Seabeach Amaranth *(Amaranthus pumilus)*

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Ecological Services
Raleigh, North Carolina

5-YEAR REVIEW
Seabeach Amaranth *(Amaranthus pumilus)*

I. GENERAL INFORMATION

A. Methodology used to complete the review: Information used in this report was gathered from peer-reviewed scientific publications, unpublished reports and field observations. The results of annual surveys were provided by biologists from the appropriate U.S. Fish and Wildlife Service (USFWS, Service) field offices, the U.S. Army Corps of Engineers and/or National Park Service and/or Natural Heritage Program offices within the species historic range and academic researchers at East Carolina University (Greenville, NC), the University of Charleston (Charleston, SC) and North Carolina State University (NCSU; Raleigh, NC). The results of genetic studies performed by researchers at the University of Charleston and Salisbury State University (Salisbury, MD) were also used in this report. In addition, some of the information provided here was gathered at a conservation meeting about seabeach amaranth that was held at the National Conservation Training Center (NCTC) in January 2003 and subsequent annual conference calls with biologists from throughout the range of the species. Public notice of this five-year review was given in the Federal Register on September 20, 2005, (70 FR 55157) and a 60-day comment period was opened. During the comment period, we did not receive any additional information about seabeach amaranth other than responses to specific requests for information from biologists familiar with the species. A draft copy of this document was distributed to federal and state government biologists and academic researchers knowledgeable of the species (see Peer Review section, Appendix D) and comments received were incorporated into the final review. Once all data were gathered or obtained, the review was completed by the lead recovery biologist for the species in Raleigh, NC.

B. Reviewers

Lead Region:
Kelly Bibb, Southeast Region, 404-679-7132

Lead Field Office:
Dale Suiter, Raleigh, NC, Ecological Services, 919-856-4520 extension 18

Cooperating Field Office(s):
Ed EuDaly, Charleston, SC, Ecological Services, 843-727-4707 extension 227
Wendy Walsh, Pleasantville, NJ, Ecological Services, 609-646-9310 extension 48
Andy Moser, Annapolis, MD, Ecological Services, 410-573-4537
Steve Papa and Steve Sinkevich, Islip, NY, Ecological Services, 631-581-2941
Robyn Niver, Courtland NY, Ecological Services, 607-753-9334

Cooperating Region(s):
Mary Parkin, Northeast Region, Hadley, MA, 617-876-6173

C. Background

1. FR Notice citation announcing initiation of this review:

September 20, 2005, (70 FR 55157)

2. Species status:

In the 2005 Recovery Data Call, seabeach amaranth was listed as declining due to some of the lowest recorded numbers since the species was listed. In 2006 Recovery Data Call, seabeach amaranth was also listed as declining as indicated by the annual survey data collected by a variety of state and federal government agencies.

3. Recovery achieved:

Seabeach amaranth = 1 (0 to 25% of species recovery objectives achieved)

4. Listing history:

Original Listing
Federal Register Notice: 58 FR 18035
Date listed: April 7, 1993
Entity listed: Species
Classification: Threatened

5. Review History:

Various studies and surveys of seabeach amaranth have been conducted since the species was listed as threatened in 1993; however, this is the first five-year review for seabeach amaranth. A complete bibliography of gray literature and peer-reviewed publications about seabeach amaranth is online at http://www.fws.gov/northeast/nyfo/es/amaranthweb/refs.html.

To summarize, status reviews and surveys have been conducted in many states within the species historic range since 1993 including New York (The Nature Conservancy 1995; NY Natural Heritage Program 1990), New Jersey (Snyder 1996; Walsh 2002), Maryland (often including parts of Virginia) (Lea and King 2001; Lea et al. 2002, Lea et al. 2003), Virginia (Belden 2000; DuBois 1996, 1998, 2000), North Carolina (Bucher and Weakley 1990; Weakley and Bucher 1991; Sellars and Jolls 1999) and South Carolina (Krelis 1995).

The recovery plan for seabeach amaranth was completed in 1996 and the Recovery Data Call compiles annual summaries of recovery progress for the species.

Relevant meetings and conference calls since 1993:
September 27, 1995 – A seabeach amaranth Recovery Planning Meeting was held at the U.S. Army Corps of Engineers District Office in Wilmington, NC.
October 22 - 23, 1998 – The National Park Service sponsored a meeting about seabeach amaranth at Assateague Island National Seashore.

November 27, 2000 – A meeting to discuss seabeach amaranth issues in the Carolinas was held at the Ft. Fisher State Recreation Area near Kure Beach, NC. January 23-24, 2003 - A seabeach amaranth conservation meeting among federal and state biologists and academic researchers who work with the species was held at NCTC. The meeting was held in conjunction with the Atlantic Coast Piping Plover Workshop. The purpose of the meeting was to gather information including seabeach amaranth population numbers, threats, conservation efforts and current research from each state where the species is currently extant. January 8, 2004, and April 7, 2005 - There have been two conference calls among federal and state biologists who are knowledgeable of the species. The purpose of the calls was similar to the 2003 meeting at NCTC.

7. Species' Recovery Priority Number at start of review (48 FR 43098):
Seabeach amaranth = 8C; Moderate degree of threat, high recovery potential, a species (not a subspecies or monotypic genus) = 8 with a C indicating the potential for conflict.

8. Recovery Plan or Outline
Name of plan: Recovery Plan for Seabeach Amaranth *(Amaranthus pumilus)* Rafinesque, U.S. Fish and Wildlife Service, Atlanta, Georgia, 59 p.
Date issued: November 12, 1996

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) Policy

This policy does not apply to this species since seabeach amaranth is a plant.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan? yes

2. Does the recovery plan contain recovery (i.e., downlisting or delisting) criteria? yes

3. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available (i.e., most up-to-date) information on the biology of the species and its habitat? no

Since listing, additional threats have been identified such as beach nourishment projects (which may bury plants), herbivory, disease and invasive species. In addition, the number of individual plants and extant populations has increased since listing.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria and there is no new information to consider regarding existing or new threats? no

Only two listing factors are addressed in the Recovery Criteria:
Listing Factor 1 (present or threatened destruction, modification or curtailment of habitat or range) is addressed in the recovery criteria by the requirement that

"mechanisms...be in place to protect the plants from destructive habitat alterations (particularly construction of sea walls and other forms of beach armoring)." Listing Factor 3 (disease and predation) is addressed in the recovery criteria by recommending the "protection of populations from debilitating webworms." Section IV of this document, Recommendations for Future Actions, includes recommendations to address these listing factors in any future amendments to the recovery plan.

4. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing supporting information. For threats-related recovery criteria, please note which of the 5 listing factors* are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here.**

The recovery plan provides only one, multi-part recovery criterion, "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 (DE), Massachusetts (MA), Maryland (MD), North Carolina (NC), New Jersey (NJ), New York (NY), Rhode Island (RI), South Carolina (SC), and Virginia (VA)] 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. This is identified as an interim goal because of the need for more specific data on the ecological requirements of the species for long-term survival.

At the time of listing, seabeach amaranth was only extant in NY, NC and SC; however, it is currently found in NY, NJ, DE, MD, VA, NC and SC. Despite surveys during recent years, seabeach amaranth has not been reported from RI or MA since the 1800s. The recovery criteria require a "minimum of 75 percent of the sites with suitable habitat be occupied by seabeach amaranth populations for 10 consecutive years" (U.S. Fish and Wildlife Service 1996). The definition of "site" in the recovery plan is somewhat subjective and leaves room for misinterpretation, especially over the range of the species. The Service is currently using NatureServe, criteria to delineate what a site is. This definition is included in the global specifications for the species. NatureServe (2005) has identified the minimum criteria for an occurrence as one or more individual plants. Since plants are not evident every year, but may survive in the seed bank, populations may be present even though plants are not visible for one or more years. NatureServe further defines the separation barriers (Element Occurrence Records [EOs]) of seabeach amaranth by any distance of estuarine water greater than 100 meters at low tide (i.e., separate islands represent separate EOs); or one kilometer or more of intervening habitat which is unsuitable for the foreseeable future, such as riprap, sea walls, or barren beach areas (with beach

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1) Present or threatened destruction, modification or curtailment of its habitat or range;
2) Overutilization for commercial, recreational, scientific, or educational purposes;
3) Disease or predation;
4) Inadequacy of existing regulatory mechanisms;
5) Other natural or manmade factors affecting its continued existence.

grooming or extremely heavy recreational use); or approximately five kilometers or more of apparently suitable, but unoccupied, habitat. Further, the recovery plan does not clearly state what constitutes an "occupied" site. The term occupied should be defined in more detail, preferably in a quantitative way. Given that seabeach amaranth is an annual species and it grows in a constantly changing environment, this is particularly difficult to do. Steve Young (NY Natural Heritage Program, pers. comm., 2006) recommends that each site should contain enough plants, averaged over five years of surveys to qualify the site as excellent (Rank A; 1000 or more individuals) or good (Rank B; 100 to 999 individuals), based on the National Rank Specifications (NatureServe 2005).

