Sandplain Gerardia
(*Agalinis acuta*)

Recovery Plan

Prepared by
Region Five
U.S. Fish and Wildlife Service

Sandplain Gerardia (*Agalinis acuta*)

RECOVERY PLAN

Prepared for

Region 5

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PART I

INTRODUCTION

The sandplain gerardia (Agalinis acuta) Pennell was listed as an endangered species under the provisions of the Endangered Species Act of 1973, as amended, on September 7, 1988 (Federal Register, Vol. 53, No. 173). A. acuta, a plant of the figwort family (Scrophulariaceae), is known to occur at two sites on Cape Cod, Massachusetts; six sites on Long Island, New York; one site in Baltimore County, Maryland; and, one site in Washington County, Rhode Island. Historically, Agalinis also occurred in Connecticut, and may be rediscovered in this State after intensive field survey. The overall plant population has declined from 49 historical records to the ten populations remaining today. The population decline of this species can be attributed to the loss and degradation of suitable habitat, caused by increased development, vegetative succession and changing historical disturbance regimes.

Description

A. acuta is an annual pale green herb, from 5.0 cm to 30.0 cm tall and occasionally up to 40.0 cm tall (see Figure 1), which turns yellowish upon drying. The smooth stem is weakly angular and is sparsely branched. Leaves are opposite, linear, scabrous above and up to 2.5 cm long. The pink or purple flowers, which appear from mid-August to mid-October, are 1.0 cm to 1.3 cm long and borne on slender pedicels 1.0 cm to 2.0 cm long.

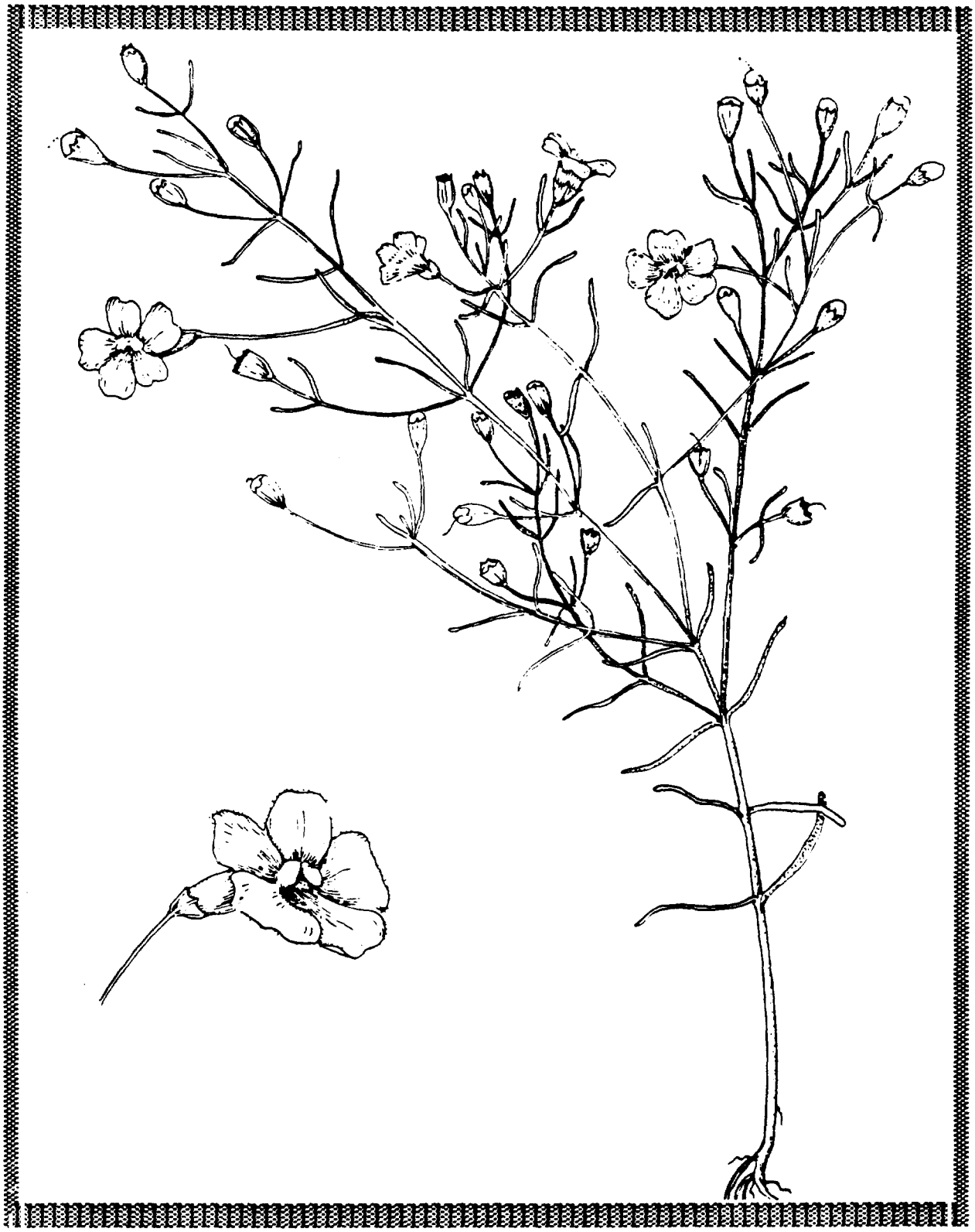

Figure 1. Agalinis acuta (sandplain gerardia)
Reprinted form Crow, G.E., 1982.

The cup-shaped calyx is fused into a short reticulately veined tube, with projecting lobes about 0.05 cm to 0.1 cm long, narrowly triangular and fringed with short glandular hairs. The corolla is from 0.5 cm to 1.3 cm long, membranous, tubular and flared distally into spreading, shallowly notched lobes. The corolla lobes have ciliate margins but the exterior surfaces of the corolla lobes are glabrous. The throat is pilose on the exterior and has hairs at the base of two upper corolla lobes on inside. The corolla is pink, except for the white throat which is distinctly spotted with purple or red. Anthers are covered with dense white hairs and the style and stigma are glabrous.

Capsules are 0.38 cm to 0.42 cm long, ovoid and yellowish-brown. Seeds are 0.04 cm to 0.06 cm long, triangular to round, yellowish-brown and with a conspicuous reticulate surface pattern. There may be as many as 29 capsules per plant, although individual plants sometimes bear only one or a few flowers and capsules (Caljouw, et al., 1988). Canne-Hilliker (1989b) reports herbarium specimens show plants that have over 100 capsules per plant.

