SENSITIVE JOINT-VETCH
(Aeschynomene virginica)

RECOVERY PLAN

U.S Fish and Wildlife Service, Northeast Region

SENSITIVE JOINT-VETCH (*Aeschynomene virginica*)

RECOVERY PLAN

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EXECUTIVE SUMMARY for the SENSITIVE JOINT-VETCH RECOVERY PLAN

Current Status: The sensitive joint-vetch (*Aeschynomene virginica*) is known from 26 extant sites, including three in Maryland, one in New Jersey, two in North Carolina, and 20 in Virginia. The historical range for the species extended to Delaware and Pennsylvania. Although population sizes at the extant sites fluctuate considerably, there is an apparent trend for relative population size to remain stable. Almost every population of *A. virginica* is susceptible to habitat loss, modification, or degradation caused by development or water withdrawal projects. The sensitive joint-vetch was Federally listed as threatened in June 1992.

Habitat Requirements and Limiting Factors: *Aeschynomene virginica* is an annual legume native to the eastern United States. The species occurs in fresh to slightly brackish tidal river systems, within the intertidal zone where populations are flooded twice daily. Its presence in a given marsh may be a factor of suppressed competition, hydrological conditions, salinity tolerances, and/or other parameters. *A. virginica* seems to favor microhabitats where there is a reduction in competition from other plant species. It typically occurs at the outer fringe of marshes or shores; its presence in marsh interiors may be a result of local nutrient deficiencies in the saturated organic soils, ice scouring, or muskrat herbivory. The sensitive joint-vetch is found in localities where plant diversity is high and annual species are prevalent. Bare to sparsely vegetated substrates appear to be a habitat feature of critical importance for establishment and growth of this species.

Recovery Objective: To fully recover *Aeschynomene virginica*, enabling its removal from the Federal list of endangered and threatened wildlife and plants.

Recovery Criteria: Delisting will be considered when the following conditions have been met: (1) the sensitive joint-vetch and the ecosystems upon which it depends are adequately protected within the following six watersheds: Manokin Creek in Maryland; Manumuskin River in New Jersey; and Rappahannock, Pamunkey, Mattaponi, and Chickahominy Rivers in Virginia; (2) annual monitoring over a 10-year period shows that the populations in these six river systems are stable or expanding; and (3) life history and ecological requirements of the species are understood sufficiently to allow for effective protection, monitoring, and, as needed, management.

Actions Needed:

1. Maintain the integrity of the tidal wetland systems upon which the sensitive joint-vetch depends.
2. Protect extant sensitive joint-vetch populations and sites.
3. Survey for additional populations.
4. Establish monitoring priorities, develop reliable monitoring techniques, and monitor populations accordingly.
5. Determine the ecological and distributional characteristics and requirements of the sensitive joint-vetch.
6. Develop an informational brochure on the importance of the sensitive joint-vetch and the tidal wetlands upon which it depends.

Projected Costs ($000):

FY	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	NEED 6	TOTAL
FY1	22.5	10.0	–	14.0	12.0	–	58.5
FY2	22.0	7.0	23.0	10.5	6.0	8.0	76.5
FY3	15.0	17.5	18.0	10.0	8.0	–	68.5
FY4-20	172.0	99.0	18.0	147.5	17.0	6.0	459.5
Total	231.5	133.5	59.0	182.0	43.0	14.0	662.0

Time Frame: Delisting should be possible by the year 2015 contingent upon accomplishment of recovery tasks.

* * *

The following recovery plan delineates actions believed to be required to recover and/or protect the threatened sensitive joint-vetch (*Aeschynomene virginica*). Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This approved plan does not necessarily represent the views or official position of any individuals or agencies involved in its formulation, other than the U.S. Fish and Wildlife Service. The plan is subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1995. Sensitive Joint-Vetch (*Aeschynomene virginica*) Recovery Plan. Hadley, Massachusetts. 55 pp.

Additional copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
telephone 301-492-6403
or
1-800-582-3421

Cost varies according to number of pages.

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PART I: INTRODUCTION

The sensitive joint-vetch (*Aeschynomene virginica*) is an annual legume of the bean family (Fabaceae) native to the eastern United States. It occurs in fresh to slightly brackish tidal river systems in four mid-Atlantic states, where almost every population is subject to habitat loss, modification, or degradation caused by development or water withdrawal projects. *Aeschynomene virginica* was listed as threatened under provisions of the Endangered Species Act of 1973, as amended, on June 19, 1992 (U.S. Fish and Wildlife Service 1992), and was subsequently assigned a recovery priority number[1] of 2, based on (1) a high degree of threat, (2) a high potential for recovery, and (3) its taxonomic standing as a species.

This plan summarizes the relevant information currently available on *Aeschynomene virginica*, identifies threats to its survival and recovery, and specifies steps that should be taken to achieve recovery objectives. The recovery program for the sensitive joint-vetch is in its beginning phase. Initial efforts will include taking actions to offset imminent threats to the species' survival and acquiring the information needed to effectively direct future recovery activities.

DESCRIPTION AND TAXONOMY

Aeschynomene virginica is a robust annual legume that typically attains a height of 1.0-2.0 meters (m) in a single growing season, although it may grow as tall as 2.4 m. The stems are single, sometimes branching near the top, with stiff or bristly hairs. The leaves are

1 Recovery priority numbers ranging from a high of 1C to a low of 18 are determined for all species listed pursuant to the Endangered Species Act of 1973, as amended. These numbers are based on criteria defined in the Federal Register (Vol. 48, No. 184). A listed taxon with a ranking of 1C receives the highest priority for the development and implementation of recovery plans.

even-pinnate, 2.0-12.0 centimeters (cm) long, with entire, gland-dotted leaflets. Each leaf consists of 30-56 leaflets. Leaflets are 0.8-2.5 cm long and 0.2-0.4 cm wide. The leaves fold slightly when touched. Pedicles are 3.0-8.0 millimeters (mm) long, bearing toothed bractlets about 4.0 mm long and 2.0-3.0 mm wide immediately below the flowers. The yellow, irregular, legume-type flowers are 1.0-1.5 cm across, streaked with red, and grow in racemes (elongated inflorescences with stalked flowers) 2.0-6.0 cm long. The flowers have uniformly-shaped anthers. The fruit is a loment with 4-10 one-seeded segments, the lowest 5.0-7.0 mm wide, turning dark brown when ripe. Fruits are 3.0-7.0 cm long, on a stipe 10.0-25.0 mm in length, and shallowly scalloped along one side.

Aeschynomene virginica has been mistaken for other members of the genus, specifically *A. indica* and *A. rudis*. These two species, not native to the United States, have spread as far north as North Carolina in recent years, where their ranges now overlap with that of *A. virginica*. *Aeschynomene indica* is common in wet agricultural areas from North Carolina to Florida, and west to Texas and Arkansas. This misidentification has resulted in references to *A. virginica* in numerous weed science publications (e.g., Boyette *et al.* 1979, Hackett and Murray 1986), but the situation was clarified by Carulli and Fairbrothers (1988), who showed the three species to be distinguishable based on electrophoretic analysis of allozyme variation.

Previous studies had also indicated the morphological distinctiveness of *A. virginica*, and numerous other authors, including Fernald (1939), Gleason and Cronquist (1963), and Radford *et al.* (1968), have recognized the taxonomic validity of *A. virginica*. The *Vascular Flora of the Southeastern United States: Volume 3* (Isley 1990) clearly distinguished among *Aeschynomene virginica*, *A. indica*, and *A. rudis*. In her monograph of the genus, Rudd (1955) distinguished *A. virginica* from *A. indica* based on the sizes of the fruit stipes and the flowers. Ware (1991) offered the following to differentiate among these species: "The flowers, leaflets, and bractlets beneath the calyx of *Aeschynomene virginica* are all notably larger than those of *Aeschynomene indica*, and the fruiting pedicel is longer (10 to 25 mm versus 3.0 to 10 mm). One way *Aeschynomene virginica* differs from *Aeschynomene rudis* is by its wider lowermost legume segment (5.0 to 7.0 mm versus 3.0 to 5.0 mm)." In addition, *A. virginica* has longer leaves and toothed margins that can be used to separate it from *A. indica*, and it can be separated from *A. rudis* by its wider lowermost legume (J. Perry, Virginia Institute of Marine Science, pers. comm. 1995).

DISTRIBUTION AND STATUS

The sensitive joint-vetch is known from a total of 26 extant sites (as determined by State Natural Heritage Programs), including three in Maryland, one in New Jersey, two in North Carolina, and 20 in Virginia (Figure 1). Table 1 summarizes these data by state. The historical range for the species extended to New Castle County, Delaware, where it was last observed in 1899, and Delaware County, Pennsylvania, where it was last observed in 1891. Potential habitat still occurs in all three counties of Delaware, and surveys within appropriate habitat should be conducted (B. McAvoy, Delaware Natural Heritage Program, pers. comm. 1995) A state-by-state discussion follows.