The Recovery Objective continues: *"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 Off Road Vehicles (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" (U.S. Fish and Wildlife Service 1996).*

All states within the current range of seabeach amaranth allow some forms of "hardened structures" along their coast and some of these structures have been built in seabeach amaranth habitat. Jetties and groins are present on Long Island, NY. Jetties are located at each of the six major inlets on the south shore and groins are present, but limited to certain portions of Long Island, primarily Long Beach Island and Westhampton (Steve Sinkevich, USFWS, Long Island Field Office, pers. comm., 2006). 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 (Pilkey and Wright, 1988 *in* U.S. Fish and Wildlife Service, 1996). Most of the NJ coast is dominated by hard structures. One state database lists 412 hard structures along NJ's roughly 120-mile Atlantic coastline, including 368 groins, 24 jetties, one breakwater, and 19 revetments or seawalls totaling over 5.5 miles in length. However, a few new structures are being proposed or built in NJ (Wendy Walsh, USFWS, NJ Field Office, pers. comm., 2006). Jetties and groins are allowed in DE, but they are infrequent and only maintained or created if absolutely necessary; however, they may not impact seabeach amaranth (William McAvoy, DE Natural Heritage Program, pers. comm., 2006). In MD, jetties are present at the Ocean City inlet and groins are common along tourist recreation beaches in Ocean City, MD from the inlet north to the MD – DE state line. The only hardened structure within Assateague Island National Seashore is the southernmost jetty of the Ocean City inlet jetty system (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006). Jetties are common at the major inlets along the coast of NC. Groins have been used sparingly in NC and the state has a law preventing the construction of hardened

structures on the coast. Jetties, groins and seawalls have been used in SC. Groins occur on several developed beaches. Sea walls are limited, but one significant jetty occurs at Murrells Inlet in the best remaining seabeach amaranth habitat in SC (Ed EuDaly, USFWS, SC Field Office, pers. comm., 2006). Since seabeach amaranth still occurs in close proximity to some of these hardened structures throughout the range of the species, it is unclear what effect these structures have on the species at this time.

ORV use or driving is allowed on at least some beaches in NY, NJ, DE, MD and NC and can be particularly destructive to seabeach amaranth populations, especially when allowed to occur during the growing season. Most municipal, state and federal beach management agencies drive on the beach for emergencies (police, fire, rescue and life guards) and maintenance activities (garbage collection, beach raking, etc.). The author has observed garbage collection trucks and backhoes run over seabeach amaranth plants on Bogue Banks, NC.

ORV use is allowed on approximately 50 percent of the seabeach amaranth habitat on Long Island, NY including areas within Fire Island National Seashore and Gateway National Recreational Area (Steve Sinkevich, USFWS, Long Island Field Office, pers. comm., 2006). Fire Island National Seashore has an Endangered Species Habitat Management Plan and they are working on a negotiated rule making agreement for ORVs. About six of 17 community districts are required to protect seabeach amaranth and their habitat as part of a special use permit they received from Fire Island National Seashore to undertake beach nourishment and dune construction (Steve Papa, USFWS, Long Island Field Office, pers. comm., 2006). ORVs are only allowed on approximately 18.5 mi (29.8 km) (15 percent) of the NJ coastline including areas within Forsythe National Wildlife Refuge, Brigantine State Natural Area, Brigantine city beaches and Island Beach State Park. Recreational driving is prohibited on most municipal beaches in NJ (Wendy Walsh, USFWS, NJ Field Office, pers. comm., 2006). ORV use is allowed on approximately 80% of the public beaches in DE and this use precludes the establishment of any vegetation (William McAvoy, DE Natural Heritage Program, pers. comm., 2006).

ORV use is allowed in the southernmost 12.1 mi (19.5 km) of the MD portion of Assateague Island National Seashore and this use occurs in approximately 10-20% of the available seabeach amaranth habitat within the Seashore. The ORV area is permitted and managed under 36 CFR, Chapter 1, Section 7.65 (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006).

In NC, both Cape Hatteras and Cape Lookout National Seashores allow beach driving. Both parks have developed an interim Protected Species Management Plan/Strategy until long-term ORV Management Plans can be completed. These plans are designed to minimize impacts to protected species that occur in areas that are open to ORV use. The implementation of these ORV Management Plans may provide some additional level of protection for seabeach amaranth that occurs within the National Seashores. Some of the best habitat for seabeach amaranth within these

two National Seashores occurs in areas that are restricted from ORV use in order to protect nesting habitat for piping plovers and other nesting shorebirds. At Cape Hatteras National Seashore, biologists survey bird exclosures for seabeach amaranth before removing bird fencing and they leave the fencing up into the fall if plants are still present. In addition, various beach towns in NC also allow beach driving, but typically the beaches are not open to driving until after Labor Day, giving the plants at least some time to produce mature fruits before potentially being run over by vehicles. It would be best if these towns prevented beach driving until after seabeach amaranth plants have produced mature seeds and senesced. ORV use or beach driving is prohibited in SC (Ed EuDaly, USFWS, Charleston Field Office, pers. comm., 2006).

The impacts of beach driving on seabeach amaranth depend on the extent of driving, seasonal restrictions, the extent of fencing, and the configuration of the specific beach (Wendy Walsh, USFWS, NJ Field Office, pers. comm., 2006). Lea, et al. (2003) believe that ORV use may act as a population sink for seabeach amaranth in that seeds disperse into the ORV use area but are typically unable to germinate and develop into mature seed producing plants because of constant disturbance. Beach driving, in general, prevents the establishment of any vegetation (William McAvoy, DE Natural Heritage Program, pers. comm., 2006).

C. Updated Information and Current Species Status

1. Biology and Habitat –

a. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

The Service has sporadic survey data for seabeach amaranth going back to 1987. However, systematic range-wide surveys for seabeach amaranth surveys only began in 2000, and since then, we have a fairly complete data set from NY, NJ, DE, MD, VA, NC and SC. Further, we only have 10 consecutive years of data from two states, NY and NC. We anticipate systematic surveys to continue in all states within the species current extant range, and occasional surveys in RI and MA incidental to beach-nesting bird management. In general, seabeach amaranth total numbers for all states have been higher since the species was listed in 1993, than before listing. This could be attributed to: increased awareness about the rarity of this species, additional people recognizing the plant and reporting locations to Natural Heritage Programs and the Service, additional surveys specifically targeting seabeach amaranth, the initiation of measures to protect natural populations, Section 7 consultations requiring protection of the species, and reintroduction and habitat restoration projects.

Given the fugitive nature of the species and the constantly changing environment where it occurs, it is difficult to make determinations about population size or trends based on limited data from annual surveys. Total seabeach amaranth numbers reported in 2005 rangewide surveys were the lowest since 1999. As

shown in Appendix A, the largest known seabeach amaranth populations in DE, NJ and NY occurred in 2002. Populations in those states have declined substantially since that 2002. The MD/VA population has steadily declined since 2001. The number of seabeach amaranth plants in NC has fluctuated from a low of 57 (in 2000) to a high of 20,716 (in 1995) since the species was listed in 1993 while South Carolina populations have fluctuated from 0 to 2,312 plants in the same time period. A summary of seabeach amaranth annual census data is provided in Appendix A.

Rosenfeld et al. (2006) analyzed 18 years of count data from the entire species' range and found that population size was not correlated with tropical storm and/or hurricane activity. Using three different extinction thresholds (190, 500 and 1000 total plants), a Population Viability Analysis (PVA) indicated that the probability of range-wide extinction is approximately 16%, 23% or 30%, respectively, within the next 50 years. The lowest extinction thresholds indicate impending extinction in DE and SC and an 84% chance of extinction within 35 years in NY. Rosenfeld et al. (2006) acknowledges that the way populations are grouped influences the PVA and that 50 years may not be a practical time period for species management and conservation planning. Given the extreme variability in the habitat where seabeach amaranth occurs and limitations of the Population Viability Analysis, the Service will take this analysis into consideration and continue monitoring the species with rangewide surveys.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
Strand (2002) used chloroplast DNA, nuclear DNA and PCR-based markers (RAPDs) to examine the genetic variation across the range of seabeach amaranth. No variation in nucleotide sequence was found across the range of the species using chloroplast DNA. However, his research indicates that there is significant heterogeneity across the range of the species for the three RAPDs markers. This genetic diversity exhibits geographic structure. Northern populations (NY and NJ) appear to be distinct from southern populations (NC and SC). Since material from DE, MD and VA was not included in this study, it is unclear whether the discontinuity among populations appears at the Chesapeake Bay or Delaware Bay (Strand 2002). Strand's (2002) seed ecology study indicates that seabeach amaranth seeds can withstand the conditions necessary to move among island conditions and it is also likely that they have the ability to persist as seed banks in inlets and possibly offshore (Strand 2002).

Due to the differentiation between northern and southern populations, Strand (2002) recommends that seabeach amaranth introduction and population augmentation projects use local seed sources. That is, projects in the Carolinas should use seeds collected from subpopulations in the Carolinas and projects in NY and NJ should use seeds collected from those states. The affinity of populations (DE, MD and VA) is unclear but could be determined relatively easily if tissue was available.