Taxonomy

The generic name Gerardia has been applied to many species in the family Scrophulariaceae including A. acuta. The International Code of Botanical Nomenclature (Voss, et al., 1983) lists Agalinis as a conserved name, thus it is now the preferred name.

Several species of Agalinis are similar in appearance to A. acuta. The following descriptions are offered to distinguish A. acuta from A. skinneriana, A. tenuifolia, A. setacea and A. decemloba (see Caljouw, et al., 1988; Canne, 1985; Canne-Hilliker, 1989a, 1989b; Sorrie, 1984).

A. skinneriana (A. Wood) Britton is a midwestern species of mesic prairie remnants, a habitat similar to the coastal sandplains in which A. acuta occurs in the eastern United States. The narrow angular ridges on the stems of A. skinneriana are more distinct than those of A. acuta (Sorrie, 1984). The former species is more strictly branched, its leaves tending to be more ascending than those of A. acuta, and the stems are scabrous rather than smooth as in A. acuta (Canne 1985, 1989b). The flowers of the species are similar, but the corolla is very pale pink to white in A. skinneriana and a darker pink in A. acuta. The corolla averages slightly smaller in A. acuta.

A. tenuifolia (Vahl) Rafinesque is a darker green plant often marked with red and drying to a dark brown color. Canne-Hilliker (1989b) described the plant as follows. The stems of A. tenuifolia are often not as sharply angular as in A. acuta, and the angles have narrow flanges of tissue along them and are slightly rough. The leaves of A. tenuifolia can be as narrow as those of A. acuta but are usually much wider with tapering tips, not narrowly linear and acute as in A. acuta. The corollas of A. tenuifolia are a dark pink-purple and more shallowly and broadly bell-shaped. The exterior surfaces of the three lower corolla lobes (and sometimes the upper ones) are pilose rather than glabrous as in A. acuta. The band of hairs at the inner bases of the two

upper corolla lobes of A. acuta are missing in A. tenuifolia. The corolla lobes are broadly rounded and all five may project forward, the lower ones, but not the upper, becoming somewhat reflexed. The upper corolla wall between the narrow tube and the lobes is much shorter than the corresponding lower wall of the throat in A. tenuifolia , but about equal in A. acuta. The calyx of A. tenuifolia varies widely in lobe length, is dark in color and therefore does not appear veiny as in the pale calyx of A. acuta. Capsules of A. tenuifolia are medium to dark brown while those of A. acuta are yellowish tan. The seeds of A. tenuifolia are tan to brown while seeds of A. acuta are yellow.

A. setacea (Walter) Rafinesque is a dark green to purple-tinged species that occurs in the coastal plain and piedmont regions of the eastern United States. A. setacea is more branched, the leaves are more numerous and narrower than in A. acuta. The main stem is rounded near the base becoming more angular above with minutely rough ridges. A. acuta stems are angular and smooth. The corolla of A. setacea is larger (11 mm to 21 mm long), pinkish-purple, and the exterior surfaces of the lower lobes are pilose, those of the upper lobes are nearly glabrous to pilose, whereas the lobe surfaces of A. acuta are glabrous (Canne-Hilliker, 1989b). The seed color in A. acuta is yellowish-brown, while in A. setacea it is dark brown to black.

A. decemloba (Greene) Pennell, like A. acuta, is found in the eastern United States, usually west of the coastal plain. Generally, A. decemloba is taller, more slender, with shorter, less divergent branches (Sorrie, 1984). The plants are more reliably distinguished by the calyx lobes, with A. decemloba

having shorter (0.5 mm) blunt lobes in contrast to A. acuta which has larger (0.5 mm to 1.0 mm), well-developed triangular lobes interspersed with sinuses (Sorrie, 1984; Canne, 1985). Floral bracts in A. decemloba tend to be shorter than those of A. acuta, but some overlap exists (Canne-Hilliker, 1989b).

Distribution and Status

A. acuta is documented most recently from 10 sites: two on Cape Cod, Massachusetts; six on Long Island, New York; one in Washington County, Rhode Island; and, one in Baltimore County, Maryland. Historic populations were reported from Connecticut and the species may be rediscovered with intense survey. Table 1 summarizes the known historic and current distribution and status of the species. Figure 2 further illustrates the known populations of the species.

TABLE 1. Distribution and Status of *Agalinis acuta* (historic locations are noted).

STATE	COUNTY	TOWN	NUMBER OF PLANTS RECORDED 1984	1985	1986	1987	1988	References
Connecticut	Hartford	Farmington (1897)						1
	New London	Voluntown (1897)						2
Massachusetts	Barnstable	Barnstable (1880)						4
	Barnstable	Barnstable (1898)						4
	Barnstable	Barnstable (1921)						4
	Barnstable	Bourne (1883)						4
	Barnstable	Falmouth (1880)						4
	Barnstable	Falmouth (1906)						4
	Barnstable	Falmouth (1911)						4
	Barnstable	Falmouth (1925)						4
	Barnstable	Falmouth	220	50	130	18	94	3,4,5
	Barnstable	Sandwich	3	10	11	1	10	3,4,5
	Bristol	Dartmouth (1888)						4
	Dukes	Edgartown (1910)						6
	Dukes	Edgartown (1917)						4
	Dukes	Edgartown (1939)						4
	Dukes	West Tisbury (1892)						6
	Dukes	West Tisbury (1917)						4
	Dukes	West Tisbury (1940)						6
	Middlesex	Natick (1905)						4
	Nantucket	Nantucket (1889)						4
	Nantucket	Nantucket (1904)						4
	Nantucket	Nantucket (1907)						4
	Nantucket	Nantucket (pre-1915)						6
	Worcester	Clinton (1949)						6
	Worcester	Douglas (1944)						7
Maryland	Baltimore	Baltimore (1965)						8
	Baltimore	Reistertown	—	—	30	1000*	150	9
New York	Nassau	Hempstead (1918)						10
	Nassau	Hempstead	1000-2000*	—	89	529	51	9
	Nassau	North Hempstead (1906)						9
	Nassau	North Hempstead (1916)						9
	Nassau	Oyster Bay (1915)						9
	Suffolk	Babylon (1868)						9
	Suffolk	Babylon (1921)						10
	Suffolk	Brookhaven	8	12	54	134	266	10
	Suffolk	Brookhaven	—	29	0	0	0	10
	Suffolk	East Hampton	140	44	134	175	349	10
	Suffolk	East Hampton	—	230	52	84	72	9
	Suffolk	East Hampton (1938)						9
	Suffolk	East Hampton (1920)						9
	Suffolk	East Hampton (1921)						9
	Suffolk	East Hampton (1927)						10
	Suffolk	Islip	—	300-500*	379	200	76	9
	Suffolk	Southampton (1899)						11
Rhode Island	Kent	North Kingstown (1875)						11
	Providence	Cumberland (1941)						11
	Providence	Lincoln (1906)						11
	Newport	Little Compton (1932)						11
	Washington	Hopkinton (1919)						12,13
	Washington	Richmond	—	—	—	—	56	

* estimate

References: (1) Canne, 1985; (2) Mehrhoff, 1978; (3) Caljouw, et al., 1988; (4) Sorrie, 1988a,b; (5) Carroll, 1988; (6) Coddington and Field (undated); (7) Reed, 1986; (8) Bartgis, 1988a; (9) Clemants, 1988; (10) Zaremba, 1988a,b; (11) Enser, 1985; (12) Raithel, 1988; (13) Caljouw, 1988.