MARYLAND

There are three extant *A. virginica* populations in Maryland. The largest, comprising over 1,000 individuals, is in the Princess Anne Marshes on Manokin Creek in Somerset County. This population occurs on two forks of Manokin Creek, one of which has a four-lane highway (U.S. Route 13) and a town upstream from the site. Although the main threat to this population is highway work, it is located in an agricultural area and could be affected by agricultural practices. Population counts were stable during 1991 and 1992 surveys.

Two small populations were rediscovered in 1994 in Calvert and Prince Georges counties. Historical records for the species are known from Anne Arundel, Calvert, Charles, Prince Georges, and Wicomico counties. All historical records have been recently field checked (W. Tyndall, Maryland Natural Heritage Program, pers. comm. 1994). Potential sites on the Eastern Shore of Maryland have been examined, but *A. virginica* has not been documented except at the Somerset County location. The Maryland side of the Potomac River has not been surveyed, and the potential for finding *A. virginica* there is good.

NEW JERSEY

There is one extant *A. virginica* population in New Jersey. It is located on the Manumuskin River in Cumberland County and contains thousands of plants. This site is partially located within The Nature Conservancy's Manumuskin River Preserve, and

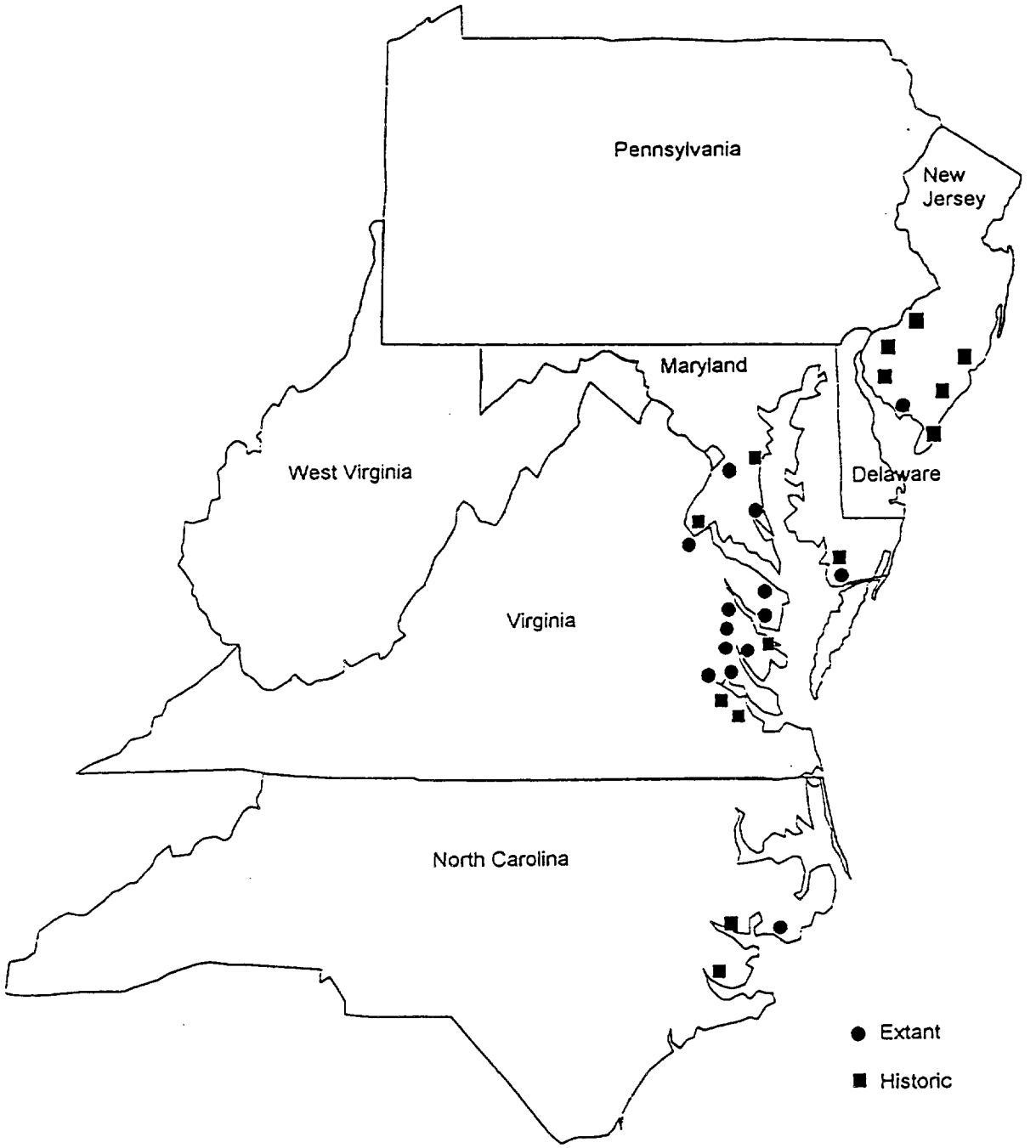

Figure 1. Distribution of *Aeschynomene virginica* in the United States as of 1994, showing counties with extant (●) versus historical only (■) occurrences. Sources: Maryland Natural Heritage Program; North Carolina Natural Heritage Program; New Jersey Natural Heritage Program; U.S. Fish and Wildlife Service, New Jersey Field Office; Virginia Department of Conservation and Recreation, Division of Natural Heritage

Table 1. Occurrence records for *Aeschynomene virginica* in Maryland, New Jersey, North Carolina, and Virginia as of 1994. Records are arranged by county (MD, NJ, NC) or watershed (VA).

STATE	EO[1] NO	COUNTY	SITE LOCATION	COMMENTS
MD	002	Anne Arundel	Unknown	Historical.
	007	Calvert	Unknown	Historical. Pre-1968: Last observation.
	006	Calvert and Prince Georges	Middle Patuxent Marshes	~~Historical. 1950: Last observation, s~~pringy marsh back of shore, along marshy tidal shore.
	011	Calvert	Graham Creek Marsh	Extant. 1904: First observation. 1994: 3 plants.
	005	Charles	Chicamuxen Creek Marsh	Historical. 1951: Last observation.
	009	Charles	Unknown	Historical. 1921: First and last observation, Chapel Point, edge of marsh.
	004	Prince Georges	Patuxent River	Historical. 1947: Last observation, in pool with *Scirpus americanus*.
	010	Prince Georges	Magruder Ferry Seep	Extant. 1949: First observation. 1994: 5 plants with flowers and leaves.
	001	Somerset	Princess Anne Marshes/Upper Manokin Section	Extant. 1941: Abundant. 1987: Subpopulation A covers 25'x15' containing 100 plants, subpopulation B covers 10'x15' with plants in flower and fruit, subpopulation C contains 100 plants. 1989: >1000 plants, flowering. 1991: 786 plants with flower/fruit estimated. 1992: 751 plants with flower/fruit.
	008	Somerset	Princess Anne Marshes/Taylor Branch	Extant. ~~1991: Approximately 1120 plants located in 5~~ distinct areas. 1992: Maximum of 1307 plants in flower in 3 distinct areas.
	003	Wicomico	Nanticoke River	Historical. Pre~~-1910: Last observation~~.
NJ	008	Atlantic	Great Egg Harbor River	Historical. ~~1937: First and last obser~~vation. 1985: Absent. 1991: Absent. 1992: Absent. Developed with homes and marina facility.
	006	Burlington	Wading River Tidal Marsh	~~Historical. 1914: First collected. 1984:~~ 12 plants during one survey; 38 plants during another survey. 1985: Absent. 1991: Absent. 1992: Absent. 1994: Absent. May have been exposed to herbicides in mid-1980s.

