	
2	1.2	Search for additional populations.	Ongoing	R4 and R5/ES	NPS, SCA, COE	15.0	15.0	15.0	
2	1.3	Determine habitat protection priorities.	3 years	R4 and R5/ES	NPS, SCA, COE	5.0	5.0	5.0	
2	2.2	Determine the effects of past and ongoing habitat disturbance.	Ongoing	R4 and R5/ES	NPS, SCA, COE	10.0	10.0	10.0	
2	2.3	Develop techniques and reestablish populations in suitable habitat within the species' historic range.	5 years	R4 and R5/ES	NPS, SCA, COE	15.0	15.0	15.0	
2	3	Develop a cultivated source of plants and provide for long-term seed storage.	5 years	R4 and R5/ES	NPS, SCA, COE	7.0	5.0	5.0	
3	5.1	Prepare and distribute news releases and informational brochures.	2 years	R4 and R5/ES	NPS, SCA, COE	5.0	5.0	5.0	
3	5.2	Prepare articles for popular and scientific publications.	2 years	R4 and R5/ES	NPS, SCA, COE	2.0	2.0	2.0	
3	6	Annually assess the success of recovery efforts for the species.	Ongoing	R4 and R5/ES	NPS, SCA, COE	1.0	1.0	1.0	

PART IV

LIST OF RECIPIENTS

The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of this plan.