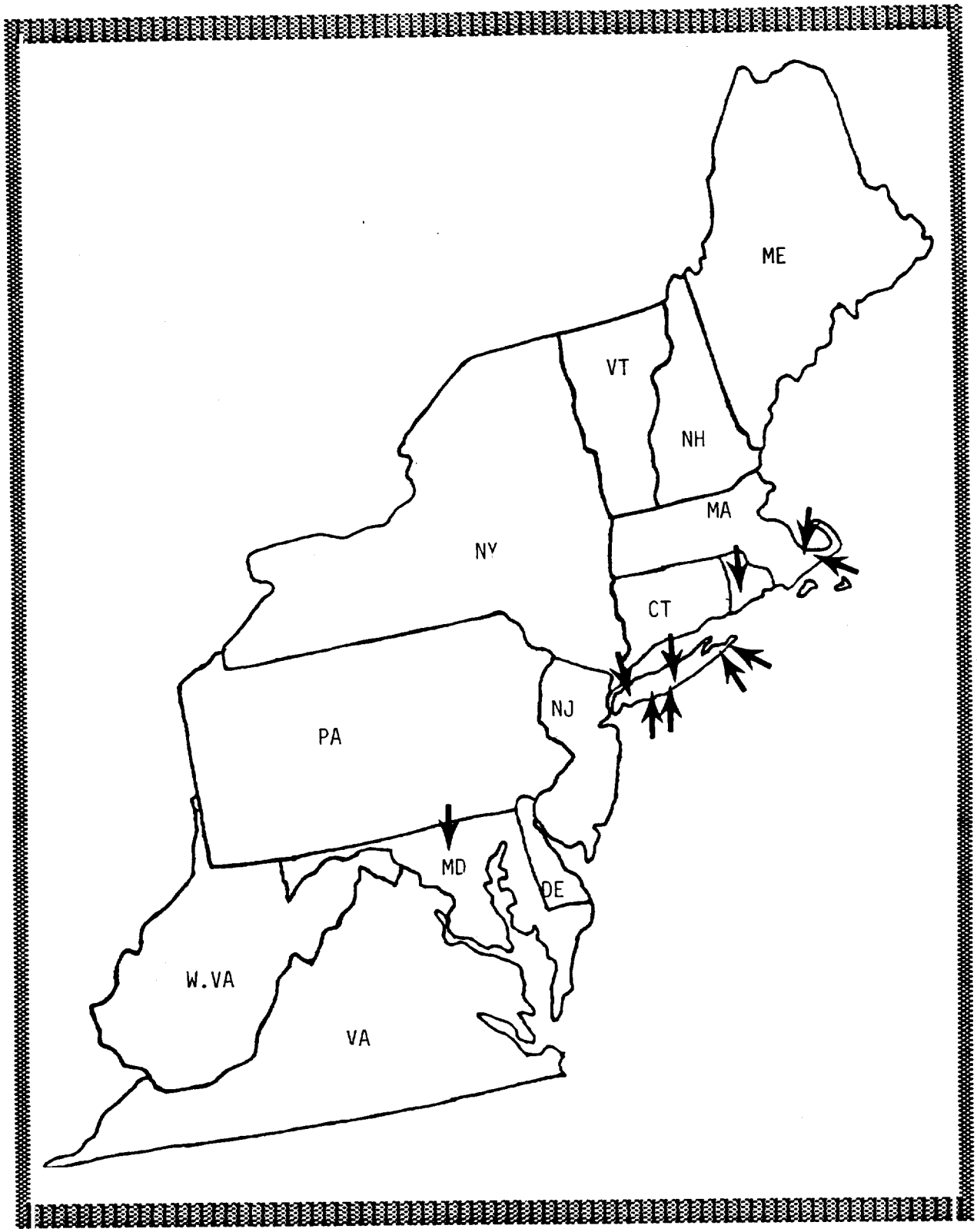

Figure 2. Current distribution of Agalinis acuta.

Connecticut

Historically, Connecticut was known to support two populations of A. acuta, in Voluntown and Farmington, Hartford County. However, there are currently no known extant occurrences in this State. Potential habitat for the species exists but has not been thoroughly searched.

Maryland

Although Maryland historically supported two occurrences of A. acuta, the sole extant occurrence of A. acuta in the State is at a Natural Environmental Area, where it occurs in a series of small openings in a pine-oak forest under primary ownership of the Maryland Department of Natural Resources. Several private inholdings exist within the Natural Environmental Area, with the potential for development. The State is actively considering the acquisition of these lands. The primary threats to this population appear to be trampling from visitors and competition from successional species associated with canopy closure, possibly due to fire suppression (MacLauchlan, 1987). A proposed high density residential development adjacent to the Natural Environmental Area may have the potential to impact this population due to the expected increase in use of this sensitive area by residents.

Massachusetts

Twenty-four occurrences of A. acuta have been documented from Massachusetts. Two extant occurrences occur on Cape Cod in small cemeteries dating back to the 1700's. It is estimated that the grasslands supporting these populations have been mowed for at least 100 years from spring through fall, perhaps contributing favorably to the maintenance of these populations. The Nature

Conservancy has listed both of the extant sites on their registry and has entered into a management agreement with the owners which prescribes mowing at certain times of the year to protect the flowering and fruiting stages of the plant. This registry agreement stipulates that no mowing take place at the site of the plants from July to November. To date, adherence to this agreement has been somewhat unsuccessful in that mowing has occurred on several occasions during the time it was not prescribed.

New York

Seventeen occurrences of A. acuta have been documented from New York. In recent years, Long Island has supported six populations, ranging from a few plants to several thousand. Of the six extant sites, five occur on land at least partially in private ownership, while one is on federal property. The site that occurs on federal property occurs on the periphery of land that has been disked over the past years. Pesticides were also used at this site in the 1960's. Other disturbances at this site appear to be trampling and small fires.