NJ cont.	001	Camden	Unknown	Historical. 1874: First and last observation, possibly an introduced occurrence.
	009	Cape May	Cape May City	Historical. 1892: First and last observation.
	002	Cumberland	Manumuskin River	Historical. 1973: First observation. 1974: Last observation. 1984: Absent. 1991: Absent. 1992: Absent. Site has been impacted by dredging and channeling; suitable habitat does not exist.
	003	Cumberland	Manumuskin River	Extant. Extensive occurrence along both sides of river. 1975: First observation. 1984: 2085 stems. 1992: Healthy population. Annual counts conducted by the Nature Conservancy; appears to be stable. 1994: 10,000 stems.
	004	Gloucester	Oldman's Creek	Historical. 1882: First observation. 1897: Last observation. 1991: Site not thoroughly surveyed, habitat conditions appear suitable and further surveys are recommended.
	005	Salem	Unknown	Historical. 1881: First observation. 1881: Last observation. 1992: Absent, but much suitable habitat remains to be searched in this part of the County.
	007	Salem	Unknown	Historical. 1934: First and last observation. 1992: Absent, but likely extant as much suitable habitat still occurs.
NC	002	Beaufort	Near Washington	Historical. 1985: Several thousand plants estimated. 1986: 400-500 plants.
	008	Beaufort	South of Washington	Historical. 1957: Last observation, site is a marshy thicket. 1985: Absent. Extirpated?
	009	Craven	Trent River	Historical. 1949: Last observation. Site is a sandy road bank. 1983: Absent. 1985: Absent. Realignment of U.S. Route 70 and bypass may have destroyed this site. Extirpated?
	010	Craven	Southwest of James City	Historical. 1956: Last observation. Site is pond margins. 1985: Could not verify. Extirpated?
	001	Hyde	Lake Mattamuskeet	Extant. 1991: 3 plants in a weedy, overgrown, roadside ditch.
	003	Hyde	Avenue Farm	Historical. Roadside ditch and wet canal (site has appearance of a freshwater marsh). 1985: 60 plants on south side of road, 5 plants 0.2 miles east on north side of road. 1986: 40-50 plants. 1988: 80 plants. 1990: Absent. Appears to be extirpated.
	004	Hyde	U.S. 264/Lake Landing	Extant. 10-12 plants in a ditch. 1985: 1000s of plants in corn/soybean field. 1986: No plants. 1990: Common.
	005	Hyde	Engelhard	Historical. 1985: 4 plants in small overgrown canal. 1986: Absent. 1990: Absent. Appears to be extirpated.

NC cont.	006	Hyde	State Route 1311	Historical. 1985: 4 plants in roadside ditch. 1986: Absent. 1990: Absent. Appears to be extirpated.
	007	Hyde	Fairfield	Historical. 1985: 4 plants in overgrown ditch. 1986: Absent. 1990: Absent. Appears to be extirpated.
	011	Hyde	West of New Holland	Historical. Last observed in 1958: Last observation. Site is a waste place. 1985: Could not verify. Extirpated?
	012	Hyde	U.S. 264	Historical. 1986: 40 plants in fruit in roadside ditch.
	013	"Lenoir?"	Unknown	Historical. Pre-1900: Last observation.
VA	016	Stafford	Brent Marsh	Extant. Potomac River Basin. 1947: Occasional. 1987: N subpopulation has 30+ plants setting fruit with some seed predation, S subpopulation has 5 plants. 1987-1994: 10-17 plants observed scattered throughout area.
	017	Stafford	Unknown	Historical. Potomac River Basin. 1939: Last observed.
	009	Essex	Piscataway Creek	Extant. Rappahannock River Basin. 1984: 11 plants.
	010	Essex	Beverly Marsh	Extant. Rappahannock River Basin. 1984: 3 subpopulations totaling 58 plants.
	011	Essex	Occupacia Marshes	Extant. Rappahannock River Basin. 1984: 300 plants. 1986: Plants in all stages of fruiting and flowering, seeds being eaten by insect larvae. 1993: 200+ plants noted from one large subpopulation of several documented at this site.
	028	Essex	Occupacia Marshes	Extant. Rappahannock River Basin. 1984: Small colony.
	034	Essex	Mount Landing Creek	Extant. Rappahannock River Basin. 1987: Several excellent occurrences in a pristine tidal creek system.
	012	Richmond	Jones Landing	Extant. Rappahannock River Basin. 1984: 3 plants.
	027	Richmond	Fones Cliffs/ Brockenbrough Creek	Extant. Rappahannock River Basin. 1989: Approximately 20 mature plants with fruits and flowers over 100 square feet.
	021	Westmoreland	Drakes Marsh	Extant. Rappahannock River Basin. 1987: 11-50 plants over 300 square meters, entire population cropped by muskrats. 1993: 7 plants, seed predation by corn earworm.

VA cont.	022	King and Queen	Melrose Landing	Extant. Mattaponi River Basin. 1987: 1-10 mature ramets all in flower and mature fruit over 1-5 square yards. 1987-88: Small population. 1988: 3 plants. 1992: 2 plants in fruit and flower; 50 plants downstream. 1993: 16 plants; 82 plants (within 20'x100' area) downstream. 1994: Absent at site; 30 plants downstream.
	025	King and Queen	Garnetts Creek	Extant. Mattaponi River Basin. 1987: 11-50 plants over 500 square meters, 100% mature, feeble vigor. 1990: 27-100 plants within 50 meter section, entire population area not surveyed. 1992: 75 plants. 1993: 49 plants in a 15'x100' area. 1994: 88 plants.
	003	King William	Horse Landing	Historical. Mattaponi River Basin. 1939: Last observed. 1987: Absent.
	008	King William	Sandy Point/Gum Marsh	Extant. Mattaponi River Basin. 1984: Approximately 200 plants. 1987: 101-1000 plants over 100 square yards-2 acres, flowers and mature fruit, exceptionally vigorous. 1993: 362 plants, some of extreme robust size, heavy predation of seed by tobacco budworm. 1994: 134 plants.
	024	King William	Gleason Marsh	Extant. Mattaponi River Basin. 1987: 11-50 individuals over 10-100 square yards, 90% in flower, 100% in fruit, some insect leaf damage. 1994: 14 plants.
	026	King William	Wakema	Extant. Mattaponi River Basin. 1987: 1-10 plants in flower and fruit over 10-100 square yards, 100% mature and vigorous, insect damage to leaves. 1992: Absent.
	015	King William	Clayborne Creek Marsh	Extant. Pamunkey River Basin. 1986: 2 subpopulations, 9 plants and 13 plants, seed being eaten (most likely by insect larvae). 1987: 11-50 plants, mature, in fruit.
	023	King William	Sweet Hall Marsh	Extant. Pamunkey River Basin. 1987: 11-50 individuals all with flowers and fruit. 1994: Absent despite monthly searches during the growing season, probably extirpated due to road work (J. Perry, Virginia Institute of Marine Science, pers. comm. 1995).
	001	New Kent	Holts Creek Marsh/ Cumberland Marsh	Extant. Pamunkey River Basin. 1986: 210 genets, flowering and fruiting plants, mostly 1 colony but with several small outlying populations. 1987: Not found in 2 trips. 1991: 2 subpopulations, about 500 plants at one site (0.25 acres) and 8 plants at another site, need additional surveys.
	005	New Kent	Holts Creek Marsh/ Cumberland Marsh	Extant. Pamunkey River Basin. Owned by The Nature Conservancy. 1983: In fruit. 1990: Phenomenal population with 1043 individuals within 10 acres, 8 subpopulations. 1994: >700 plants.
	013	New Kent	Holts Creek Marsh/ Cumberland Marsh	Extant. Pamunkey River Basin. 1984: 6 plants. 1990: 5 plants; detailed count not made.

VA cont.	014	Charles City	Old Neck Creek	Extant. Chickahominy River Basin. 1991: 2 subpopulations observed, 40 plants and 7 plants, in flower. 1993: 26 plants, some in flower.
	019	Charles City	Unknown	Historical. Chickahominy River Basin. 1939: Last observation.
	033	Charles City	Unknown	Historical. Chickahominy River Basin. 1938: Last observation.
	006	James City	Yarmouth Creek	Extant. Chickahominy River Basin. 1984: About 49 plants, 1 more plant about ½ mile away. 1991: Sought intensively and not found.
	031	New Kent	Chickahominy River Megasite	Historical. Chickahominy River Basin. 1939: Last observation.
	007	Charles City	Kittewan Creek	Extant. James River Basin. 1985: Several small subpopulations, total of 8 plants.
	029	Charles City	Willcox Wharf	Historical. James River Basin. 1936: Last observation.
	030	Charles City	Four Oaks	Historical. James River Basin. 1939: Last observation.
	002	James City	Unknown	Historical. James River Basin. 1938: Last observation. 1990: Area developed into a communal beach and campground complete with much erosion and incessant trampling, boat traffic has increased.
	018	James City	Unknown	Historical. James River Basin. 1939: Last observation. 1990: Absent.
	004	Prince George	Unknown	Historical. James River Basin. 1939: Last observation. 1981: Absent.
	032	Surry	Crouch Creek	Historical. James River Basin. 1939: Last observation.
	020	Unknown	Unknown	Historical. 1915: Last observation, *Spartina* marsh.

[1] EOs = Element occurrences (occurrences of the species as determined by the respective state natural heritage programs).