In 2005, Jay Kelly (Rutgers University, New Brunswick, NJ, pers. comm., 2006) collected tissue samples from seabeach amaranth populations in NC, MD, VA, DE and NJ. He plans to study the population genetics and dispersal ecology of the species.

Kim Hunter (Salisbury State University, Salisbury, MD) used intersimple sequence repeats (ISSR) to generate a phylogeny of seabeach amaranth, *Amaranthus caudatus, A. cruentus, A. dubius, A. flimbriatus, A. hybridus, A. hypochondriacus* and *A. rudis* as well as to determine the levels of intraspecific variation and to determine the ploidy levels of a portion of these *Amaranthus* species. The ISSR data produced results similar to the RAPD data, but significantly more variability was detected. Multiple polyploid levels were detected within several species of amaranth (Gordon et al. 2002).

According to Dr. Hunter, an unidentified student in Iowa has done some chloroplast DNA work with seabeach amaranth. To date, the Service has been unable to identify this person or obtain additional information about their research.

c. Taxonomic classification or changes in nomenclature:
There have been no changes to the taxonomic classification of *Amaranthus pumilus* since it was listed as threatened in 1993.

d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.):
There has been no change in the historic range of the species since listing. In addition, the species has not been found in MA (Paul Somers, Massachusetts Natural Heritage Program, pers. comm., 2006), RI (Rick Enser, Rhode Island Natural Heritage Program, pers. comm., 2006) or CT (Nancy Murray, Connecticut Natural Heritage Program, pers. comm., 2006) since listing despite local botanists being aware of the species and searching for it during coastal plant surveys. In addition, biologists conducting shore bird surveys in New England have also been asked to report any seabeach amaranth plants that they may find.

Since listing, seabeach amaranth has been rediscovered in four states, all within the historic range of the species: NJ, DE, MD and VA. Seabeach amaranth was found in NJ in 2000, but had not been reported from the state since 1913 (Walsh 2002. Seabeach amaranth was rediscovered in Sussex County, DE during 2000, after a 125-year absence from the State (McAvoy 2002). Seabeach amaranth was also rediscovered on Assateague Island (MD) in 1998, 31 years after the last known specimen was collected in 1967 (Ramsey et al. 2000) and then, in 2001, 9 plants were found on the portion of Assateague Island that lies in VA (Lea et al. 2002). Restoration efforts were conducted at Assateague Island National

Seashore in 2000, 2001, and 2002 (Lea, et al. 2003). Seabeach amaranth has remained extant in NY, NC and SC since the species was listed in 1993. Appendix B contains a list of state and federal lands that contain seabeach amaranth populations.

Several seabeach amaranth reintroduction projects have been initiated throughout its range. The intent of each project was to supplement existing natural populations rather than to create new populations in areas where seabeach amaranth was previously known but has not occurred in the past several years. Restoration projects have occurred in NJ, DE, MD, NC and SC. No seabeach amaranth restoration projects have occurred in NY (Steve Sinkevich, USFWS, Long Island Field Office, pers. comm., 2006) or VA.

In NJ, seabeach amaranth seedlings were planted in 2003 as part of the requirements for section 7 consultation between the Service, U.S. Army Corps of Engineers, and the National Park Service to offset impacts from a beach nourishment project in the Sandy Hook Unit of Gateway National Recreation Area. Plants were grown by Bill Skaradek at the USDA's Cape May Plant Materials Center. The NJ Field Office has not recommended any additional plantings in the State (Wendy Walsh, USFWS, New Jersey Field Office, pers. comm., 2006).

In DE, 143 seedlings were planted at Delaware Seashore State Park from seeds collected in Delaware in 2000 and germinated at the Mt. Cuba Center for the Study of Piedmont Flora in Greenville, DE. In addition, about 1,500 seabeach amaranth seeds were sown at Cape Henlopen State Park in 2001 (McAvoy 2001). Eighteen seedlings were planted at Cape Henlopen State Park in 2002 (McAvoy, et al. 2003). No seabeach amaranth seedlings were planted in DE in 2004, but hundreds of seeds collected from greenhouse grown plants were sown in the spring of 2005 at Cape Henlopen and Delaware Seashore State Parks (McAvoy and Pepper 2005).

In MD, 1,156, 2,442 and 1,881 seedlings were planted Assateague Island National Seashore in 2000, 2001 and 2002, respectively (Lea et al. 2003).

From 2001-2003, Claudia Jolls, biology professor at East Carolina University, has conducted several research experiments within Cape Hatteras and Cape Lookout National Seashores, NC, where graduate students planted 1,698 seabeach amaranth seedlings to determine survival rates at different elevations and distances from the mean high tide line in order to develop a model that could be used to determine appropriate seabeach amaranth habitat for additional survey work or to plan reintroduction efforts. While the intent of this research was not to reintroduce additional plants to the study areas, seeds produced by those plants likely contributed to the existing seed bank. In 2003, Kristen Rosenfeld and Tom Wentworth reintroduced 314 seabeach amaranth plants at Bird Island, just west of Sunset Beach, NC. This undeveloped portion of the island is part of the NC

Coastal Reserve Program. Seabeach amaranth had not occurred at Bird Island for 10 years prior to this reintroduction. The purpose of Rosenfeld's (2004) study was to quantify the relationship between distance from the ocean and survivorship. This work was part of a larger master's thesis project involving a comprehensive study of the vegetation of Bird Island by Rosenfeld.

In SC, Richard Hamilton with the SC Department of Natural Resources' Waddell Mariculture Center conducted seabeach amaranth propagation experiments in 1998 and reintroduction efforts in 1999 projects. In 1999, 1,372 seabeach amaranth seedlings were transplanted to six experimental test sites in Beaufort and Georgetown Counties, SC. In addition, 26,000 seabeach amaranth seeds were scattered at six experimental test sites in Beaufort and Georgetown Counties, SC, but there was virtually no germination. In 2000, 2,507 seabeach amaranth seedlings were transplanted to three experimental test sites in Charleston and Georgetown Counties, SC (Dewees Island, Huntington Beach and Cape Island in the Cape Romain National Wildlife Refuge) (Hamilton 2000). The Service carried out a seabeach amaranth augmentation project at Cape Romain National Wildlife Refuge (2001-2004), Huntington Beach State Park (2001-2004) and Myrtle Beach State Park (2003), all areas where seabeach amaranth has occurred in recent years. During this project, over 4,000 propagated seedlings were planted and monitored primarily at Cape Romain NWR and Huntington Beach State Park (Ed EuDaly, U.S. Fish and Wildlife Service, Charleston, SC Field Office, pers. comm., 2006). Ed EuDaly has completed the only Propagation Plan for seabeach amaranth and that plan addressed reintroduction efforts in SC.

David Nash (NCSU Cooperative Extension Service, pers. comm., 2006) began seabeach amaranth propagation and transplantation work in 1998. Using funds provided by the USFWS's Asheville NC Field Office, the Town of Oak Island built a greenhouse to propagate seabeach amaranth and other native dune species in 2000. Approximately 7,000 seabeach amaranth plants have been produced in this facility since 2000 for use in seabeach amaranth transplanting projects in NC and SC. Monitoring is ongoing, but it appears that transplantation efforts result in an increase in the number of seabeach amaranth plants in years immediately after the transplant event, but those populations may not be sustainable over the long term.

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Using LIDAR data, Sellars and Jolls (2004; Jolls et al. 2004) created a 3D map of Cape Lookout, Cape Hatteras and Assateague Island National Seashores and determined that areas that are 0.77 to 2.0 meters above mean high water with limited vegetation cover provide the best habitat for seabeach amaranth. In addition, south to southwest-facing beaches are particularly favorable to seabeach amaranth survival. Using diameter of plants as a measure of success, they found high survival but low growth on the upper beach, but growth increased with decreased elevation. Using seed traps, they collected seeds weekly and found that

seed output increased with size of plant. Larger plants at lower elevations may produce more seeds but are at a high risk for overwash. Similar results were found in Monmouth County, NJ studies. Fewer, but larger plants were found in the wrack line (USFWS 2004). Rosenfeld (2004) found that distance from the ocean significantly affected survivorship, size and reproduction of seabeach amaranth.

Johnson (2004) studied the nearest associates and the effects of competition on seabeach amaranth. Her research identified three species as the most frequent associates of seabeach amaranth. Seacoast marshelder (*Iva imbricata)* had the strongest effect on seabeach amaranth, followed by seaoats (*Uniola paniculata)* and American sea rocket (*Cakile edentula)*. Her research also suggests that competition may influence the distribution of seabeach amaranth on the upper sections of beach where other plant species occur.

Strand (2005) noted that, in addition to the habitat types cited in the recovery plan and previous reports by Bucher and Weakley (1990), seabeach amaranth also occurs in dune blowouts. This habitat occurs throughout the Atlantic Coast especially on long barrier beaches within the range of the species that experience overwash or strong winds that create a breech in an otherwise continuous dune system.

Since listing, a prevalence of seabeach amaranth populations has been observed on nourished beaches, even those featuring hardened structures. In NJ, the largest populations are on nourished beaches in front of sea walls with groins every few hundred feet (Wendy Walsh, USFWS, New Jersey Field Office, pers. comm., 2006).