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APPENDIX

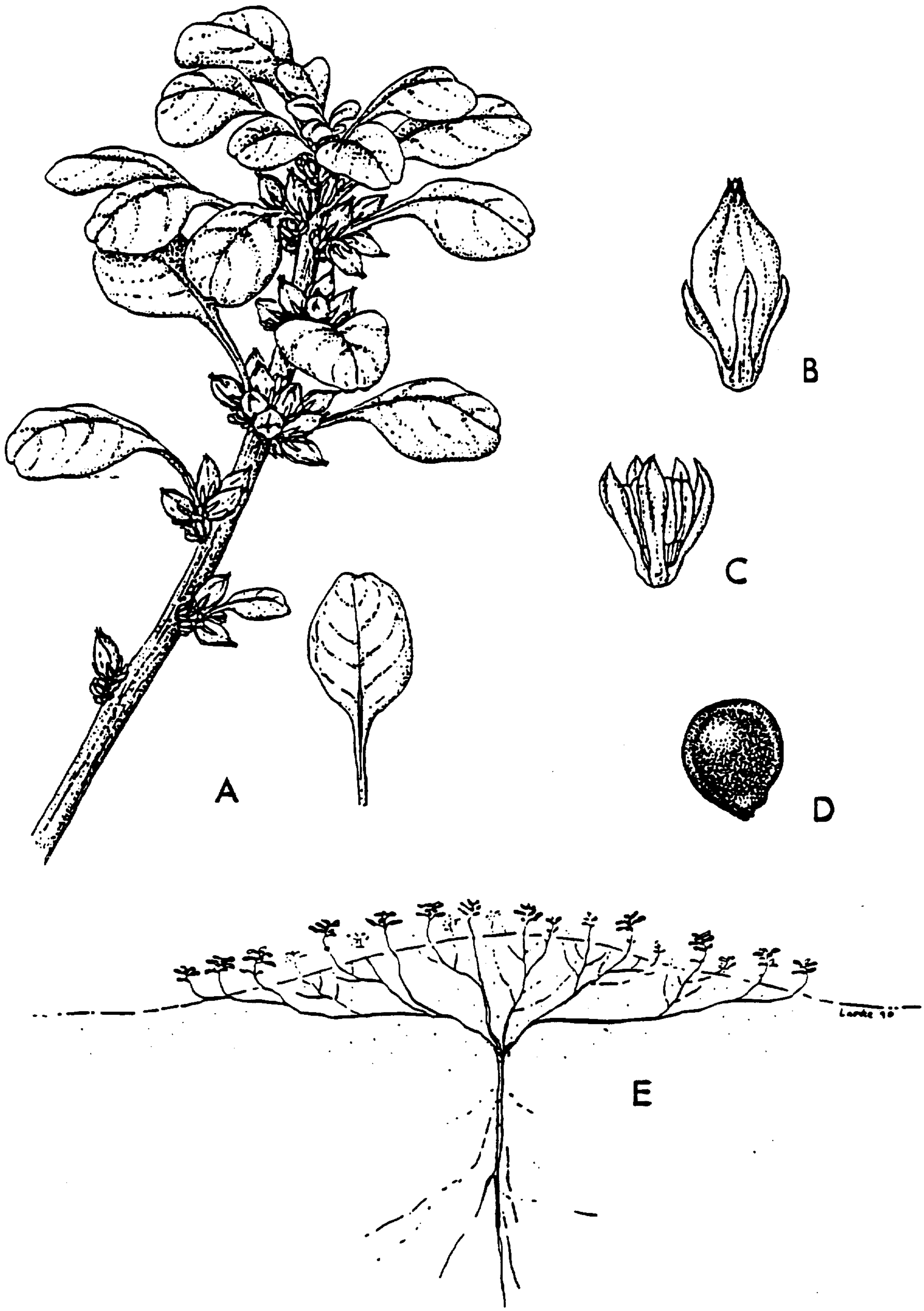

Figure 1. Seabeach amaranth (*Amaranthus pumilus*). A) Fruiting branch of mature plant and top view of leaf (1.5 X), B) Fruit (6 X), C) Flower (7 X), D) Seed (8 X), and E) Habit sketch of large plant, showing branching pattern and sand accretion around plant (1/8 X).