Sources of information in table: Maryland Natural Heritage Program; North Carolina Natural Heritage Program; New Jersey Natural Heritage Program; Rouse 1994 and 1995; Mark Strong, Smithsonian Institute; The Nature Conservancy; U.S. Fish and Wildlife Service, New Jersey Field Office; Virginia Department of Conservation and Recreation, Division of Natural Heritage.

represents one of the few remaining examples of pristine freshwater tidal marsh habitat in the state. The population was surveyed from 1982 through 1984 and from 1988 through 1994. These counts were conducted by The Nature Conservancy from a canoe by counting the vertical stems or stalks that could be seen (this may include counting a few large branches as well as individual plants) (E. Johnson, New Jersey Field Office of The Nature Conservancy, pers. comm. 1994). The number of stems counted has ranged from 229 in 1982 to 5,039 in 1991 (Rapp 1991); the average for nine years of count data was 1,843 stems. During a 1992 survey, no human disturbance was documented at the site, but houses and docks with boats could be seen downstream (Hill 1992). In 1993, *Phragmites australis* near the site had expanded rapidly and may become a problem. In 1994, over 10,000 vertical stems of *A. virginica* were counted at this site (E. Johnson pers. comm. 1994). This site is potentially threatened by a proposed highway (Route 55 extension) and a proposed power plant.

A total of nine element occurrence records exist for New Jersey. Historical records for *A. virginica* occur in Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, and Salem counties. Raccoon Creek in Gloucester County, the Great Egg Harbor River in Atlantic County, the Wading River in Burlington County, the Maurice River in Cumberland County, the Salem River in Salem County, Kelly Point (Delaware River)/Miles Creek in Salem County, the Mullica River in Atlantic and Burlington counties, and the Tuckahoe River in Atlantic and Cape May counties were surveyed via boat by Hill (1992) in 1992, but *A. virginica* was not found. Hill (1992) stated that all of the sites except Kelly Point/Miles Creek had some suitable habitat for *A. virginica*. The sensitive joint-vetch was last seen at the Wading River site in 1984 (approximately 50 individual plants). When this site was resurveyed in 1991, *A. virginica* was not found, and a number of residences with boat docks and boats were observed in the area. In 1992, this site appeared to have suitable habitat for *A. virginica*, although no individuals were documented (Hill 1992). The site was re-checked in 1994 and *A. virginica* was not present (A. Scherer, U.S. Fish and Wildlife Service, pers. comm. 1995). The Tuckahoe River site, which may contain *A. virginica*, was not surveyed until mid-October when the wetland vegetation had already begun to die back (Hill 1992). One historical site that was not visited during this survey was Oldman's Creek in Salem and Gloucester counties; this site should be checked for the presence of *A. virginica* (Hill 1992). Hill (1992) recommended that the Tuckahoe River, Raccoon Creek, Wading River, and tributaries to the Maurice River be resurveyed. Hill (1992) concluded that at the time of his survey, the Manumuskin River site "...is the only known population of the plant in New Jersey."

NORTH CAROLINA

As of the summer of 1990, *A. virginica* was extant in North Carolina only in two ditches connected to Lake Mattamuskeet in Hyde County. These sites in man-made habitats are very likely temporary and are not considered truly viable populations. All recent *A. virginica* records from North Carolina have been documented only in disturbed habitats such as roadside ditches and wet cornfields that are nearly tidal. It appears that *A. virginica* is exploiting moist, disturbed habitats where competing species such as smartweed and alligator-weed do not overtop the young seedlings (Leonard 1985). The plant also occurred historically in Beaufort and Craven counties, and what was identified as "Lenoir" County.

Several historical locations in North Carolina were field checked in 1985, but *A. virginica* was not found and is presumed extirpated from these sites. Collection dates for these historical records range from 1949 to 1958. Apparent causes of population loss include commercial and housing development, realignment of a highway, habitat conversion to a public beach, and competition from weedy species.

In 1985, six new occurrences of *A. virginica* were found, two in or adjacent to cornfields and the remainder in roadside ditches (Leonard 1985). These new populations were not stable: three disappeared the year following their discovery, and another population has since disappeared. It is possible that these atypical and short-lived populations resulted from an introduced seed source (A. Weakley, North Carolina Heritage Program, pers. comm. 1990); however, the seed source, if one exists, is unknown, as there are no known extant sites in North Carolina in natural habitat. Furthermore, the species is no longer present at any historical locality, and the habitat at some of these localities has been considerably altered (Leonard 1985, A. Weakley pers. comm. 1991). Intensive field work in North Carolina's estuarine freshwater tidal marshes during the 1990 field season revealed no new *A. virginica* populations (A. Weakley pers. comm. 1990). More surveys are needed in the vicinity of Lake Mattamuskeet National Wildlife Refuge and other natural habitats.

VIRGINIA

The only comprehensive survey for *A. virginica* in Virginia was conducted in 1987 (Hershner and Perry 1987). Data from this and other more limited efforts show a total of 20 extant sites in Virginia, consisting of six populations along four major river systems: (1) a population of approximately 40 individuals along the Potomac River in Stafford County; (2) an extensive population consisting of seven subpopulations along approximately 25 miles of the Rappahannock River in Essex, Richmond, and Westmoreland counties; (3) a large population consisting of five subpopulations along an approximate 15-mile stretch of the Mattaponi River, a tributary to the York River, in King and Queen and King William counties; (4) five subpopulations along a 15-mile stretch of the Pamunkey River, a tributary to the York River, in King William and New Kent counties; (5) a population of about 50 plants on the Chickahominy River, a tributary to the James River, in Charles City and James City counties; and (6) a population of approximately eight plants along the main stem of the James River in Charles City County.

The species is apparently extirpated from its type locality farther downstream on the Rappahannock River in Middlesex County. Historical records also exist for Prince George and Surry counties along the James River, where the species is in decline. The Virginia Department of Conservation and Recreation, Division of Natural Heritage data base contains seven records for the species along the James River, but only one of these records is from the last ten years, and recent attempts to relocate the species at several historical locations along the James River have been unsuccessful.

Most of these Virginia populations could be affected by proposed water withdrawal projects, filling, erosion, impoundments, commercial and residential development, as well as other anthropogenic and natural threats. Caljouw *et al.* (1995) provides a comprehensive overview of threats to each of the six population areas in Virginia. Holts Creek Marsh on the Pamunkey River in New Kent County is partially owned by The Nature Conservancy and is the only site in Virginia that receives any form of land protection.

LIFE HISTORY AND ECOLOGY

LIFE HISTORY

Aeschynomene virginica plants flower from July through September (Davison and Bruderle 1984, Wieboldt 1984) and into October in some years (Hershner and Perry 1987). In autumn, senescence may be triggered by the drop in water temperature or by salinity intrusion due to a decrease in freshwater flow, and plants typically die back by late October. Greenhouse studies have shown that bagged flowers self-pollinated at the rate of 13%, but outcrossing also occurred (Davison and Bruderle 1984). Morphological or behavioral features that would indicate asexual reproduction have not been observed (Rouse 1994, 1995). Limited pollinator observations of small bumblebees have been made (Davison and Bruderle 1984).

Fruits are produced from July through late October, concurrent with flowering (Davison and Bruderle 1984, Wieboldt 1984, Hershner and Perry 1987, Rouse 1994). Although flowering continues until late fall, production of vigorous fruits appears to decline significantly by mid-October. Seed maturation generally begins in August and continues through October (Rouse 1994). Rouse (1994, 1995) estimated an average seed output of 324 seeds/plant in 1993 and 688 seeds/plant in 1994; on the Mattaponi River in Virginia, seed output ranged from 323 to 1,383 seeds/plant in 1994 (Rouse 1995). Rouse (1994, 1995) observed that plants located at upstream sites produced significantly more seed than downstream populations, and he speculated that this could be a result of upstream sites having fresh water for a longer period. He also noted that many pods had fully disarticulated by mid-October. Fruits disseminate as individual articles and have been observed to float, but duration of floatability is not known (Davison and Bruderle 1984).

Germination has been reported by Davison and Bruderle (1984) to take place from late May to early June. They also reported that stratification improves germination slightly; in germination experiments, stratified seeds showed a high germination rate of 63% (Bruderle and Davison 1984). Further germination experiments conducted by Baskin and Baskin (1994) included exposing scarified and non-scarified seeds to light (12 hours) and dark (12 hours) under various incubation temperatures, measuring seed coat permeability after various

periods of dry storage and flooding, burying seeds at various depths, and exposing seeds to differing salinity levels. The results of these experiments are summarized below.