Tom Hancock (Wake Forest University, Winston Salem, NC; pers. comm., 2006) is conducting life history studies on seabeach amaranth and American sea rocket (*Cakile edentula*) at Topsail Island, NC (Hancock 1995; Hancock and Hosier 1996, 2003). Wigent et al. (2004) studied the effects of salinity and draught on seabeach amaranth.

2. Five Factor Analysis (threats, conservation measures and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

As discussed in the seabeach amaranth recovery plan, the destruction of suitable habitat is probably the largest threat to this species. The construction of various structures to harden the land/water interface (e.g., sea walls, bulkheads) typically occurs in the narrow strip of habitat where seabeach amaranth would most likely occur. In addition, other structures built to minimize coastal erosion (e.g., jetties, groins) may be detrimental to seabeach amaranth populations because they are built in areas that are habitat for seabeach amaranth. In addition, jetties and

groins may prevent the movement of seabeach seeds along the beach (by blocking blowing sand) or in the water (by affecting longshore current at the micro level). On the north end of Assateague Island the number of plants found within the vicinity of a constructed berm has been, on average, three times less than that of the rest of the island, indicating that the constructed berm limits seabeach amaranth recruitment within the berm's zone of influence (Mark Sturm, Assateague Island National Seashore; pers. comm., 2006). However, it should be noted that although almost none of these structures have been removed, the geographic distribution and numbers of individual plants have both increased, since listing.

The recovery plan also states that "seabeach amaranth is rarely encountered in areas that have sand fences" (U.S. Fish and Wildlife Service 1996). However, on Bogue Banks in NC, thousands of seabeach amaranth plants have been observed growing in areas where miles of sand fencing have been placed along the beach. While the purpose of sand fencing is to trap sand and rebuild a dune system, little dune vegetation occupies these areas during the first two or three years following beach nourishment projects, hurricanes or other disturbances. On Bogue Banks, these areas of accreting sand between parallel sand fences are often occupied by seabeach amaranth. It is likely that these populations are producing thousands, if not millions of seeds that make a significant contribution to the local seed bank.

In NJ, seabeach amaranth plants are often found on the ocean side of areas that have sand fences. However, as the sand fences collect sand, dune vegetation spreads seaward onto new fill material. Eventually, erosion shortens or eliminates the width of the non-vegetated beach and seabeach amaranth habitat, resulting in less area for seabeach amaranth to grow and generally changing the habitat dynamics of the shortened beach. This results in reduced reproduction and seed set for seabeach amaranth plants. Subsequent nourishment projects do not impact the vegetated dunes (Wendy Walsh, USFWS, New Jersey Field Office, pers. comm., 2006).

To summarize, jetties, groins, bulkheads and other structures may have a negative affect seabeach amaranth if they are built upon seabeach amaranth habitat or if they change the natural distribution of seeds. While seabeach amaranth often occurs around sand fencing on newly created dunes, the number of seabeach amaranth plants decreases over time as other vegetation stabilizes the area. It doesn't appear that sand fencing is detrimental to the species, but the dune stabilization that they facilitate encourages other vegetation to colonize these areas and effectively reduces habitat for seabeach amaranth.

Pedestrians and Off Road Vehicles

As mentioned in the recovery plan, pedestrian and ORV use of seabeach amaranth habitat continues to be a problem throughout the range of the species. Pedestrian impacts are most common on beaches in resort towns and especially in close proximity to large hotels and condominiums. In NC, the effects of pedestrian

traffic on the beach are noticeable in areas where seabeach amaranth is distributed with some regularity along the shore. In populated areas, there is often an increase in human traffic on the sand. Beach chairs and umbrellas are frequently set up in the upper beach area near the edge of the dunes and informal sand volleyball courts are delineated on the upper beach. In general, visitor use has increased at National Seashores since seabeach amaranth was listed in 1993. Visitor use at the coastal parks where seabeach amaranth occurs (Fire Island, Assateague, Cape Hatteras and Cape Lookout National Seashores and Gateway National Recreation Area) and all National Parks can be found on the internet at <www2.nature.nps.gov/stats>.

While the effects of ORV use on seabeach amaranth have not been quantified, it appears that vehicles are most harmful to seabeach amaranth in areas such as National Seashores and on beaches that are less accessible to pedestrians. Often, little to no seabeach amaranth is found in areas that receive high ORV use with the exception of areas that are specifically protected by symbolic or restrictive fencing like that used to restrict access to shorebird nesting and foraging areas. Most fencing intended to protect shorebird areas is removed after the nesting season; generally after Labor Day. This allows seabeach amaranth the opportunity to produce some seeds, but it does not allow them time to produce as many seeds as they would if they were allowed to senesce naturally, later in the fall. Staff at Cape Hatteras National Seashore has noticed an increase in the number of vehicles on the beach in recent years. This could be attributed to the fact that Sport Utility Vehicles (SUVs) sales have increased from 7% of all vehicle sales in 1990 to 19% in 1999 (Davis and Truett 2000). Cape Hatteras and Cape Lookout National Seashores are currently working on ORV Management Plans to address the impacts of ORV use on Park resources.

Beach raking

Another threat to seabeach amaranth, especially in NY and NJ is beach raking. Some beach park and beach community staff regularly drive the beach pulling various types of rakes in order to collect trash, seaweed, marsh grasses and other things that are considered undesirable to human beach visitors. This activity increases the potential of running over, or pulling up seabeach amaranth plants. Beach raking occurs in 30-40% of the available seabeach amaranth habitat on Long Island, NY. Little vegetation occurs in the areas where beach raking occurs (Steve Sinkevich, USFWS, Long Island Field Office, pers. comm., 2006). Beach raking is practiced extensively in NJ, even on some state and federal beaches, and is considered an important threat to seabeach amaranth in this state. Seabeach amaranth has been observed growing in areas where beach rakes cannot go such as those areas fenced off to protect piping plovers (*Charadrius melodus*) and at the toe of the dunes. The distribution of seabeach amaranth in certain parts of NJ can be anecdotally, but clearly, correlated with local patterns of ranked and un-raked beaches (Wendy Walsh, USFWS, New Jersey Field Office, pers. comm., 2006). In DE, beach raking occurs only on the swimming beaches where seabeach amaranth is unlikely to occur. Beach raking is practiced along much of

Fenwick Island (Ocean City, MD) and probably limits seabeach amaranth from being able to disperse to this section of MD. Beach raking is not done on Assateauge Island National Seashore (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006). While beach raking has been proposed in NC, no municipalities or parks are currently using beach rakes and the USFWS and the NC Wildlife Resources Commission have opposed their use in the State. In SC, beach raking occurs only in Myrtle Beach. This area is heavily developed resort area and seabeach amaranth has not been observed in Myrtle Beach (with the exception of Myrtle Beach State Park) in many years.

It appears that threats to seabeach amaranth habitat such as the construction of hardened structures, sand fencing, pedestrian traffic, ORV use and beach raking have all increased since the species was listed in 1993.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

During recent years, the Service and the NC Plant Conservation Program (with authority delegated by the Service) have issued various research and recovery permits to allow various entities to conduct research on different aspects of seabeach amaranth biology including reproduction, propagation/seed germination, reintroduction and genetics projects. The Service's NJ Field Office completed an intra-Service consultation in 2004 to address Service-sponsored or Service-conducted collection for purposes of carrying out tasks specified in the recovery plan. The results of this research are presented in Baskin and Baskin (1998a and 1998b), Blazich et al. (2005), Hancock (1995) and Hancock and Hosier (2003), Rosenfeld (2004), Sellars and Jolls (2004), Strand (2002 and 2005). See the bibliography at <www.fws.gov/northeast/nyfo/es/amaranthweb/refs.html> for others. Overutilization is not a factor in the status of this plant species.

c. Disease or predation:

As stated in the recovery plan, four species of webworm and one other species of caterpillar have been identified as feeding on seabeach amaranth leaves. In addition, the yellow striped armyworm (*Spodoptera ornithogalli*) was identified on seabeach amaranth plants in MD and DE and spotted cucumber beetles (*Diabrotica undecimpunctata*) were collected on seabeach amaranth plants in DE (USFWS 1996). The seaside grasshopper (*Trimerotropis maritima*), which was recently identified by David Nickle of the Smithsonian Institution, has been observed using seabeach amaranth as a host plant in Maryland (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006).

In NJ, webworms (Pyralidae) and cutworms (Noctuidae) have been identified feeding on seabeach amaranth, including the noctuid species *Spodoptera exigua* (beet armyworm). A field monitor in NJ also reported aphids on the plants. In Monmouth County, NJ surveys, 3.5 to 12 % of plants have shown damage from 2003-2005. This does not seem to kill the plants unless a white papery leaf condition is also observed (Wendy Walsh, USFWS, New Jersey Field Office,

pers. comm., 2006).