A golf course supports six subpopulations in its grassland/shrub community and adjacent maintenance area. The golf course grasses are mowed frequently. The maintenance area is moderately disturbed, with topsoil scarification and possible herbicide use. None of the specific areas where A. acuta occurs are known to have been mowed (Zaremba, 1988b).

A grassy roadside supports a population subject to litter and road maintenance, including mowing and salt applications. Despite survey attempts,

this population has not been documented for the past three seasons (1986-1988). Three plants were noted in 1988; however, these plants were determined to be A. setacea (Zaremba, 1988a).

A narrow strip of land between a highway and a railroad right-of-way supports another population. This population is exposed to heavy disturbance from herbicides, vegetative clearing and other maintenance activities commonly associated with buffer areas.

A remnant 16-acre sandplain plant community supports one of the larger populations. A community college currently has a 99-year lease on the property, which it uses for educational purposes. The Nature Conservancy holds a 5-year management agreement with the college. The site has been moderately disturbed from past land use as an airfield and is vegetated by numerous exotic plant species. A subpopulation on land owned by the County Parks Department, is separated by a roadway and receives heavy disturbance from recreational off-road vehicles. The County is aware of the plants existence and has attempted to restrict off-road vehicle use in the area. The area is currently fenced to limit access to the population by recreationists.

The final New York population is located on sandy glacial outwash near the ocean shore. The plants are confined to a small area along a horse trail in exposed soil. This site is perhaps the most natural grassland community among the Long Island sites, and population numbers have remained essentially stable over the past several years. The current landowners do not reside on the property, and the site is high in development pressure, due to its location

within a highly desirable oceanside community. The land is on The Nature Conservancy's acquisition list. Access to this site for the purpose of population monitoring has been limited due to its occurrence on private property.

Rhode Island

Historically, six populations were reported from this State, of which only one is extant. The Rhode Island Division of Fisheries and Wildlife recently located a population on a remnant grassland in a historic cemetery in Washington County. The population consists of three aggregations, two within the cemetery and one on an adjacent roadside. There are no obvious threats to this population. Disturbance consists of mowing and evidence exists that some kind of soil scarification had occurred in the past. A registry agreement similar to the ones for the Massachusetts cemeteries has been arranged through The Nature Conservancy.

Ecology and Life History

A. acuta typically occurs on dry, sandy, poor-nutrient soils of sparsely vegetated sandplain environments and serpentine barrens, whose harshness may eliminate potentially competitive species. Rawinski (1983) found Andropogon sp. (beardgrass) and Chrysopsis mariana (Maryland golden aster) occupying the same openings of bare mineral soil as A. acuta on one Long Island site to be stunted. Similarly, Ludwig (1988) found vegetation other than A. acuta to be sparse in the low-nutrient, mineral soils of the Maryland population.

A. acuta populations fluctuate widely from year to year in the number of plants. Such fluctuations are not uncommon in annual species; however, it is unknown at this time whether population fluctuations are intrinsic in the species, or if they reflect the influence of external factors limiting the overall population size and survivability of the species. Further, it is unknown what role seed dormancy may play in the life history of this species. Seed banks probably play a major role in the maintenance of populations.

Some investigation into specific habitat characteristics has been accomplished. Vegetation of the grassland communities supporting Agalinis is typically dominated by one of three grasses: little bluestem (Schizachyrium scoparium), Virginia broomgrass (Andropogon virginicus) or Indian grass (Sorghastrum nutans). Other common associates include poverty grass (Danthonia spicata), panic grasses (Panicum spp.), fescue (Festuca rubra) and winter bent grass (Agrostis stolonifera; A. spp.) (Sorrie, 1988b; Caljouw, et al., 1988).

The soils supporting Agalinis are generally nutrient-poor, acidic, and excessively drained. Few studies of soils have been done at the known A. acuta sites. Sandy, silty soils associated with the Massachusetts populations were reported to be acidic (pH 5.1), low in macronutrients and high in the trace metals aluminum, zinc and iron (DiGregorio and Wallner, 1986). The soils at the disjunct southern population in the Maryland serpentine barrens were found to be xeric and nutrient-poor, with a pH from 6 to 7 (Ludwig, 1988).

There has been no comprehensive study of the life history of this species. William Brumback studied germination of A. acuta in a controlled setting from 1983 to 1985 (Caljouw, et al., 1988). Brumback concluded that a cold period may be beneficial, although not necessary, for germination. While a number of seedlings germinated under these conditions, they were considered to be in generally poor condition. Any number of factors may have contributed to the poor condition of the plants, including the lack of a host species, as many species in the family Scrophulariaceae are root parasites, including several in the genus Agalinis (Musselman and Mann, 1977). A further investigation of the role of parasitism in the life history of A. acuta is warranted. Brumback and Susan Kelley of the New England Wild Flower Society have been contracted by the Fish and Wildlife Service to further investigate conditions and techniques required to establish and grow A. acuta in cultivation, including studies of parasitism. This study will also include an analysis of existing seed banks at at least three of the extant sites to determine seed abundance and viability. To date it has not been determined how much seed is produced, the extent of seed viability, the rate of seed germination and the percentage of seedlings that survive to flower. Conclusions may provide insight into factors that may be limiting wild populations. A final report of findings is scheduled to be completed in 1990.

The Nature Conservancy and the Massachusetts Natural Heritage and Endangered Species Program extensively studied the two Massachusetts sites in 1983 (Lundgren, 1983). That study was not intended to provide the most conclusive data on the chronology of life history events; however, the information

obtained does provide a solid base for further investigation. As part of the aforementioned study, observations on flower and fruit phenology were conducted from September 6, 1983 to September 20, 1983. Dates of peak flowering were observed during this time period (with the majority of flowers observed on the first day), as was individual plant maturity. The presence of fruit on the first day of observation indicates that some flowering had occurred before the study was initiated. Pollination did not appear to be a limiting factor in the sampled plants, as most flowers resulted in fruit. Fruit was well-developed and numerous on recorded plants. Similarly, fruit production over the entire population was equally high, although it is unknown if all seeds were viable or how much fruit is needed to sustain the population. Maturation was estimated to continue well into October. In New York maturation continues beyond early November (Zaremba, 1988b).

The Massachusetts study confirmed that individual flowers bloom for only a single day, blooming in the morning and dropping the corolla by late afternoon, as was indicated in past records. However, the time of anthesis was more difficult to determine. Researchers found the majority of fresh blossoms in the morning, although others were produced in late afternoon and before sunrise. Thus, some flowers may bloom in the evening or before dawn.