One-month-old scarified seeds germinated at 28-33% in both light and dark at an incubation temperature of 15° C (12 hours of light)/6° C (12 hours of dark), to high percentages in light and dark at incubation temperatures of 20°/10° C (90-97%), 25°/15° C (100%), 30°/15° C (100%), and 35°/20° C (100%). Only a few one-month-old, non-scarified seeds germinated irrespective of light and temperature conditions. After dry storage in the laboratory for approximately five months, coats of a high percentage of the seeds had become permeable to water. Thus, 70-90% of the non-scarified seeds germinated at 20°/10° C, 25°/15° C, 30°/15° C, and 35°/20° C in light and dark, and 50-60% of the seeds germinated at 15°/6° C in light and dark. Germination for five-month-old scarified seeds was 89-100% in light and 100% in darkness over the entire range of temperatures (15°/6°-35°/20° C). Only 28-33% of the one-month-old scarified seeds germinated at 15°/6° C, whereas 89-100% of the five-month-old scarified seeds did so, indicating that a high percentage of the embryos exhibit some physiological dormancy at seed maturity.

The period during which seeds of *A. virginica* are impermeable to water equals physical dormancy. During dry storage in the laboratory, the seed coat of some legumes, including the sensitive joint-vetch, becomes permeable. When submerged, a high percentage of one-month-old seeds did not imbibe water, but after five months of dry storage in the laboratory, up to 90% of the seeds imbibed water and germinated. A portion of the seed population remained impermeable for longer than 11 months in the laboratory.

Approximately two-thirds of 11-month-old non-scarified seeds imbibed water and germinated during submergence. Seeds flooded for 1, 2, 3, 5, and 7 days germinated to 62.7%, 67.3%, 68.7%, 72.7%, and 70.0%, respectively, during submergence. Only a few additional seeds had germinated five days after they were transferred to moist sand in Petri dishes. The non-flooded control seeds germinated at 71.3%. All seedlings that had been flooded (1-7 days) were more vigorous than those in the non-flooded control. Roots of the control seedlings were stunted compared to those that had been flooded. The results of the flooding experiment show that, at least in distilled water, seeds of *A. virginica* can retain their vigor during flooding for at least 7 days. Baskin and Baskin (1994) hypothesized that roots of flooded seedlings are more vigorous than those of the non-flooded controls because of the

greater dilution of a brown leachate from the seeds in the cups than the Petri dishes, and transfer of the submerged seeds/seedlings from the leachate-water solution in the cups to clean, moist sand in Petri dishes. This brown leachate probably has no effect on seedlings in nature, since it would be greatly diluted or washed away by tidal activity.

After four weeks, 93.3%, 84.0%, 56.0%, 13.3%, and 18.7% of the seeds buried at depths of 1, 2, 3, 4, and 5 cm, respectively, had emerged. Thus, most seedlings from seeds that germinate more than 3 cm below the soil surface would not be expected to emerge.

Approximately one-month-old scarified seeds germinated to 100% at sodium chloride concentrations of 0%, 0.5%, 1.0%, and 1.5%. At 1.5% sodium chloride, the radicle of the germinated seedlings were stunted and black. All seeds in the 2.0% sodium chloride solution were killed. Sensitive joint-vetch germination thus exhibited some tolerance to salinity. This tolerance is lower than that of some strict halophytes but similar to that of some semi-halophytic species (Waisel 1972).

A. virginica seedlings grow quickly, approximately doubling in size every two weeks during the first six weeks (Davison and Bruderle 1984). Plants are 15-45 cm tall by mid-summer (Wieboldt 1984) and reach nearly half their attainable height of 1-2 m by July (Rouse 1994). Rouse (1994, 1995) noted that the total number of individual plants observed at a site was lower during the late growing season when compared to early season counts; Rouse (1995) stated, "... it is estimated that, in some cases, the reduction in number was due to predation by small mammals and/or general degradation of plants associated with the end of the growing season." Self-pruning of lower branches is evident in both greenhouse and natural populations (Davison and Bruderle 1984, Rouse 1994). This is most likely a response to shading from the plant and its competitors.

POPULATION SIZE

Although this species shows considerable annual fluctuation in population numbers (for example, the extant New Jersey population varied from approximately 50 to 2,000 vertical stems over a three-year period), stands of *A. virginica* reappear for many consecutive years at isolated sites, indicating that either a significant number of the seeds lodge near their source or that seed banking is involved, or both (Davison and Bruderle 1984). This has been

observed in New Jersey (for at least nine years) and in Maryland (Davison and Bruderle 1984). During a review of previous data on numbers of plants counted at his Virginia study sites, Rouse (1994, 1995) concluded that although populations do fluctuate, there is an apparent trend for large populations to remain large and small populations to remain small.

HABITAT CONDITIONS

General:

The largest and most viable populations of *Aeschynomene virginica* typically occur in the estuarine meander zone of tidal rivers where sediments transported from upriver settle out and extensive marshes form. The substrate may be sandy, muddy, peaty, or gravelly (Fernald 1950, Porter 1979, Ferren and Schuyler 1980, Wieboldt 1984, Rawinski and Cassin 1986, Hershner and Perry 1987). The sensitive joint-vetch is generally found on substrates that are sparsely vegetated due to natural disturbances such as storms, ice scour, accreting sediments, or muskrat (*Ondatra zibethica*) "eat outs," where muskrats remove all of the vegetation within a small area of a marsh, disrupting the vegetation cover. Local nutrient deficiencies in the saturated organic sediments of some interior marshes may also maintain such sparsely vegetated substrates (Caljouw *et al.* 1995). All these processes help retain microhabitat conditions favorable for germination and establishment of *A. virginica*. As long as such conditions persist, the species appears to be self-sustaining.

Habitat zones:

The presence of *A. virginica* in the intertidal zone, where populations are flooded twice daily, may be attributed to suppression of competition, specific hydrological requirements, or possibly lower salinity levels. Rouse (1994) found that on the Rappahannock and Mattaponi rivers in Virginia, *A. virginica* occurs at the outer fringe of marshes or shores at an elevation near the upper limit of tidal fluctuation. Hershner and Perry (1987) had previously observed that, in Virginia, the sensitive joint-vetch occurred in the levee marsh zone with the exception of the Sweet Hall population on the Pamunkey River, which was located on the marsh edge of a man-made causeway. Along the Potomac River in Virginia, the sensitive joint-vetch is found on the upper peaty or sandy substrate of tidal marsh within the intertidal zone that "is saturated but not submerged at high tide and is characterized by

sand and peat deposited after high tides and storms" (Strong and Kelloff 1994). In New Jersey it usually grows within two m of the low-water mark on raised banks.

The sensitive joint-vetch is also found in marsh interiors. In Maryland, 80% of the plants are found in the marsh interior, and the sensitive joint-vetch has also been documented in the marsh interior at sites in Virginia (J. Perry pers. comm. 1994). T. Rawinski (Virginia Division of Natural Heritage, pers. comm. 1994) indicated that, "Of the several subpopulations of sensitive joint-vetch at Lilly Point Marsh, Virginia, at least two occur away from creek banks in the marsh interior. One of these, consistently encompassing about 600 plants, occurs with another legume, the perennial wild bean (*Strophostyles umbellata*). At Lilly Point Marsh, the perennial wild bean usually occurs along the landward edge of fresh tidal marshes, and one can surmise that the micro-environmental conditions which promote the wild bean may also be responsible for promoting growth of sensitive joint-vetch. Although tidal fresh marshes tend to be eutrophic systems, these nitrogen-fixing legumes may be at a competitive advantage at sites where conditions are more acidic and nitrogen less available to competitors. At the other interior marsh subpopulation of sensitive joint-vetch, the stature and density of wild rice (*Zizania aquatica*) is much reduced from that typically present closer to the, presumably more enriched, water's edge, further suggesting local nutrient deficiencies in the saturated organic sediments."

Substrate conditions:

Bare to sparsely vegetated substrates appear to be a critical habitat feature for *A. virginica*. As an annual, it requires such microhabitats for establishment and growth. These microhabitats may include accreting point bars that have not yet been colonized by perennial species, low swales within extensive marshes, areas of nutrient deficiencies in saturated organic sediments, or areas of muskrat herbivory. Establishment of seedlings may be restricted by deposition of flotsam on the river bank and dense stands of perennial species such as *Peltandra virginica* and *Pontederia cordata* (Davison and Bruderle 1984). Wieboldt (1984) found that shores where erosion was occurring appeared to offer sites for the establishment of the sensitive joint-vetch. In North Carolina, *A. virginica* appears to be a species that remains at a particular site for a relatively short period of time, and maintains itself by colonizing new, recently disturbed habitats where it may compete successfully

among other early-successional species (Virginia Department of Conservation and Recreation, Division of Natural Heritage 1986).