While the Service is not aware of any attempts to control webworms on seabeach amaranth, the recovery plan suggests that *Bacillus thuringiensis* (Bt) is likely the best alternative to kill webworms. Although webworms may not affect the survival of the species, land managers who attempt to control them should consider the potential impacts to other beach and dune species. For example, on Bogue Banks, NC, a very rare, yet undescribed skipper occurs in areas with natural dune vegetation. While it appears to feed on seaside little bluestem (*Schizachyrium littorale*), little is known about its life cycle and individuals could be harmed by overspray onto neighboring dune vegetation. Care should be taken to ensure that pesticides are applied on days with little or no wind and that protective measures are taken to prevent overspray in order to prevent harm to other species. Rosenfeld (2004) found that the presence of webworms and ghost crabs did not significantly affect plant size or reproduction.

Claudia Jolls (East Carolina University Biology Department) reported at the December 2000 seabeach amaranth meeting at Ft. Fisher, NC that she has observed grasshoppers feeding on seabeach amaranth plants but she does not believe that the effects are devastating. Hancock (1995) also suggests that grasshoppers may feed on seabeach amaranth, but does not indicate whether this was documented in the field.

It is believed that white-tailed deer (*Odocoileus virginianus)* forage on seabeach amaranth plants throughout the range of the species. White tailed deer, Sika deer (*Cervus nippon*) and feral horses (*Equus caballus*) have been observed grazing on seabeach amaranth plants at Assateague Island National Seashore (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006). While seabeach amaranth seed production has been shown to be exponentially correlated to plant size (Lea, et al. 2003), deer and feral horse grazing has been found to significantly reduce average plant size and survival throughout seabeach amaranth's reproductive season at Assateague Island National Seashore (Mark Sturm, Assateague Island National Seashore, unpublished data, pers. comm., 2006). White-tailed deer have been observed in close proximity to plants with herbivore damage on Bald Head Island, NC (Maureen Dewire, Bald Head Island Conservancy, pers. comm., 2006). Deer have been seen eating seabeach amaranth at Fire Island National Seashore in NY (Stephen Young, NY Natural Heritage Program, pers. comm., 2006). Deer and feral horses may also graze on seabeach amaranth at Cape Lookout National Seashore in NC. In addition, nutria (*Myocaster coypus*) tracks have been observed around a seabeach amaranth with browse damage at Cape Lookout National Seashore (Jeff Cordes, Cape Lookout National Seashore, pers. comm., 2006). Van Schoik and Antenen (1993) report rabbits and migratory song birds feeding on amaranth.

White rust (*Albugo bliti*) was first reported on seabeach amaranth plants growing in SC (Keinath, et al. 2003). According to information reported at the seabeach

amaranth meeting at Ft. Fisher, NC in December 2000, white rust spreads quickly through individual populations. Rust lesions are scattered throughout the leaves and the leaves become yellowed, dwarfed and cup upward rather than downward. White rust is also known from lambsquarters (*Chenopodium album*) and other species in the Amaranth Family (Amaranthaceae) and is found from NY to FL (Keinath, et al. 2003).

At the time of listing, webworms were the only known predator of seabeach amaranth. Since that time, several species of animals have been identified as feeding on seabeach amaranth. While impacts from predation and disease on seabeach amaranth plants are localized, poorly understood and mostly based on observations, it is generally believed that vertebrate predators may negatively affect seabeach amaranth growth and reproduction, while invertebrates do not.

d. Inadequacy of existing regulatory mechanisms:

Beach nourishment projects are becoming more common in order to replace sand on eroded beaches. These projects can have varying effects on seabeach amaranth survival. They may benefit seabeach amaranth by creating habitat in the form of wide, vegetation free beaches. However, deposition of sand on the beach during the growing season may bury living seabeach amaranth plants, resulting in a negative impact to the species. Nourishment projects may artificially redistribute seeds in the coastal environment, leaving them in locations where they may or may not be able to germinate. Some believe that these projects actually deposit seeds that have been buried offshore or in inlets on the beach and may temporarily increase the number of plants within a given area. The timing, implementation and design of beach nourishment projects may affect seabeach amaranth, but the full effects of beach nourishment projects on seabeach amaranth, throughout its range, are unknown.

In NC, beach nourishment projects are usually limited to occurring between November 16 and March 31 during a time of year when sea turtles are not nesting on the beaches and seabeach amaranth has senesced. In general, the Service believes that nourishment projects that are initiated and completed during the winter months are not detrimental to seabeach amaranth. However, in NJ, beach nourishment projects are often, but not always, restricted to August 15 to March 15 to protect piping plovers. This window does not protect seabeach amaranth during the latter part of the growing season when it is setting seed, which is likely to be harmful to seed production and distribution.

While the full effects of beach nourishment projects on seabeach amaranth are unknown, these projects typically create wider beaches that are free of vegetation and these areas provide additional habitat for this species that otherwise would not be present because the beaches may be eroded back to hardened structures, development or dense vegetation.

In addition, the lack of appropriate ORV management plans at National Wildlife Refuges, National Seashores, military bases and other federal properties within

the historic range of seabeach amaranth should be addressed. The Endangered Species Act requires federal agencies to manage their lands in a way that protects federally listed species such as seabeach amaranth. In NJ, the Land Use Regulation Program (LURP) has worked with the Service to prohibit beach raking and other adverse beach management activities in seabeach amaranth habitat. The LURP also supports the Service as they work with local land managers to develop endangered species management plans for every beach in NJ.

Regulatory mechanisms are being applied to address threats to this plant, however, the inability of regulations to allow appropriately timed projects, that consider this plant species is a threat to its status.

e. Other natural or manmade factors affecting its continued existence:
Invasive Species
Beach vitex (*Vitex rotundifolia*), an invasive plant native to coastal regions in Asia, has been introduced to the southeastern U.S. as an ornamental landscape plant and its usage has been encouraged in oceanfront and dune landscapes, especially in NC and SC. It is typically planted on the foredunes in the same habitat where seabeach amaranth occurs. Since beach vitex readily produces seeds, grows rapidly and can also propagate by runners, it has the potential to occupy many acres of seabeach amaranth habitat. While future actions to control or eradicate this species will likely benefit seabeach amaranth by providing additional habitat for the species, these actions should carefully consider potential negative impacts to seabeach amaranth, especially during the project implementation stage (i.e. herbicide application, physical removal of the plants, etc.).

Japanese sedge or Asiatic sand sedge (*Carex kobomugi*) is an invasive species found on beaches from MA to VA. In DE, Japanese sedge has been found at Cape Henlopen, Fenwick Island and Delaware Seashore State Parks. Populations ranged in size from 15 x 21 ft to 75 x 54 ft (Payton and Grezlikowski 2002). A total of 17 populations were found in 2003 and ranged in size from 30 x 30 ft to 110 x 240 ft. Control efforts have been initiated by the Delaware Natural Areas Program (McAvoy, et al. 2003). Several populations of Japanese sedge have been found at Assateague Island National Seashore and Chincoteague National Wildlife Refuge. All of the populations combined previously occupied approximately one hectare of land at Assateague. These sites were successfully treated with the glyphosate herbicide and the species was found in only two small areas in 2005 (Mark Sturm, Assateague Island National Seashore, pers. comm., 2006). Japanese sedge is established at several locations in NJ including parts of Sandy Hook, where control efforts have proved difficult. Based on anecdotal observations during seabeach amaranth surveys, Japanese sedge appears to be increasing but is not yet a major threat to most of the populations in NJ like it is in DE, MD and VA.

Puncturevine *(Tribulus terrestris)*, a tropical mat forming plant has also been found growing in seabeach amaranth habitat in NY (Steve Young, NY Natural Heritage Program, pers. comm., 2006).

Although unknown as impacts to the species at the time the recovery plan was written, these and other invasive species have the potential to negatively impact seabeach amaranth and other native dune species.

Although not an invasive species issue, two native dune species, purple sand grass (*Triplasis purpurea*) and American beach grass (*Ammophila brevigulata*) form extensive stands on NJ beaches and can occupy suitable habitat for seabeach amaranth to the point of crowding out other species (Wendy Walsh, USFWS, New Jersey Field Office, pers. comm., 2006).

Propagation / Reintroduction Efforts
Since little is known about the genetic differences between seabeach amaranth populations or how moving seeds and plants between them could have negative effects on the species. Strand (2002) observed genetic differences between northern and southern populations and recommended that introduction and population augmentation projects use local seed sources until more is known about how these plants are related to northern and southern subpopulations. Caution should also be taken against possibly spreading disease from site to site or between the greenhouse and field. Even well-intentioned propagation projects could have negative effects on seabeach amaranth.

Invasive species are increasingly becoming a threat to the seabeach amaranth on a localized level but not to the overall species status. The potential for reintroduction efforts to be harmful to seabeach amaranth plants is also localized and caution should be taken in their implementation.

In summary, we believe that habitat destruction, poorly timed beach nourishment projects, beach raking and ORV use are the greatest threats to seabeach amaranth. In general, we do not consider the other factors to be substantial threats to the continued existence of the species, but we will continue to work with our partners to monitor their effects on the species.