To date there has been no study of pollination in this species. However, evidence of fruit set at known sites suggests that pollination is not a limiting factor. Flower flies (Syrphidae) were observed at New York and Massachusetts populations and were collected from one Massachusetts site. Maier (1985) found the specimens to be very similar to Toxomerus marginatus;

however, the small size of the specimens precluded a positive identification. Adults of T. marginatus are thought to feed on over 200 species of plants, thus they are probably not a dependable pollinator of A. acuta (Maier, 1985). Canne-Hilliker (1989a) suggests the possibility that flowers may be self pollinated when the corolla detaches and drags the stamens over the stigma.

The mode of seed dispersal is not well understood. Herbivores may ingest and distribute seeds. Zaremba (1985) reported evidence of herbivory on almost all of the plants at a Long Island population numbering from 1000 to 2000 plants. Herbivory was also noted at the other Long Island populations and both Massachusetts sites (Zaremba, 1988a). Herbivory was not significant at the Maryland site in 1988 (Bartgis, 1988b). Canne-Hilliker (1989a) suggests that seed dispersal may occur when wind causes oscillation of capsules on their slender pedicels and branches.

Evidence of disturbance at all extant sites has led some experts to believe that habitat disturbance, whether through fire, grazing, soil scarification or other disturbance, may play a key role in the species life history. Potential disturbances at sites of known populations include the following:

- mowing;
- soil scarification;
- herbicide or pesticide use;
- trampling from human and nonhuman activities;
- dumping;
- salt spray associated with road maintenance and oceanic storms;

- o small confined or possible sporadic fires;
- o off-road vehicle use;
- o disking; and,
- o herbivory.

Threats and Limiting Factors

The most significant threat to A. acuta is the direct loss or degradation of its habitat. Residential, commercial and recreational development has encroached on the species community. Shopping malls, condominiums and expanding highway systems have taken the place of much of the species natural habitat. Agricultural development and sand and gravel mining have destroyed large amounts of potential habitat.

A. acuta appears to require some form of habitat disturbance to maintain conditions conducive to its survival. At this time, the type, regularity and amount of disturbance favorable to the species is not clearly understood. Over the past century, disturbances have changed along with changing land-use patterns. For example, grazing, tilling, and other practices associated with agriculture have been replaced by off-road vehicles, herbicides and pesticides, mowing, mechanical scarification of the soil, and industrial expansion common to the modern world. The practices of grazing and burning were important factors in maintaining the sandplain ecosystem, particularly in those areas essential to the existence of A. acuta. The suppression of fires has led to the encroachment of woody vegetation into the grasslands once

populated by A. acuta.

Grazing by rabbits or deer has occurred at the Massachusetts and the Long Island populations. No significant herbivory was noted at the Maryland site (Bartgis, 1988b). At this time it has not been determined whether this poses a threat to the plant since animals may serve as dispersal agents for seed, or graze and trample competing vegetation.

Due to the relatively small population size of extant occurrences, it is likely that other factors may have the potential to affect the species. Natural disasters, reproductive failures and other influences on growth, reproduction and distribution have the potential to eliminate a site, if the effects are dramatic enough to prevent the plants from fully recovering.

Although historic collections are known from many sites, scientific collecting does not appear to be a major threat facing A. acuta today. Recent publicity of several Long Island sites, however, could lead to exploitation by observers in the future. All available efforts to retain the confidentiality of known occurrences should be stressed to control collecting and trampling by interested people.

Some protection through federal and State legislation is provided to the species. All States with current and historical populations have cooperative plant agreements with the Fish and Wildlife Service as specified under section 6(c)(2) of the Endangered Species Act. The State of Maryland has listed A. acuta as an endangered species, prohibiting taking without landowner consent

and trade in the species. Massachusetts lists the plant as endangered, but the listing only serves to recognize the plants rarity; it does not provide any legal protection. New York includes this species on a State list of endangered plants. This listing carries a fine for taking the plant without landowner consent. Rhode Island law prohibits collection of the species for sale. None of the existing plant lists protect plants from habitat modifications which pose the most serious threat.

Conservation Measures

The Nature Conservancy and State Natural Heritage and Endangered Species Programs have been active in monitoring extant populations of A. acuta, locating new populations, arranging management agreements with landowners, and initiating preliminary life history studies. The Nature Conservancy is also involved in efforts to acquire Agalinis habitats, thereby protecting them from habitat destruction.

Conservation activities accomplished to date for A. acuta are summarized below:

- Population monitoring has been carried out by The Nature Conservancy and State Natural Heritage Programs.

- Surveys for additional sites were made in each State where A. acuta occurs. A new population was located in Rhode Island in 1988 as a result of intense survey. Further surveys should be focused in

States with the largest numbers of historical sites and occurrence of potentially suitable habitat.

- The Nature Conservancy has been successful in contacting landowners of Massachusetts, Rhode Island and several of the New York populations and encouraging them to assist in the protection of the sites. In addition, the Fish and Wildlife Service has made initial contact with landowners of New York sites to solicit assistance in protecting those sites. Registry agreements with The Nature Conservancy have been arranged for all three of the cemetery populations in Massachusetts and Rhode Island which stipulate that mowing be done at certain times of the year to promote the flowering and fruiting stages of the plant. The Long Island Railroad has been contacted regarding the population that occurs on its property. The Railroad has agreed to work cooperatively with The Nature Conservancy and the Fish and Wildlife Service to protect this site. Other agreements have been arranged with some landowners in New York to prevent deleterious disturbances to the populations. The Nature Conservancy is continuing to arrange similar agreements on other New York sites.

- Germination of A. acuta has been studied in a controlled setting by William Brumback of the New England Wild Flower Society. Brumback and Susan Kelley have been contracted by the Fish and Wildlife Service to further investigate the conditions and techniques needed to germinate, establish and grow seed to set in cultivation. The

existing seed bank of at least three sites will also be investigated to determine the relative abundance and viability of the seeds. Any seed beyond that needed for the study will be stored at the Center for Plant Conservation, Fort Collins, Colorado. A progress report is due in December 1989, and a final report in December 1990.

- The Nature Conservancy and the Massachusetts Natural Heritage and Endangered Species Program extensively monitored the two Massachusetts populations in 1983 to gain baseline data on the life history of the species.

- The Maryland Natural Heritage Program has an on-going research program to study the vegetation of serpentine barrens. In 1989, a management program will be initiated on a barren to investigate techniques for slowing or reversing successional trends. This information will be of value in determining future management plans at the A. acuta site.