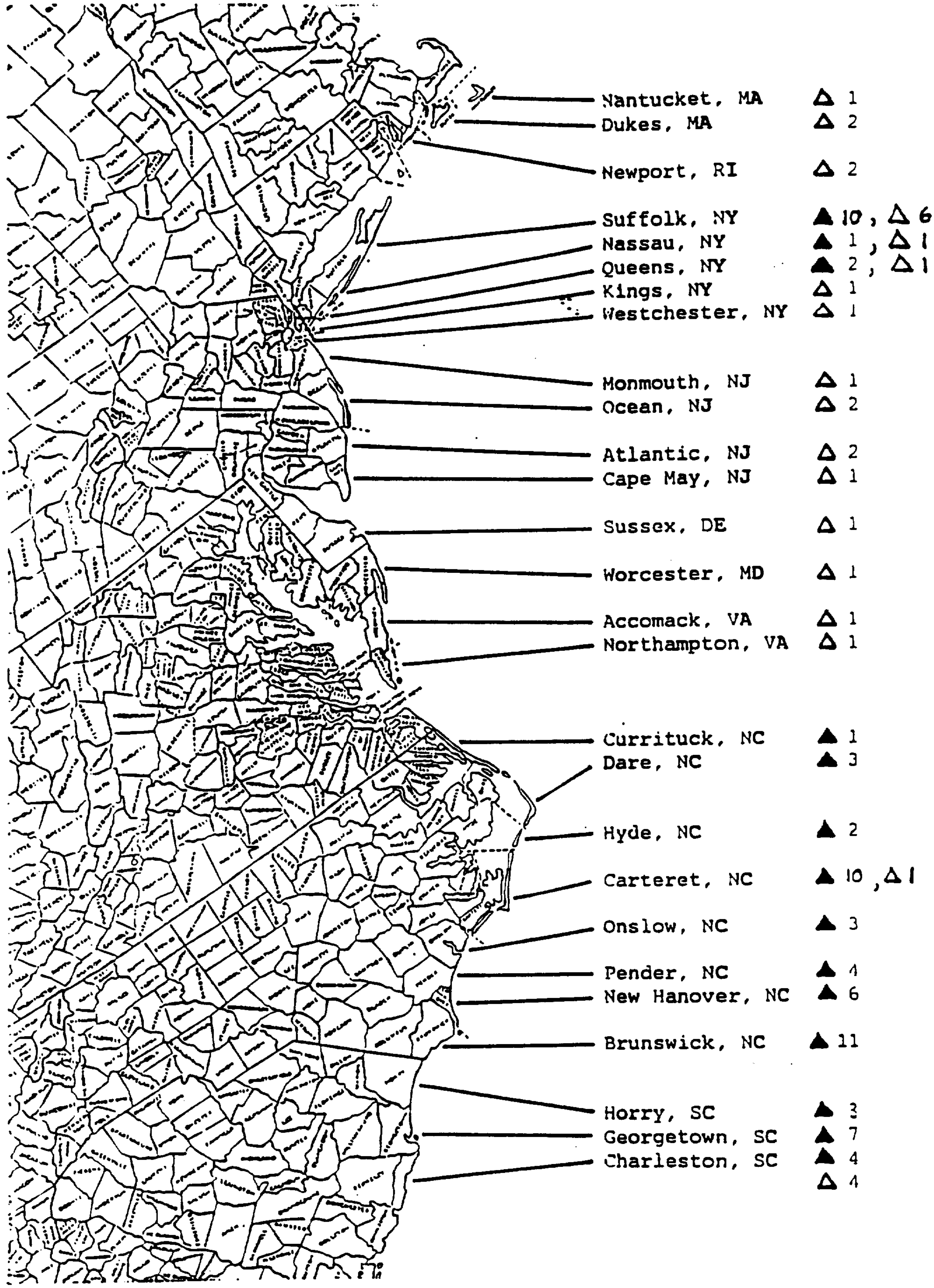

Figure 2. Range of seabeach amaranth (*Amaranthus pumilus*).

▲ Extant population in county (followed by number of extant populations).

△ Extirpated population in county (followed by number of extirpated populations).

Table 1: Range of Seabeach Amaranth. Barrier island counties are listed from north to south, from Cape Cod to Kiawah Island. Populations are classified into five categories, based on an average of all population censuses from the previous decade (from 1 to 6 censuses). The categories are Excellent or A (greater than 1000 plants), Good or B (100-999 plants), Fair or C (10-99 plants), Poor or D (1-9 plants), and Extirpated or X (0 plants). The number of populations in each status category is reported for each county. For counties from which seabeach amaranth has been extirpated, the year of the last sighting in the county is given.

		Exc. A	Good B	Fair C	Poor D	Extirpated X
MA:	Nantucket	-	-	-	-	1 (1849)
	Dukes	-	-	-	-	2 (pre-1840)
	Plymouth	-	-	-	-	-
RI:	Newport	-	-	-	-	2 (1856)
	Washington	-	-	-	-	-
NY:	Suffolk	-	1	3	6	6
	Nassau	-	-	1	-	1
	Queens	-	-	1	1	1
	Kings	-	-	-	-	1 (1877)
	Richmond	-	-	-	-	-
	Westchester	-	-	-	-	1 (?)
NJ:	Monmouth	-	-	-	-	1 (1899)
	Ocean	-	-	-	-	2 (1913)
	Atlantic	-	-	-	-	2 (1876)
	Cape May	-	-	-	-	1 (1882)
DE:	Sussex	-	-	-	-	1 (1875)
MD:	Worcester	-	-	-	-	1 (1973)
VA:	Accomack	-	-	-	-	1 (1973)
	Northampton	-	-	-	-	1 (1972)
	Virginia Beach	-	-	-	-	-
NC:	Currituck	-	-	-	1	-
	Dare	1	1	-	1	-
	Hyde	1	1	-	-	-
	Carteret	1	2	5	2	1
	Onslow	1	1	1	-	-
	Pender	-	2	1	1	-
	New Hanover	1	3	1	2	-
	Brunswick	1	2	7	2	-
SC:	Horry	-	-	2	1	-
	Georgetown	-	3	2	2	-
	Charleston	-	-	1	3	4
Total (average, to 1990)		6	16	25	22	30
Total (1990 data only)		2	16	19	21	41
Total (average, to 1988)		8	19	11	12	36