Soils:

In New Jersey, *A. virginica* occurs on peat in high marsh zones (Ferren and Schuyler 1980). In North Carolina, sensitive joint-vetch sites are disturbed, weedy habitats in low coastal ditches and corn fields adjacent to wetlands (Rawinski and Cassin 1986). In Virginia, the soils at sensitive joint-vetch sites are peaty muck from 10 to 20 inches deep, with sandy to silty clays below (Rouse 1994), although one site on the Mattaponi River occurs on stratified sands and loamy sands with a thin organic layer buried at approximately 18 inches below the surface (Rouse 1994). Testing of soil samples at *A. virginica* sites revealed generally medium to low concentrations of nutrients relative to recommended levels for agricultural applications; however, magnesium concentrations were high at five of the six study sites, which may be an indirect result of application of dolomitic limestone to nearby agricultural fields (Rouse 1994).

Salinity tolerance:

Preliminary data gathered by Rouse (1994) from two rivers in Virginia showed that soluble salt concentrations for soils on *A. virginica* sites ranged from 0.23 to 2.496 parts per thousand (ppt), with higher concentrations at downstream sites than upstream sites. Sites downstream of known sensitive joint-vetch populations had concentrations greater than 2.5 ppt. Data collected by Rouse (1994) indicated that pore water (water collected from auger holes) salinity levels more closely approximate the conditions of the root environment, which is better buffered from tidal changes and weather events. Pore water salinities at *A. virginica* sites in October 1993 ranged from 0.1 to 1.4 ppt, while pore water salinities at two sites downstream of *A. virginica* were in excess of 1.5 ppt. Pore water salinity at sensitive joint-vetch sites on the Mattaponi River in September 1994 ranged from 0.2 to 0.7 ppt (Rouse 1995).

Strong and Kelloff (1994) found that species known to occur in low salinity habitats (0.2-0.5 ppt) do not occur in marshes with *A. virginica* on the Potomac River in Virginia, but are found about 30 miles upstream. Some species documented from higher salinity habitats

(6-14 ppt) were found in the same marsh as the sensitive joint-vetch (Strong and Kelloff 1994). Further analysis, across the entire range of the species, of salinity concentrations within and beyond *A. virginica* sites and during other times of the year is needed to accurately determine the salinity tolerance of this species.

Parameters affecting water salinity include time of year, rainfall, stage of tidal cycle, depth within water column, and relative geographic position within a given drainage (Rouse 1994). In two Virginia rivers, salinity increased over the summer and was highest during October 1993 (measurements were taken July through October) (Rouse 1994). In 1994, salinities again increased throughout the summer and were usually highest in September (measurements made from July through September) (Rouse 1995). The Virginia Department of Environmental Quality (VDEQ) collects salinity data from various sites in Virginia. Those sites located near *A. virginica* populations have approximately 10 years of data that indicate much variability between years and over successive months within a given year for salinity within 1 m of the surface. Using these data, Rouse (1994) calculated a mean salinity for each month of the year, showing that salinity is lowest in March and April and highest in October. One VDEQ monitoring station near the most downstream known population of *A. virginica* on the Rappahannock River system showed that this site had a salinity range of 0.4 ppt in April to 4.2 ppt in October. J. Perry (pers. comm. 1994) has found 0.5 ppt salinity in surface water at *A. virginica* sites in Virginia. Salinity at the New Jersey site ranges from 0.7 to 0.8 ppt, although measurements vary with tidal cycles and river discharges. The extant Maryland site is fairly saline and should be monitored to determine salinity range. Because salinity changes annually and seasonally, the only way to precisely determine salinity tolerance is in controlled greenhouse experiments. As discussed under the *Life History* section, preliminary laboratory experiments conducted Baskin and Baskin (1994) indicated that germination in the sensitive joint-vetch occurs within certain salinity tolerances, similar to that of some semi-halophytic species.

Water temperature:

Rouse (1994) found that surface water temperatures in 1993 ranged from 25.5-32.0° C between early July and mid-September on the Mattaponi and Rappahannock Rivers in Virginia. From mid-September to early October, surface water temperatures dropped to 16-19° C (Rouse 1994). In 1994, surface water temperatures ranged from 23-30.5° C between

early July and late September on the Mattaponi (Rouse 1995). Pore water temperature was generally two to three degrees cooler than surface water measurements (Rouse 1995). The partial senescence of a majority of the plants at these sites appears to have occurred during this time; however, *A. virginica* sites farther upstream appear to persist longer than downstream sites. It is possible that increasing salinity may also be an important factor in whether or not plants persist late in the growing season. Pore water temperatures were generally within one to three degrees of surface water measurements (Rouse 1994, 1995).

Associated species:

Microhabitat for *A. virginica* typically includes a high percentage of annual species that die back – and thus may provide germination sites (Davison and Bruderle 1984) – and high plant diversity (typically 50 species per acre). Strong and Kelloff (1994) reported *A. virginica* occurring in a marsh that supports 121 taxa. Associated species frequently include: *Z. aquatica, P. virginica, P. cordata, Bidens laevis, Polygonum arifolium, Polygonum sagittatum, Leersia oryzoides,* and *Aster novae-belgii* (Davison and Bruderle 1984, Hershner and Perry 1987). Vegetation at the extant New Jersey site was observed to be diverse and included *P. arifolium, Z. aquatica, P. punctatum, B. laevis, P. virginica, Typha* species, *Sagittaria latifolia, Rosa palustris,* and *Hibiscus palustris* (Hill 1992). In Maryland, the three species typically found with the sensitive joint-vetch are *Z. aquatica, Echinochloa* species, and *Kosteletzkya virginica.* At one of the recently rediscovered Maryland sites, plant associates include: *Spartina cynosuroides, Polygonum* species, *P. virginica, Juncus* species, *Scirpus pungens,* and *Hibiscus moscheutus.* Plants associated with the disturbed sites in North Carolina include *P. punctatum, Cuscuta* species, *Echinochloa crusgalli, Zea mays, Mikania scadens, Commelina diffusa, Saururus cernuus, Ludwigia* species, *Polygonum hydropiper, Sambucus canadensis, Salix caroliniana, Cicuta maculata, Onoclea sensibilis, Paspalum urvillei,* and *Alternanthera philoxeroides.*

On the Mattaponi and Rappahannock rivers in Virginia, Rouse (1994) observed that at or just downriver of *A. virginica* populations, *Pluchea purpurascens* and *S. cynosuroides* were found, although *P. purpurascens* was sporadic in occurrence. *Spartina cynosuroides* was dominant where it occurred. He hypothesized that the potential occurrence of *A. virginica* may be inversely related to the presence and abundance of *S. cynosuroides,* because *S. cynosuroides* may have a greater salinity tolerance and therefore may be a more effective

competitor as salinity increases. However, Strong and Kelloff (1994) reported *S. cynosuroides* occurring in a marsh that supports the sensitive joint-vetch on the Potomac River in Virginia. The sensitive joint-vetch is also associated with *S. cynosuroides* in Maryland.

THREATS TO THE SPECIES

ANTHROPOGENIC

Aeschynomene virginica is susceptible to population and habitat destruction or degradation from a wide variety of anthropogenic sources, including:

- sedimentation
- competition from exotic plant species
- dams
- dredging and filling activities
- boating activities
- shoreline stabilization and structural development
- road and bridge construction
- commercial and residential development
- water withdrawal projects
- changes in water quality
- agricultural practices
- introduced pest species
- mining
- timber harvest
- over-visitation to sensitive joint-vetch sites
- declines in muskrat populations
- sea level changes (possibly in conjunction with natural cycles)
- plant collection

Each of these factors is discussed below with respect to its potential effects on the survival and recovery of *A. virginica*. Consideration is also given to their cumulative or synergistic impacts.

Sipple (1990) noted that sedimentation of the Patuxent River in Maryland has allowed *P. australis* to extend its range, displacing much of the *Z. aquatica* that occurred historically along this river. Establishment of *P. australis* or other invasive species could be especially detrimental to *A. virginica*, which thrives in an environment with little competition from other

plants. Aggressive species such as *P. australis* frequently invade disturbed areas and, once established, have the potential to spread rapidly into in less disturbed habitats, thus outcompeting characteristic freshwater tidal marsh plants. The sensitive joint-vetch appears vulnerable to invasion by this aggressive grass and other alien plants, as its occurrence in a given habitat is contingent on disturbance events (regardless of whether they are natural or anthropogenic). Certain microhabitats occupied by the sensitive joint-vetch may be too harsh for invasive plant species to persist, but other microhabitats, such as open patches within marsh interiors, may be susceptible to invasion by aggressive alien plants. For example, *Murdannia keisak*, a non-native species, is prevalent in many otherwise pristine sensitive joint-vetch sites in Virginia. *Murdannia* is a low, prostrate annual recorded in the 1930s by Fernald, and although it has spread throughout some *A. virginica* sites like a carpet, its overall effects on *A. virginica* are not known.