- The Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program and The Nature Conservancy in New York and Massachusetts initiated a study of habitat disturbance in 1988. In the opinion of some persons knowledgeable in the species, habitat disturbance may play a key role in the existence of the species and therefore an understanding of this factor is needed to accomplish recovery objectives. At this point, the nature and timing of disturbance needed by the species is

unknown. To further their investigation, the Eastern Region of The Nature Conservancy was contracted in 1988 by the Fish and Wildlife Service to begin a two-year study of the effects of habitat manipulation, including studies on mowing and manual soil scarification in relation to the establishment and maintenance of wild populations.

PART II

RECOVERY

It is anticipated that recovery efforts for this species will be most efficiently and effectively accomplished through an integrated strategy of protection, research and management. Protection efforts should focus on landowner cooperation and commitment to ensure avoidance or minimization of adverse impacts to known populations from existing and potential threats. Research should consist of conscientiously implemented monitoring plans and cautiously designed and carefully monitored experiments in management of known populations and cultivated plants. Documentation of results of these research efforts will contribute to a better understanding of the species biology and enable the formulation of management and protection plans to maintain populations throughout the species range.

Primary Objective

The Fish and Wildlife Service will consider reclassifying A. acuta from an endangered to a threatened species when all of the following conditions have been met:

1. There are 20 stable, wild populations located throughout the species historic range to ensure against any unpredictable events that could lead to reproductive failure and subsequent population decline. In order to be deemed "stable," a population must maintain a 5-year running geometric average population size of at

least 100 individuals.[1] The geometric average is considered a better indicator of the stability of a population that exhibits wide year-to-year size fluctuations than is the arithmetic average.

2. At least 15 of these populations are located on protected sites. Protection may be accomplished through: 1) ownership by government agency or a private organization that considers maintenance of the A. acuta population to be the predominating management objective for the site; or, 2) a deeded easement or covenant that effectively commits present and future landowners to implementing any management activities needed to perpetuate the population. This high level of landowner commitment to site protection is necessary because of the species apparent need for active habitat manipulation to counteract the effects of removing natural sources of disturbance from the plants environment.

3. There must be a proven technology for: 1) propagating the species in a cultivated setting; or, 2) storing seed in a seed bank and successfully sowing them on a wild site.

Attainment of these conditions of the primary objective would remove A. acuta from the danger of extinction. While full recovery and delisting of this species is ultimately the long-term goal, the conditions that must be met

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[1] The five-year geometric average is the fifth root of the product of the population sizes in each of the five years. In the event that the population declines to zero in any given year, one will be added to each value in the computation.

prior to consideration of this action cannot be specified until a better understanding of the species is achieved. Three years from the date of this plan, at funding levels indicated and with completion of tasks outlined, a recovery completion date will be projected. The estimated agency cost to implement FY1, FY2 and FY3 tasks (excluding those for which implementation will be deferred pending necessity) is $35,750.00.

Stepdown Outline

1.0 Protect known populations.

1.1 Seek cooperation and active support of landowners in protection of known sites.

1.2 Monitor existing and potential threats to known sites.

1.3 Develop site-specific land protection strategies for each known site.

1.4 Hand-sow seeds on sites which experience a critical decline in seed production.

2.0 Investigate species and habitat characteristics necessary to maintain and establish populations throughout the range of the species.

2.1 Describe life history of A. acuta, including potential limiting factors in different portions of the species range.

2.11 Monitor populations.

2.12 Determine effects of habitat disturbance on population biology.

2.13 Investigate the existing seed bank and seed viability at known

sites.

2.14 Conduct carefully designed experiments to augment poorly reproducing populations by sowing seeds.

2.15 Determine whether the species is parasitic or hemiparasitic and identify host(s).

2.16 Identify pollinators and time of pollination.

2.17 Determine the role of herbivory in the species population biology.

2.18 Determine micro-habitat requirements for reproduction, germination and growth of the species.

2.19 Determine community preferences.

2.2 Estimate the minimum viable population size and number necessary to insure the species continued existence.

2.3 Carry out morphological analysis to establish taxonomic distinctness.

3.0 Formulate and implement measures to maintain existing sites and locate, establish and maintain new sites.

3.1 Develop and implement management plans to preserve natural disturbances and maintain other management schemes that play a role in the reproduction, growth and survival of the species.

3.2 Locate, establish and maintain new populations.

3.21 Search for additional populations.

3.22 Establish new populations in suitable habitat within species historic range.

3.23 Protect and maintain newly located or established populations.

4.0 Develop technology for cultivating plants and provide for long-term seed storage.

4.1 Determine conditions and techniques required to germinate, establish and grow A. acuta to seed set in cultivation.

4.2 Test and refine techniques to establish and grow cultivated plants in natural habitats in the wild.

4.3 Provide seed for research into life history, habitat disturbance, augmentation of wild populations and/or establishment of new populations.

4.4 Produce or obtain seed representative of various ecotypes and from a variety of sites within the species range for long-term storage.

5.0 Periodically review progress towards species recovery and modify elements as appropriate.

Narrative

1.0 Protect known populations. Continued survival of this species is dependent upon protection of extant sites from adverse effects resulting from development or other deleterious disturbances.

1.1 Seek cooperation and active support of landowners in protection of known sites. Landowner cooperation and support is particularly important in protection efforts for this species, as the majority of extant sites are in at least partial private ownership. Cooperation is necessary in order to prevent land use changes in existing disturbance regimes and allow habitat manipulation or other management activities if necessary.

1.2 Monitor existing and potential threats to known sites. Development and other disturbances have destroyed or severely degraded much of the suitable habitat for the species. Known sites should be closely monitored to document existing and potential threats, such as changes in land use, dumping, uncontrolled off-road vehicle traffic, uncontrolled use of herbicides and other disturbances that could eradicate or damage existing plant communities. Herbivory by deer or rabbits may also be a threat to some populations.

1.3 Develop site-specific land protection strategies for each known site. Plans outlining protection strategies for each site should be developed to ensure that populations receive adequate protection.

Possible strategies include land or easement acquisitions, land use constraints, development of buffer zones, etc. Strategies will be formulated based on information gained from ongoing monitoring, research and management activities.

The federal agency that owns the property on which one of the Long Island sites is located has been informed that the Endangered Species Act requires: 1) that they carry out programs for the conservation of threatened and endangered species; and 2) the agency must ensure that all activities undertaken, funded or carried out by the agency will not jeopardize the continued existence of the species, and that if such an activity may affect the species, consultation will be required with the Service.

The Fish and Wildlife Service has requested the development of a protection plan for this site to be undertaken cooperatively with the agency.