D. Synthesis

Since listing, seabeach amaranth has remained extant in NY, NC, and SC and has been rediscovered in four states: NJ, DE, MD, and VA. Seabeach amaranth is now found in seven of the nine states considered in its historical range. Despite surveys, seabeach amaranth has not been found in RI or MA in more than 100 years. It has never been reported from CT. There has been no change in the historic range of the species since listing. Although the number of individual plants observed in each state and the number of extant populations has increased since listing in 1993, populations in MD/VA, DE, NJ, and NY are showing a general trend of decline since 2002 while the total number of plants in NC has increased during that same time period.

Since the recovery plan was written in 1996, various entities have conducted research on

different aspects of seabeach amaranth biology including reproduction, propagation/seed germination, genetics and reintroduction projects. Genetics research indicates that there is significant heterogeneity across the range of the species for the three RAPDs markers tested. Northern populations appear to be distinct from southern populations (Strand 2002). A seed ecology study indicates that seabeach amaranth seeds can withstand the conditions necessary to move among island conditions and it is also likely that they have the ability to persist as seed banks in inlets and possibly offshore (Strand 2002). There have been no changes to the taxonomic classification of *Amaranthus pumilus* since it was listed as threatened in 1993.

Using LIDAR data, Sellars and Jolls (2004; Jolls et al. 2004) created a 3D map of Cape Lookout, Cape Hatteras and Assateague Island National Seashores and determined that areas 0.77 to 2.00 meters above mean high water with limited vegetation cover provide the best habitat for seabeach amaranth. Using plant diameter as a measure of success, they found high survival but low growth on the upper beach, but growth increased with decreased elevation. They also found that seed output increased with size of plant. Rosenfeld (2004) found that distance from the ocean significantly affected survivorship, size and reproduction of seabeach amaranth. Johnson (2004) identified seacoast marshelder (*Iva imbricata*), seaoats (*Uniola paniculata*) and American sea rocket (*Cakile edentula*) as the most common associates of seabeach amaranth. Her research suggests that competition by these species may influence seabeach amaranth distribution on the upper beach. Strand (2005) noted that, in addition to the habitat types cited in the recovery plan and previous reports by Bucher and Weakley (1990), seabeach amaranth also occurs in dune blowouts.

There have been several seabeach amaranth propagation and transplantation projects conducted since the late 1990s. Monitoring is ongoing and no conclusive results have been made, but it appears that seabeach amaranth numbers increase in years immediately after transplanting and then start to drop off over time.

The recovery plan listed the destruction of suitable habitat and webworm herbivory as the largest threats to this species. Since listing, additional threats have been identified such as beach nourishment projects (completed during the growing season), beach raking, herbivory by insects, birds and mammals, disease such as white rust and invasive species such as beach vitex and Japanese sedge. While the full extent of these threats has not been quantified, Service biologists and our partners believe that these some of these factors may have net negative effects on some seabeach amaranth populations.

Pedestrian and ORV use of seabeach amaranth habitat continues to be a problem throughout the range of the species. Pedestrian impacts are most common on beaches in resort towns and especially in close proximity to large hotels and condominiums. ORV use typically causes more impacts to the species in areas such as National Seashores and other sections of coast that are less accessible to pedestrians and more commonly open to ORV use.

The recovery criteria address only two listing factors: Listing Factor 1 (present or threatened destruction, modification or curtailment of habitat or range) is addressed in the recovery criteria by the requirement that "mechanisms...be in place to protect the plants from destructive habitat alterations (particularly construction of sea walls and other forms of beach armoring)." Listing

Factor 3 (disease and predation) is addressed in the recovery criteria by recommending the "protection of populations from debilitating webworms." Neither of these criteria has been met. It will be difficult to reverse decades of poor beach management and it will be nearly impossible to remove hardened structures from the beach. Studies indicate that webworms may not affect seed output so it may not be necessary to protect seabeach amaranth from them. Section IV of this document includes recommendations to address these listing factors in any future amendments to the recovery plan.

In spite of so many efforts to protect this species, there are still many challenges to its recovery. Many of the original listing factors or threats remain and new threats have come to light since listing. These threats include, but are not limited to habitat modification through beach nourishment projects and beach raking. Although there has been progress in recovery efforts for the seabeach amaranth, this plant remains vulnerable to habitat destruction and has experienced in recent years declines in certain populations. Therefore, this plant continues to meet the definition of threatened species under the Act

Seabeach amaranth was originally assigned a recovery priority number of 8C, indicating a moderate degree of threat and a high recovery potential. The "C" indicates the potential for conflict. We recommend that the recovery priority number remain unchanged.

III. RESULTS

A. Recommended Classification:

____ Yes, downlist to Threatened
____ Yes, uplist to Endangered
____ Yes, delist
_X__ No, no change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

Range-wide, there has been a lot of interest in seabeach amaranth since the species was listed in 1993 and much work is being done toward the recovery of this federally threatened species. Since the species is currently found in seven states, many local, state and federal government agencies as well as academic and private groups are interested in protecting this species. We are fortunate to have so many partners interested in protecting seabeach amaranth. The following recommendations, listed in order of priority, should be considered in order to facilitate seabeach amaranth recovery:

1. Revise or clarify sections of the Recovery Plan
    a. Some of the terms used in the existing Recovery Plan need further definition in order for the Service to determine when the recovery criteria have been met.

The current recovery criteria require a "minimum of 75 percent of the sites with suitable habitat be occupied by seabeach amaranth populations for 10 consecutive years" in order for the species to be de-listed (U.S. Fish and Wildlife Service 1996). The recovery plan does not define what a "site" is or what constitutes "occupied." These words are somewhat subjective and leave a lot of room for misinterpretation, especially over the range of the species. These words should be defined in any future revisions or clarifications of the recovery plan as it will be difficult to say that the recovery criteria has been met until these terms are further defined and the criteria specified in more detail.

b. The following two listing factors were addressed in the recovery criteria section of the recovery plan, but they need additional clarification:

Listing Factor 1 (present or threatened destruction, modification or curtailment of its habitat or range) is addressed in the recovery criteria by the requirement that "mechanisms ... be in place to protect the plants from destructive habitat alterations (particularly construction of sea walls and other forms of beach armoring)." The recovery plan does not provide additional advice on how to accomplish this goal. Since the construction of these types of structures is already allowed by most states where seabeach amaranth occurs, it will be difficult to convince each state government to change the rules allowing their construction. Further, the impact of these structures on seabeach amaranth has not been documented through quantitative research. Such research should occur before any measures to remove these structures are recommended. Depending on the results of this research, it may be necessary to revise this criterion.

The full effects of beach nourishment projects on seabeach amaranth are unknown at this time. More research needs to be conducted on this subject in order to determine what the effects are. The results of this research and any recommendations from it should be incorporated into future recovery plan revisions or clarifications.

The effects of ORV use on seabeach amaranth germination, growth and survival needs to be evaluated quantitatively. Since beach driving occurs in varying degrees throughout the range of seabeach amaranth, studies should be conducted to determine the full effects it has on seabeach amaranth. In the interim, it would be best if state parks, national seashores and municipalities prevented beach driving during the time of year when the species is actively growing (May-November). The results of this research should be incorporated into future recovery plan revisions or clarifications.

Listing Factor 3 (disease and predation) is addressed in the recovery criteria by recommending the "protection of populations from debilitating webworms." Although not stated in the recovery criteria section, the threats section of the recovery plan suggests the use of *Bacillus thuringiensis* (Bt) to control webworms in seabeach amaranth populations. It should be noted that on Bogue Banks, NC, a

very rare, yet undescribed skipper (a type of butterfly) occurs in areas with natural dune vegetation. While it appears to feed on seaside little bluestem (*Schizachyrium littorale*), little is known about its life cycle and individuals could be harmed by overspray from seabeach amaranth onto neighboring dune vegetation. Since Bt is lethal to the larval stage of many insects, care should be taken to ensure that pesticides are applied on days with little or no wind and that protective measures are taken to prevent overspray in order to prevent harm to other species. It should also be noted that Bt would not affect mammalian herbivory. Further, Rosenfeld (2004) found that the presence of webworms and ghost crabs did not significantly affect plant size or reproduction. It may be prudent to remove this recommendation from any future recovery plan revisions or clarifications.

c. The following listing factors were not addressed as Recovery Criteria in the Recovery Plan, but should be addressed in any future amendments or revisions:

Listing Factor 2 (Overutilization for commercial, recreational, scientific or educational purposes) is not addressed in the recovery plan. The recovery plan should consider state and federal requirements for the issuance of research and recovery permits for seabeach amaranth. The Service's Propagation Policy should be consulted for all permit applications that will involve the propagation and/or reintroduction of seeds or seedlings into suitable habitat within the historic range of this species. A propagation plan should be prepared before any future propagation activities are permitted. The introduction of seeds or seedlings outside of the historic range should not be permitted. Precautions should be taken to ensure that local subpopulations are not contaminated by genetic material from distant subpopulations. Specifically, Strand (2002) suggests that restoration, augmentation and transplantation projects in NC and SC should use seeds from the Carolinas and; likewise, such projects in NY and NJ should only use seeds from those two states. Little is known about the genetic affinity of populations in DE, MD and VA. Restoration projects in those states should also use local seed sources, at least until more is known about how these plants are related to northern and southern subpopulations. Caution should also be taken against possibly spreading disease from site to site, field to greenhouse or greenhouse to field.