Activities such as dam construction, dredging, filling, and shoreline stabilization result in direct habitat destruction and loss of individual plants. These activities may also alter natural river currents, channel migration, and sediment cycling, thereby preventing the development of accreting point-bar habitat for *A. virginica* and/or causing erosion of that habitat. Dam construction may alter diurnal flood regimes, create hydrologic barriers to movement, reduce freshwater input into the system, change water temperatures, and alter sediment deposition patterns (Caljouw *et al.* 1995).

Dredging may either cause direct loss of plants and their habitat or indirectly affect the plants through resuspension of sediments and/or pollutants. Dredging can result in placement of spoil material in potential habitat, invasion of exotic plants, changes in the seed bank, resuspension of contaminants, slumping or other effects on the substrate, and increased boat traffic. Motorboat traffic is detrimental to freshwater tidal systems (A. Schuyler, Academy of Natural Sciences of Philadelphia, pers. comm. 1989). In addition to direct toxic effects from fuel leaks, the wave action from boat wakes can rapidly erode the mudflats and banks where *A. virginica* grows. Along narrower river stretches, the wake from a single boat can affect both shorelines simultaneously.

Many of the marshes where *A. virginica* occurred historically have been dredged and/or filled, and the riverbanks have been bulkheaded or stabilized with riprap. This is most evident in historical locations around Philadelphia (Bruderle and Davison 1984). Shoreline

stabilization can destroy the species' habitat directly and may alter local sediment deposition patterns. In addition, shorelines cleared of vegetation during the stabilization process may become terrestrial barriers to colonization. This may be especially detrimental for those small *A. virginica* populations that are disconnected from other populations and thus genetically isolated. Construction of piers, boat ramps, duck blinds, and other shoreline structures may either cause direct destruction of *A. virginica* or its habitat or affect the plants through shading.

Activities such as road and bridge construction can result in direct habitat destruction, water pollution, channel alterations, and localized but excessive sediment loading into river habitats where *A. virginica* occurs. These altered sediment deposition patterns may affect *A. virginica* by inhibiting seed germination, smothering seedlings, and/or promoting the invasion of competing plant species. Construction of bridges and roads may also result in shading and act as barriers to movement of *A. virginica* propagules. Residential and commercial development projects can pose similar impacts.

Residential and commercial development is increasing in many parts of the range of the sensitive joint-vetch. The stretch of the Mattaponi River in Virginia along which *A. virginica* occurs is bounded by King William County to the south and King and Queen County to the north. Over the past decade, the human population of the section of King William County near the sensitive joint-vetch population increased by more than 60% (Oberg 1990), and this growth rate is projected to continue. In early 1991, a 200-acre subdivision, including a pier and boat ramp, was completed on the Mattaponi River in eastern King and Queen County. In another case, a 1,200-acre development on the Widewater Peninsula in Stafford County, Virginia, has been in the planning stages since 1987. The Widewater Peninsula, which is about three miles long and is bordered by the Potomac River and Aquia Creek, harbors Virginia's only known Potomac River occurrence of *A. virginica*. The current intended land use is relatively high intensity waterfront development. Without careful planning, such developments could affect *A. virginica* or other freshwater tidal plants.

Between 1990 and 2020, Virginia's human population within the Chesapeake Bay watershed is projected to increase by 32% (Oberg 1990), accompanied by an increased demand for potable water. Tidal freshwater river systems are one source of fresh water in close proximity to coastal communities, and have been presented as an inexpensive, readily

available alternative. The demand for potable water in southeastern Virginia has already led to the destruction of sensitive joint-vetch habitat. The Newport News Waterworks construction of Walker's Dam on the Chickahominy River eliminated tidal influence on a significant portion of that river. Two *A. virginica* populations occurred upstream of Walker's Dam prior to its construction (J. Perry pers. comm. 1994).

The effects of these proposed water withdrawal projects on *A. virginica* are likely to be detrimental and clearly need to be evaluated, both on a local and regional basis. The withdrawal of large amounts of fresh water could raise the salinity of the marsh systems occupied by this species, possibly beyond the species' tolerance limits. Certain other key plant and animal species in this community type would also succumb, with unknown impacts to the system as a whole. Salinity changes could also promote the invasion of other plant species that would readily outcompete *A. virginica*. In addition, water withdrawal projects may alter river currents and sediment deposition patterns locally in the vicinity of river intake sites.

The following water withdrawal projects in Virginia, presented by river system, have the potential to adversely affect *A. virginica* and its habitat. It should be noted that the Henrico County, City of Richmond, and Spotsylvania County projects, described below, do not involve salinity intrusion; these projects are mentioned regarding potential future cumulative impacts.

James River proposals:

- Henrico County has applied for Corps of Engineers' authorization for a water intake structure located upstream of Bosher's Dam, over 40 river miles upstream from the current known distribution of *A. virginica* on the James River. The proposed withdrawal is for up to 55 million gallons per day (mgd) by the year 2010. The project is designed to supply an adequate quantity of water, meet new water quality standards for drinking water, increase long-term reliability, serve regional water needs, and reduce costs for water treatment and distribution (County of Henrico, James River Water Supply Intake Final Environmental Impact Statement, U.S. Army Corps of Engineers, June 1995).

- The City of Richmond currently has the capacity to withdraw 96 mgd from the James River, either at Williams Island Dam or through the James River and Kanawha Canal, with plans to increase their withdrawal capacity. The City's plant is undergoing modernization, flood proofing, filter improvements, and expansion to increase the capacity to 132 mgd, which will not require Corps authorization. Future plans include expansion to 150 mgd. Richmond also diverts water from the James River to their canal system, which includes the James River and Kanawha Canal, Haxall Canal, East Canal, City Docks, and Manchester Canal. Together, the canal diversions constitute the most significant withdrawal of water from the James River. Water management of these canals is currently unregulated. Richmond is planning a multi-billion dollar canal restoration project to revitalize downtown and improve tourism. The remaining restoration work will likely require authorization from the Corps and is currently in the application stage. The City has received authorization from the Corps under Nationwide Permits 3 and 33 for a portion of the canal restoration work.

York River proposals:

- Hanover County has proposed construction of an impoundment on Crump and Pollard Creeks that will store Pamunkey River water withdrawals to provide a water supply of 15.5 mgd. As proposed, this would affect 276 acres of wetlands and 3,100 acres of forested uplands, with unquantified impacts on the Pamunkey River from salinity intrusion. In the fall of 1993, Hanover announced plans to build a side-hill reservoir to provide offstream storage of water pumped from the Pamunkey River. The reservoir and intake point would be located between State Routes 301 and 360 in the County. Despite this modification of the proposed project, salinity intrusion remains a potential concern.

- A Regional Raw Water Study Group (RRWSG) for the lower Peninsula of Virginia, which includes the cities of Newport News, Williamsburg, Poquoson, and Hampton, York County, and a portion of James City County, projects a water supply deficit of 30.2 mgd by the year 2040. Six alternatives to relieve this potential deficit (three reservoir options combined with fresh groundwater, groundwater desalination, and use restrictions) have been determined to be practicable. The RRWSG's preferred alternative is a reservoir with pumpover from the Mattaponi River, averaging 32 mgd withdrawal with peak withdrawals up to 75 mgd. Cumulative stream flow reductions for the Mattaponi may

average 6.5% yearly, with mean June flows potentially reduced as much as 12.6%. On a daily scale, during low flow events from August through October, withdrawal of 75 mgd could comprise 40% of all freshwater flow past Scotland Landing. Cumulative stream flow reductions from a Pamunkey River pumpover alternative could potentially average 10% of yearly stream flow.

Rappahannock River proposals:

- In 1995, Spotsylvania County received Corps authorization to construct a water supply reservoir on Hunting Run, a tributary to the Rapidan River as well as intake structures on the Rapidan and Rappahannock rivers. Intake pumping capacity will be 20 mgd on the Rapidan and 12 mgd on the Rappahannock. The Corps' permit conditions require Spotsylvania to adhere to river flowby requirements.

- The City of Fredericksburg has a direct intake on the Rappahannock River with a 6 mgd capacity. Although the City currently obtains its water by direct withdrawal from the Rappahannock below Interstate 95, they have investigated relocating the water intake above Interstate 95 and increasing the withdrawal to 12 mgd, which will require Corps authorization. The City of Fredericksburg has also considered working with Spotsylvania County on a regional solution for their water needs. At this time, however, Fredericksburg intends to design and construct improvements to the existing plant (T.M. Slayden, City of Fredericksburg, letter to Corps dated 1/27/95). This proposal will not entail any increased water withdrawals.

- Stafford County plans to construct a reservoir on Rocky Pen Run, a tributary of the Rappahannock River, between its confluence with the Rapidan River and the City of Fredericksburg. This proposal, which will involve withdrawing water from the Rappahannock for the reservoir, is still in the planning stage.