1.4 Hand-sow seeds on sites which experience a critical decline in seed production. Hand sowing of seed may be useful as a means to increase the population size of certain existing or newly established populations that are experiencing a critical decline in seed production; however, it should only be considered after other methods have been investigated and with attention toward minimizing potential risks to the existing population.

2.0 Investigate species and habitat characteristics necessary to maintain and establish populations throughout the range of the species. Studies of life history, minimum viable population size and morphology will lead to a better understanding of the requirements for perpetuation, propagation and protection of the species and enable maintenance and establishment of populations throughout the species range.

2.1 Describe life history of A. acuta, including potential limiting factors in different portions of the species range. Accomplishing this task is likely to involve a combination of: 1) observations made in the course of monitoring known populations; 2) specific experiments designed to investigate life history; and, 3) documentation of efforts to propagate plants in cultivation. A comparative study with a closely related species may reveal unique habitat or species attributes which are contributing to the species existence.

2.11 Monitor populations. All known sites should be monitored at least annually. Observations should include population size, seed production, fruit set, spatial distribution and other factors relating to the development of the plants or environmental influences that may contribute to an understanding of that population or the species in general in order to provide insight to ensuring the continued existence of the species. This task is closely tied to task 1.2 (monitoring threats) and will likely be accomplished concurrently.

2.12 Determine effects of habitat disturbance on population biology. Available information suggests that habitat disturbance may play a critical role in this species existence (Whether or not disturbance is a factor in maintenance of the Maryland serpentine barrens site is subject to question and should be investigated). Disturbances that may play a role in establishment and maintenance of populations include mowing, grazing, fire, herbicides and pesticides, salt spray, soil scarification, and trampling by wild and domestic animals and humans. The type, quantity and timing of disturbances beneficial to the plants must be ascertained.

A study to determine effects of disturbance (primarily soil scarification and mowing) has been initiated by the Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program and The Nature Conservancy in Massachusetts and New York. This effort has been supported by a recent funding from the Fish and Wildlife Service. Availability of seed from cultivated plants will facilitate expanded experimentation (under controlled conditions) to accomplish this task.

2.13 Investigate the existing seed bank and seed viability at known sites. Current information suggests that plants on the known sites produce seed. However, it is unclear how much seed is produced, whether the number of seeds produced per site varies

from year to year, the extent of seed viability, what the rate of seed germination is and what percentage of those seedlings survive to flower. It is unknown whether viable, ungerminated seed is present in the soil of any of the known sites. An investigation of soil seed banks at at least three sites will be accomplished by the New England Wild Flower Society under contract with the Fish and Wildlife Service. Any seed beyond that needed for the study will be stored at the Center for Plant Conservation, Fort Collins, Colorado.

2.14 Conduct carefully designed experiments to augment poorly reproducing populations by sowing seeds. Augmentation of poorly reproducing sites may involve redistributing seed produced on the same site if the plants are producing adequate seed and lack of seed transport is preventing population growth. An alternative seed source includes cultivated plants derived from the same site. Carefully designed experiments to sow seed (with attention to minimizing potential risk to existing populations) may contribute information on the species biology and also stem declines in those populations.

2.15 Determine whether the species is parasitic or hemiparasitic and identify host(s). Many species in the genus Agalinis are parasitic. Lack of a host species may have contributed to the poor condition of plants grown by William Brumback in 1983-1985. An investigation into the role of potential host

species will be pursued in the course of further greenhouse work to be done by Brumback and Susan Kelley of the New England Wild Flower Society in 1988-1990. This information is important in cultivating this species and the ability to cultivate the plants will be useful in other aspects of the recovery effort.

Canne-Hilliker (1989a) has reported what appear to be haustoria on the roots of A. acuta from Maryland and on some herbarium specimens; however, anatomical confirmation that these root swellings are haustoria is lacking.

2.16 Identify pollinators and time of pollination. Studies should determine the mode of pollination and dispersal. It is unknown whether lack of pollination is limiting reproduction of this species. Evidence of fruit set suggests that pollination may not be a limiting factor.

2.17 Determine the role of herbivory in the species population biology. Sites in New York and Massachusetts show evidence of herbivory, however; research is lacking to determine whether this is beneficial or deleterious.

2.18 Determine micro-habitat requirements for reproduction, germination and growth of the species. If, after other priority tasks are implemented, there still appear to be

unknown factors that are significantly threatening the continued survival of this species, it will be necessary to investigate micro-habitat requirements (e.g. soil nutrient content, depth of water table, ground level humidity) to determine if any such factors are limiting germination or development of the plants.

2.19 Determine community preferences. Studies of the plant community may reveal habitat preferences of the species. This will aid in determining potential new sites for species introduction and may provide insights into discovery of previously unknown occurrences.

2.2 Estimate the minimum viable population size and number necessary to insure the continued existence of the species. Through monitoring and research activities, information necessary to estimate minimum viable population size to ensure the continued existence of the species and to maintain its evolutionary and ecological significance will be obtained. Measurable recovery objectives may be reassessed upon evaluation of this information.

2.3 Carry out morphological analysis to establish taxonomic distinctness. A comprehensive comparison of A. acuta with other similar taxa (e.g., A. decemloba) is needed to definitively identify its distinctness as a species and to enable an assessment of the potential for hybridization of A. acuta with other Agalinis species

and take measures to avoid interbreeding.

3.0 Formulate and implement measures to maintain existing sites and locate, establish and maintain new sites. Information gained from research and carefully designed experiments in management of populations will aid in development of management plans to preserve and protect existing and established populations, enhance potential of locating new sites and provide insight in establishing new sites.

3.1 Develop and implement management plans to preserve natural disturbances and maintain other management schemes that play a role in the reproduction, growth and survival of the species. Once a better understanding of the role of disturbance and other management needs in the species life history is attained through research and investigation, it will be necessary to develop and implement plans for each site that maintain such activities. Available information indicates that disrupting natural or man-induced sources of disturbance may pose a threat to known sites. Plans which provide for proper types and timing of disturbance will be complicated by the major alterations in land use surrounding most populations and will include efforts to mitigate affects of off-site actions which impede necessary disturbance.

3.2 Locate, establish and maintain new populations. Location or establishment of additional populations is a prerequisite for reclassification of the species, as this will increase the security

of the species.

3.21 Search for additional populations. While intensive searches for A. acuta have been conducted in Massachusetts, New York and Rhode Island, it may be possible to locate additional populations in these and other States, particularly if botanists who have not been involved in previous search efforts can be recruited for this task (most searches to date have been conducted by a few individuals, who feel that they have exhausted their lists of potential sites). Search efforts should be conducted during the few weeks each year when the plants are flowering. Use of a cash reward (contingent on the locator furnishing a photo, not a specimen) may be a cost-effective way to locate new populations. Another method is to provide line drawings and descriptions to local native plant societies and garden clubs.