Listing Factor 4 (Inadequacy of existing regulatory mechanisms) is not addressed in the recovery criteria of the current recovery plan. The recovery criteria should address the impacts of ORV use and beach raking and recommend or require that each government entity that allows ORV use consult with the Service to ensure that such actions do not jeopardize the continued existence of seabeach amaranth. Further, a significant portion of appropriate seabeach amaranth habitat should be roped or fenced off and protected from vehicles through the end of the growing season to allow plants to mature and produce seeds. A fencing guidance document was recommended at the 2003 seabeach amaranth conservation

meeting and a draft document addressing when and where fencing is recommended was prepared.

Listing Factor 5 (Other natural or manmade factors affecting its continued existence) is not addressed in the recovery plan. Any revisions of the recovery plan should address the potential affects of invasive species such as beach vitex, Japanese sedge and puncturevine and/or their control. Efforts to control or eradicate these species should carefully consider potential negative impacts to seabeach amaranth and other native dune plant and animal species that may result from trampling, herbicide drift, etc. In addition to habitat degradation by invasive species, some native species such as purple sand grass and American beach grass have created monocultures in NJ that prevent the establishment of other native dune vegetation, including seabeach amaranth.

2. Define what constitutes "Likely to Adversely Affect" and "Jeopardy" for this species in order to improve consistency in USFWS consultations.

3. Develop a list of list of conservation measures that Service biologists can use in formal consultations that address impacts to seabeach amaranth, such as:

- in the southern part of its range, restrict the project to winter months between senescence and germination (this may not be possible in the northern part of its range because of safety concerns due to bad weather, delays could extend work past the March 15 piping plover deadline and late winter fills may produce longer-lasting impacts on the benthic plover prey resource in the intertidal zone),
- survey plants immediately before the start of work and fence/avoid all plants directly within the fill template,
- attempt to salvage/transplant all plants within the fill template and document the results,
- attempt conservation of the top layer of sand and replacement on top of the fill,
- collect seeds from plants to be impacted, preferably during the growing season prior to project construction,
- plant seedlings grown from locally collected seeds,
- request time of year restrictions for ORV use and beach raking that reduce impacts to seabeach amaranth,
- request funding for research to answer questions about the impacts of various projects on seabeach amaranth,
- monitor seabeach amaranth before and after project construction, transplantation, seed distribution and seedling planting, and
- collect specimens from impact areas and deposit at various herbaria so they can be used later for taxonomic or genetic work.

4. Develop survey protocols in accordance with USFWS policy and continue annual rangewide monitoring. Submit annual survey data to the lead recovery biologist for analysis.

5. Develop management recommendations in accordance with USFWS policy.

6. Develop guidelines for restoration, augmentation and transplantation.

   Restoration, augmentation and transplantation projects in NC and SC should use seeds from the Carolinas and; likewise, such projects in NY and NJ should only use seeds from those two states. Little is known about the genetic affinity of populations in DE, MD and VA. Restoration projects in those states should also use local seed sources, at least until more is known about how these plants are related to northern and southern subpopulations.

7. Discuss potential impacts of ORV use and beach raking with local governments.

   Such discussions would ensure that ORV use and beach raking would avoid or minimize effects to seabeach amaranth. Since ORV use is frequently allowed after Labor Day, plants are not allowed to produce mature fruits before they are run over by vehicles. It would be best if these coastal towns managed beach driving around seabeach amaranth plants until after they have produced mature seeds and senesced (late October or early November). Further, a significant portion of appropriate seabeach amaranth habitat should be roped or fenced off and protected from vehicles through the end of the growing season to allow plants to mature and produce seeds.

8. Ensure that seed collections and herbarium specimens represent a variety of populations from throughout the species range

   See Appendix C for additional information on seed collection and specimen collection recommendations.

9. Work with academic institutions to address the additional research needs.

   There has been a lot of interest in seabeach amaranth since the species was listed and much research has already been conducted. Some recommendations for additional research include:

   - quantifying the effects of beach nourishment projects on seabeach amaranth recruitment (including population trends before and after nourishment, the relationship of re-colonization time to the distance from populations, the configuration of fill material/work zone [*i.e.*, minimal overlap with the growing zone, meaning little seed burial]),
   - quantifying the effects of hardened structures (jetties, groins and seawalls) in seabeach amaranth habitat,
   - quantifying the effects of ORV use and mechanical beach raking on seabeach amaranth germination, growth and reproduction,
   - quantifying the effects of symbolic fencing on seabeach amaranth germination, growth and reproduction,
   - determining the genetic affinity of seabeach amaranth plants found in DE, MD and VA using techniques similar to Strand 2002 (or something more appropriate or sophisticated),

- determining the ecological requirements of seabeach amaranth, especially pertaining to the nutrients provided by birds, wrack and other beach vegetation, and
- determining the location of seed banks and seed dormancy.

10. Work with partners to fulfill the following outreach needs:
    - revise the photo identification cards using a better photo that represents what the plant looks like from eye level and include more information on the back such as more location information, web site address, etc.
    - produce interpretive signs for beach access sites, maybe include other coastal species (Long Island has a sign that includes least tern, piping plover and seabeach amaranth),
    - encourage media coverage of all protected species and coastal events,
    - maintain an up to date web site about seabeach amaranth.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF SEABEACH AMARANTH *(AMARANTHUS PUMILUS)*

Current Classification _Threatened_
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__X_ **No change is needed**

Appropriate Listing/Reclassification Priority Number _____

Review Conducted By _Dale Suiter, Fish and Wildlife Biologist_____

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 4/10/07

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 5/8/07
Acting ARD-ES

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. Written concurrence from other regions is required.

Cooperating Regional Director, Fish and Wildlife Service

X Concur ____ Do Not Concur

Signature _____ Date 6-4-07
Richard O. Bennett, Ph...
Acting Regional Dire...

Appendix A. Seabeach amaranth annual census data organized by state.

Year	DE	NY	MD-VA	NC	NJ	SC	RI-CT-MA
1987	0	0	0	3395	0	1341	0
1988	0	0	0	4433	0	1800	0
1989	0	0	0	0	0	0	0
1990	0	331	0	1127	0	188	0
1991	0	2251	0	1170	0	0	0
1992	0	422	0	6148	0	15	0
1993	0	195	0	12386	0	0	0
1994	0	182	0	7598	0	560	0
1995	0	599	0	20716	0	6	0
1996	0	2263	0	3042	0	0	0
1997	0	7990	0	741	0	2	0
1998	0	8599	2	5440	0	141	0
1999	0	19155	1	230	0	196	0
2000	32	138602	4	57	1039	2312	0
2001	83	179305	878	628	5813	231	0
2002	423	190589	857	2583	10908	0	0
2003	13	112148	481	6989	5084	1381	0
2004	4	30830	533	7904	6820	2110	0
2005	9	11092	558	13740	5795	0	0
State Totals	**564**	**704553**	**3314**	**98327**	**35459**	**10283**	**0**

Seabeach amaranth survey data for Delaware.

Year	BPINP	CHSP	DSSP	FISP	TFIP	Year Totals
1987	0	0	0	0	0	**0**
1988	0	0	0	0	0	**0**
1989	0	0	0	0	0	**0**
1990	0	0	0	0	0	**0**
1991	0	0	0	0	0	**0**
1992	0	0	0	0	0	**0**
1993	0	0	0	0	0	**0**
1994	0	0	0	0	0	**0**
1995	0	0	0	0	0	**0**
1996	0	0	0	0	0	**0**
1997	0	0	0	0	0	**0**
1998	0	0	0	0	0	**0**
1999	0	0	0	0	0	**0**
2000	0	0	28	4	0	**32**
2001	0	0	80	3	0	**83**
2002	0	4	419	0	0	**423**
2003	0	1	11	1	0	**13**
2004	0	2	2	0	0	**4**
2005	0	5	4	0	0	**9**
Site Totals	**0**	**12**	**544**	**8**	**0**	**564**

Site Codes

BPINP	Beachplum Island Nature Preserve
CHSP	Cape Henlopen State Park
DSSP	Delaware Seashore State Park
FISP	Fenwick Island State Park
TFIP	Town of Fenwick Island Beach

Source: McAvoy & Pepper 2005

Seabeach amaranth survey data for Maryland and Virginia.

Year	AI	CNWR	Reintro	Year Totals
1987	0	0	0	**0**
1988	0	0	0	**0**
1989	0	0	0	**0**
1990	0	0	0	**0**
1991	0	0	0	**0**
1992	0	0	0	**0**
1993	0	0	0	**0**
1994	0	0	0	**0**
1995	0	0	0	**0**
1996	0	0	0	**0**
1997	0	0	0	**0**
1998	2	0	0	**2**
1999	1	0	0	**1**
2000	4	0	1156	**4**
2001	878	10	2444	**878**
2002	857	55	1881	**857**
2003	481	22	0	**481**
2004	533	2	0	**533**
2005	558	30	0	**558**
Site Totals	**3314**	**119**	**5481**	**3314**

Site Codes

AI	Assateague Island - Maryland side
CNWR	Chincoteague National Wildlife Refuge - Virginia side
Reintro	Reintroduced plants on Assateague Island

Source: Lea & Sturm 2003

Note: *Hog Island, False Cape State Park, Cape Henry/Fort Story, & Fisherman's Island in VA have been surveyed a various times and no plants found*

Seabeach amaranth survey data for New Jersey.