An extant site was located in Washington County, Rhode Island in 1988. The number of historical sites in Rhode Island (six in four counties) and occurrence of habitat similar to known sites in Massachusetts and New York indicate that it would be worthwhile to conduct further searches in Rhode Island. Similarly, searches of suitable habitat and historic locations in Connecticut should be continued.

Searches should also be focused on serpentine barrens in

northeastern Maryland and southeastern Pennsylvania.

3.22 Establish new populations in suitable habitat within species historic range. Location of currently unknown populations will afford opportunities for protection and may also increase understanding of the species habitat preferences. Efforts to establish new populations should not be initiated until there is a better understanding of the conditions required to establish and maintain this species. Sites to be considered are those: 1) within the historic range of the species; 2) with habitat characteristics similar to naturally occurring populations (known historical sites where the species is no longer found might be used); and, 3) which are protected (sites should conform with the definition of a protected site as stated in the primary objective).

3.23 Protect and maintain newly located or established populations. Protection will be achieved through measures described at task 1.0. Management strategies will be developed as research and investigations of other sites leads to effective measures.

4.0 Develop technology for cultivating plants and provide for long-term seed storage. Development of techniques needed to propagate A. acuta in a cultivated setting will resolve many questions about conditions required by the plants to germinate and grow. Cultivated plants can potentially be used in experiments to determine effects of disturbance, so as to

avoid risking wild populations. These plants can also furnish seed for various studies and other recovery activities. Long-term storage of seeds representative of various ecotypes will decrease risks that a significant portion of the species gene pool could be lost if several major populations disappear.

4.1 Determine conditions and techniques required to germinate, establish and grow A. acuta to seed set in cultivation. Accomplishment of this task is already underway via contract between the Fish and Wildlife Service and the New England Wild Flower Society.

4.2 Test and refine techniques to establish and grow cultivated plants in natural habitats in the wild. Once the conditions and techniques required to establish and grow A. acuta in a cultivated setting have been accomplished, techniques must be developed to establish and grow the species in the wild.

4.3 Provide seed for research into life history, habitat disturbance, augmentation of wild populations and/or establishment of new populations. Seed made available as a result of other tasks may be used to further research in the species biology or in augmenting certain populations. Seed sown on wild sites should derive its ancestry from that site.

4.4 Produce or obtain seed representative of various ecotypes from a

variety of sites within the species range for long-term storage. It is possible that some populations are experiencing a decrease in their genetic variability. The duration of seed viability in storage needs to be determined. Determination of the variability of genotypes within and among sites should also be incorporated into this task.

5.0 Periodically review progress towards species recovery and modify elements as appropriate. Recovery efforts are likely to result in rapid evolution of the base of information about this species. Review of new information and evaluation (and redirection, if necessary) of ongoing recovery activities will assure an efficient and effective recovery effort. Reviews of recovery progress should be conducted annually and the plan updated as necessary.

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Part III
IMPLEMENTATION SCHEDULE

Key to Implementation Schedule

General Categories for Implementation Schedule

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

General Priority Categories

Priority 1: All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: All actions that must be taken to prevent a significant decline in the species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Abbreviations used:

FWS - U.S. Fish and Wildlife Service
GSA - General Services Administration
TNC - The Nature Conservancy
States - Maryland, Massachusetts, Rhode Island and New York

IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY	FISCAL YEAR COSTS			COMMENTS
						FY1	FY2	FY3	
M3/A3/A2	Seek landowner cooperation	1.1	1	ongoing	FWS/States/TNC GSA	1000	1000	500	coordinate with GSA regarding federally-owned site
I14	Monitor threats	1.2	1	3 years	FWS/States/TNC	500	1000	1000	
M7	Develop protection strategies	1.3	1	ongoing	FWS/States/TNC GSA	1000	1000	1000	coordinate with GSA regarding federally-owned site
M1	Hand-sow seeds	1.4	1	as needed	States/TNC	---	---	---	implement only if necessary
I1	Monitor populations	2.11	1	ongoing	FWS/States/TNC	1000	1000	1000	
R3	Determine effects of habitat disturbance	2.12	1	5 years	FWS/States/TNC	2000	2000	2000	
R6	Investigate seed bank	2.13	2	2 years	FWS/TNC	750	750	---	
M1	Augment populations	2.14	3	as needed	States/TNC	---	---	---	implement only if necessary
R14	Determine role of parasitism	2.15	3	2 years	FWS/States/TNC	500	500	---	
R14	Study pollination	2.16	3	2 years	FWS/States/TNC	500	500	---	
R9	Study herbivory	2.17	3	2 years	FWS/States/TNC	200	200	---	
I3	Study micro-habitat	2.18	3	unknown	FWS/States/TNC	---	---	500	implement if necessary
I3	Determine community preference	2.19	3	unknown	FWS/States/TNC	---	---	500	implement if necessary
R6	Determine population size and number	2.2	3	ongoing	FWS/States/TNC	---	---	---	accomplished in conjunction with other tasks
R5	Taxonomic studies	2.3	3	1 year	FWS	500	---	---	
M3	Develop management plans	3.1	2	ongoing	FWS/States/TNC	1000	1000	1000	
I14	Search for new sites	3.21	3	2 years	FWS/States/TNC	1000	1000	---	
M2	Establish new sites	3.22	3	unknown	FWS/States/TNC	---	---	---	defer implementation
M3	Protect and maintain new sites	3.23	3	ongoing	FWS/States/TNC	---	---	---	defer until completion task 3.22
R7	Determine cultivation techniques	4.1	2	2 years	FWS	1750	1750	---	
R7	Determine techniques to grow in wild	4.2	2	2 years	FWS	---	---	1750	defer until complete task 4.1
M1	Provide seed	4.3	3	1 year	FWS/States	---	---	500	contingent upon seed production
M7	Seed storage	4.4	2	2 years	FWS/States	---	300	300	
I14	Review progress	5.0	2	ongoing	FWS/States/TNC	1000	1000	1000	

LIST OF REVIEWERS

A technical draft of this plan was mailed out to reviewers on November 18, 1988. Comments were received and incorporated into an agency draft which was mailed to reviewers on March 22, 1989. Public Notices were placed in local newspapers announcing the availability of the plan for public review and comment.

The Service appreciates comments received from the following persons/agencies on one or more of the draft documents. These comments are on file at the author's address.

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