Year	SH	SB	MB	SM	OC	AC	CMC	Year Totals
1987	0	0	0	0	0	0	0	**0**
1988	0	0	0	0	0	0	0	**0**
1989	0	0	0	0	0	0	0	**0**
1990	0	0	0	0	0	0	0	**0**
1991	0	0	0	0	0	0	0	**0**
1992	0	0	0	0	0	0	0	**0**
1993	0	0	0	0	0	0	0	**0**
1994	0	0	0	0	0	0	0	**0**
1995	0	0	0	0	0	0	0	**0**
1996	0	0	0	0	0	0	0	**0**
1997	0	0	0	0	0	0	0	**0**
1998	0	0	0	0	0	0	0	**0**
1999	0	0	0	0	0	0	0	**0**
2000	120	823	96	0	0	0	0	**1039**
2001	561	4701	482	23	10	35	1	**5813**
2002	904	9117	784	92	8	1	2	**10908**
2003	542	4215	178	10	29	8	102	**5084**
2004	1667	3807	1237	32	14	1	62	**6820**
2005	3280	1493	883	100	10	0	29	**5795**
Site Totals	**7074**	**24156**	**3660**	**257**	**71**	**45**	**196**	**35459**

Site Codes

SH	Sandy Hook
SB	Sea Bright
MB	Monmouth Beach
SM	Southern Monmouth
OC	Ocean County
AC	Atlantic County
CMC	Cape May County

Source: Walsh 2005

Seabeach amaranth survey data for New York.

Year	GB	RB	JBI	FI	WHI	SFB	PB	Year Totals
1987	0	0	0	0	0	0	0	**0**
1988	0	0	0	0	0	0	0	**0**
1989	0	0	0	0	0	0	0	**0**
1990	1	11	188	85	46	0	0	**331**
1991	3	0	420	139	1651	38	0	**2251**
1992	26	0	261	7	93	35	0	**422**
1993	30	0	132	1	22	10	0	**195**
1994	1	0	123	14	35	9	0	**182**
1995	1	338	65	21	174	0	0	**599**
1996	3	2000	39	10	211	0	0	**2263**
1997	15	2946	4586	11	431	1	0	**7990**
1998	29	2309	5483	0	778	0	0	**8599**
1999	12	504	18064	234	341	0	0	**19155**
2000	78	1996	134442	341	1745	0	0	**138602**
2001	145	5885	157100	922	15253	0	0	**179305**
2002	149	4014	107823	1232	77243	128	0	**190589**
2003	245	1480	22228	2089	85802	285	19	**112148**
2004	1050	173	14356	392	13646	1144	69	**30830**
2005	1569	0	6645	232	2625	16	5	**11092**
Site Totals	**3357**	**21656**	**471955**	**5730**	**200096**	**1666**	**93**	**704553**

Site Codes

GB	Gateway Beaches
RB	Rockaway Beaches
JBI	Jones Beach Island
FI	Fire Island
WHI	Westhampton Island
SFB	South Fork Beaches
PB	Peninsula Beaches

Source: Steve Young - email 2005

Seabeach amaranth survey data for North Carolina.

Year	CB	SB	BC	CH	OI	HBSP	CLJ	BB	WF8	Year Totals
1987	58	0	3337				0	0	0	**3395**
1988	900	2	3531				0	0	0	**4433**
1989	0	0	0				0	0	0	**0**
1990	339	175	613				0	0	0	**1127**
1991	0	0	0			703	0	467	0	**1170**
1992	0	10	3175			407	0	2556	0	**6148**
1993	1290	975	6286			73	0	3762	0	**12386**
1994	704	948	4762			3	0	1181	0	**7598**
1995	75	1155	4710				0	14776	0	**20716**
1996	1	3	3038				0	0	0	**3042**
1997	2	51	607				0	81	0	**741**
1998	125	369	0			1000	0	3946	0	**5440**
1999	2	9	0			1	0	218	0	**230**
2000	4	13					0	40	0	**57**
2001	51	126					0	451	0	**628**
2002	71	261		133	13	50	0	1983	72	**2583**
2003	206	1354		54	36	66	0	5270	3	**6989**
2004	79	58				22	1797	5292	656	**7904**
2005	284	671					1302	10711	772	**13740**
Site Totals	**4191**	**6180**	**30059**	**187**	**49**	**2325**	**3099**	**50734**	**1503**	**98327**
										98327

Site Codes

CB	Core Banks
SB	Shackleford Banks
BC	Brunswick County
CH	Cape Hatteras
OI	Ocracoke Island
HBSP	Hammocks Beach State Park
CLJ	Camp Lejeune
BB	Bogue Banks
WF8	Wrightsville & Figure 8

Source: USACE, etc.

Seabeach amaranth survey data for South Carolina.

Year	GC	HC	CC	SC	Year Totals
1987	1305	1	35	0	**1341**
1988	1668	95	37	0	**1800**
1989	0	0	0	0	**0**
1990	172	15	1	0	**188**
1991	0	0	0	0	**0**
1992	15	0	0	0	**15**
1993	0	0	0	0	**0**
1994	560	0	0	0	**560**
1995	6	0	0	0	**6**
1996	0	0	0	0	**0**
1997	2	0	0	0	**2**
1998	141	0	0	0	**141**
1999	0	0	196	0	**196**
2000	1136	0	1176	0	**2312**
2001	0	0	231	0	**231**
2002	0	0	0	0	**0**
2003	0	0	0	1381	**1381**
2004	0	0	0	2110	**2110**
2005	0	0	0	0	**0**
Site Totals	**5005**	**111**	**1676**	**3491**	**10283**
					10283

Site Codes

GC	Georgetown County
HC	Horry County
CC	Charleston County
SC	state total, not specified by county

Sources: Old Nora spreadsheet, origin unknown
Strand 2005 (for 2001-2004)
Suiter, personal observations for Huntington Beach State Park
Eudaly email 2001, Charleston County 2001

Appendix B. Seabeach amaranth populations occurring on state and federally owned lands.

National Seashores:
Assateague Island, Cape Lookout, Cape Hatteras, Fire Island, Gateway National Recreation Area

National Wildlife Refuges:
Cape Romain, Chincoteague, Forsythe, Cape May

State Parks:
Corsons Inlet State Park, NJ
Island Beach State Park, NJ
Strathmore Natural Area, NJ
Cape May Point State Park State Park, NJ
Delaware Seashore State Park, DE
Fenwick Island State Park, DE
Cape Henlopen State Park, DE
Assateague Island State Park, MD
False Cape State Park, VA
Hammocks Beach State Park, NC
Myrtle Beach State Park, SC
Huntington Beach State Park, SC

Military Bases:
Camp Lejeune Marine Corps Base near Jacksonville, NC
New Jersey Army National Guard, National Guard Training Center in Sea Girth Borough, NJ

Appendix C. Seabeach amaranth seed collection and specimen collection recommendations.

The North Carolina Botanical Garden (NCBG) has been designated as the official seabeach amaranth seed repository by the Center for Plant Conservation (CPC). Efforts should be made to regularly collect and contribute seeds from throughout the species range in order to supplement the NCBG collections. Seed collectors should obtain the appropriate state and federal permits and should follow CPC guidelines. Collectors should contact Johnny Randall (919-962-0522) at NCBG for specific information about seed collection.

In addition, David Brenner of the USDA's Plant Introduction Station at Iowa State University curates seed collections for the National Plant Germplasm System. He currently has six accessions of seabeach amaranth that were collected in 1989 from NC and SC. He would like to acquire one accession each from the other states where the species is found. David Brenner should be contacted at 515-294-6786 for specific information about how to collect seeds for the National Plant Germplasm System.

Since few herbarium specimens exist for seabeach amaranth, collections representing different populations throughout the range of the species should be made and deposited at the University of North Carolina Herbarium (Chapel Hill, NC) with any duplicate specimens going to the New York Botanic Garden.

Appendix D. Peer Review

A draft copy of this review was distributed to federal and state government biologists and academic researchers knowledgeable of the species for their review. USFWS biologists at field offices throughout the range of the species Ed EuDaly (SC), Wendy Walsh (NJ) and Steve Papa and Steve Sinkevich (NY) work on seabeach amaranth and provided valuable comments in their review of this document. Mark Sturm (Assateague Island National Seashore), Steve Young (NY Natural Heritage Program) and Kristen Rosenfeld (graduate student in the Plant Biology Department at NC State University) are conducting ongoing research related to seabeach amaranth and coastal dune biology. John Taggart, Ph.D., (Professor of Environmental Studies at the University of North Carolina – Wilmington) was the former director of the N.C. Coastal Reserve Program. Many comments were received on topics like the biology of this plant, life history, optimal habitat requirements, and threats to this plant and incorporated into the document as appropriate.