Water quality degradation in streams inhabited by *A. virginica* can result from uncontrolled runoff of sediments, pesticides, fertilizers, and other chemicals commonly used on golf courses, lawns, and gardens. Further, industrial plants and increased sewage effluent in an area may cause pollution or nutrient loading of local stream systems. While the direct effects of water pollution on the sensitive joint-vetch are unknown, pollution generally

appears to reduce species diversity within marshes and may promote the encroachment of aggressive, weedy species. Pollution or deposition of fine material can cause soil pores to become clogged or plugged. If soil pores are clogged, plant roots may not be able to carry out normal functions during periods when the plants are not inundated.

Aeschynomene virginica may be susceptible to the effects of various agricultural practices, including withdrawal of water for irrigation with potentially contaminated return water; pesticide, fertilizer, and herbicide runoff or drift; sedimentation; and introduction of insect pests that are influenced by crop rotation and other management practices. J. Perry (pers. comm. 1994) suggested that cattails and aggressive weedy species may be increasing in some freshwater tidal marshes where nutrient runoff from fertilizers and manure enter local streams and adequate best management practices are not in place.

In 1983, the corn earworm (*Heliocoverpa zea*) was collected from *A. virginica* plants by the Virginia Cooperative Extension Service. Rouse (1994) noted heavy predation of *A. virginica* seed pods by the corn earworm and tobacco budworm (*Heliocoverpa virescens*) in Virginia. E. Johnson (pers. comm. 1994) collected two tobacco budworm larvae feeding on the sensitive joint-vetch on the Manumuskin River in New Jersey, but the budworm is not a common species in that State. These two non-native pests were introduced to the United States centuries ago; the tobacco budworm has been present for 300 years. The corn earworm and tobacco budworm occur on a variety of host plants, and the tobacco budworm will feed on corn when tobacco is not present. In August, the corn crop is usually no longer available and the tobacco budworm looks for alternative food sources; this is the time when it is most likely to forage on *A. virginica*. Rouse (1994) observed that the caterpillars of both species chewed a hole through the face of each fruit and consumed the immature seeds. The larvae typically consumed all the seed in a pod and most of the seeds within an inflorescence before moving to a new foraging location. Rouse (1994) randomly collected 2,000 seed pods from one *A. virginica* population on the Mattaponi River and found that 43% of the fruits had been predated. Observations in North Carolina also indicated severe predation of seeds by tobacco budworms and corn earworms (Leonard 1985).

Sand and gravel mining occurs in the floodplains of the Pamunkey, Mattaponi, James, and Chickahominy Rivers in Virginia. This type of mining may cause sedimentation, destruction of habitat, and slumping or other effects on the substrate. In addition, it may alter

groundwater flows and hydrology. Clay mining, which is conducted in uplands, can result in sedimentation of fine particles that could clog soil pores. Mining may also result in an increase in pollutants and a decrease in water quality.

Although timber harvest does not appear to be a major threat to *A. virginica*, it may result in changes in water temperature, degradation of water quality, changes in plant community structure, or increased sedimentation at *A. virginica* sites.

In Maryland, the Town of Princess Anne is planning a canoeing event in observance of a "vetch day" to provide town residents and tourists with the opportunity to view *A. virginica*. While such an event would increase public awareness of endangered and threatened species, as well as tidal wetlands and their functions and importance as an ecosystem, there is cause for concern that over-visitation to a single population could result in degradation or loss of that population. Sensitivity to the need for constraint is imperative in conducting these types of activities.

Although there is debate as to whether muskrats can be trapped out of an area, declines in local muskrat populations as a result of trapping should be considered as a potential threat to *A. virginica* (J. Perry, pers. comm. 1994). If muskrat herbivory allows for colonization of a site by *A. virginica*, loss of muskrats may result in a loss of future *A. virginica* habitat. Unlike muskrats, nutria (*Myocaster coypus*) are non-native rodents that can destroy *A. virginica* habitat. While muskrats eat the vegetation at a site, nutria slough off the sides of banks and eat the exposed roots, destroying existing and potential *A. virginica* habitat. Muskrats may be more likely to decline as a result of nutria expanding their range northward, abandonment of farmland practices on adjacent uplands, and increased riverfront development.

Changing sea levels may represent a long-term influence on sensitive joint-vetch habitat quantity and quality. Rising sea levels may result in salt water intrusion; changes in the water table, diurnal tidal fluctuations, and sedimentation patterns; channel migration; and loss or movement of fresh- and brackish water marshes. The long-term viability of the sensitive joint-vetch in response to such influences will depend upon its ability to find corridors for colonization and adapt to new habitat conditions upstream of existing riverine habitats (C. Caljouw and A. Belden, Jr., Virginia Division of Natural Heritage, pers. comm. 1994).

Sensitive joint-vetch has not been a target for collectors because it grows in a specialized habitat and would not survive under normal garden conditions.

Preventing or arresting anthropogenic threats to *A. virginica* is complicated by the difficulties involved in adequately conserving its habitat (Davison and Bruderle 1984). Habitat conservation for this species can be achieved through on-site protection of marshes supporting plant populations only when coupled with protection of the natural ecological processes responsible for creating and maintaining habitat for the sensitive joint-vetch. These natural processes include, but are not limited to, diurnal tidal fluctuations, natural sediment deposition patterns and channel migration, stochastic storm events, herbivory of marsh vegetation by rodents and large mammals, and maintenance of the quality and quantity of freshwater and saltwater inputs to the marsh and riverine ecosystem. Three factors are critical to adequate habitat conservation for this species: (1) on-site protection of the marsh where the plant occurs, (2) protection of water quality and quantity, and (3) protection of an adequate upland buffer (Davison and Bruderle 1984). Because of the large number of off-site threats to the sensitive joint-vetch, it will not be possible to protect the species through land acquisition alone. *A. virginica* is probably susceptible to the cumulative effects of many large and small development-related activities that may slowly degrade the species' habitat. Many of these activities may occur a considerable distance away from a given *A. virginica* population. Because human population levels are increasing substantially throughout the species' entire range, development-related threats to the species are expected to grow.

NATURAL

Natural threats are often identified with disturbances, such as wave and ice action associated with severe storm events, competition, herbivory, channel migration, sea level rise (see previous discussion), and natural sedimentation processes. Healthy metapopulations of the sensitive joint-vetch are adapted to these stresses, and in some cases dependent upon them over time. Certain subpopulations may be locally extirpated, but others are able to establish and reproduce in newly opened habitat patches if seed viability and mobility are good and the frequency of disturbance events allows for biotic responses. Small populations are more vulnerable to these stresses than larger populations, especially if the disturbance event occurs during the growing season and plants are unable to compensate for high mortality rates within a particular year class.

Severe hurricanes along the mid-Atlantic coast have the potential to temporarily or permanently destroy *A. virginica* habitat (Rawinski and Cassin 1986).

A. virginica is found at sites that generally have little vegetative competition, although competition from native vegetation such as *Spartina* species probably occurs. However, since *A. virginica* evolved with this form of competition, it is not likely to adversely affect *A. virginica*, except when the natural system is altered as a result of human disturbances.

Herbivory of *Aeschynomene* plants (mainly stems) by small mammals such as muskrats has been observed but does not appear to be a serious threat (Davison and Bruderle 1984). Some predation of seed pods has been observed in New Jersey and Virginia (Davison and Bruderle 1984). Rouse (1994, 1995) observed plants had been "gnawed" off at the base, and he suspected this was a result of small mammal herbivory (perhaps by muskrats), but no small mammals were actually observed feeding on *A. virginica*. J. Perry (pers. comm. 1994) indicated that browsing by white-tailed deer (*Odocoileus virginianus*) has occurred at the Fones Cliffs site on the Rappahannock River in Virginia.

Whether due to human-induced causes or to other, as yet unidentified, threats, the extent of *A. virginica* along river systems in Virginia is contracting. On both the Rappahannock and James Rivers, *A. virginica* was collected historically some 10 miles farther upstream and downstream than its current distribution. It remains on only one section of the Chickahominy River, where it once had a much broader distribution as noted from historical collections (T. Wieboldt, Virginia Polytechnic Institute and State University, pers. comm. 1990). This is due, at least in part, to the construction of Walker's Dam. Additional inventory work is needed to confirm the long-term trends on these three rivers. If the apparent declines are indeed real, possible causes include alteration of sediment deposition patterns, water pollution, and altered flood regimes (C. Caljouw and A. Belden, Virginia Division of Natural Heritage, pers. comm. 1994).

CONSERVATION MEASURES

CURRENT LEGAL PROTECTION

Conservation measures provided to Federally listed species include: recognition, recovery actions, opportunities and requirements for Federal protection, and limitations on certain practices. Recognition through listing encourages and results in conservation actions by Federal, state, and private agencies, groups, and individuals. The Endangered Species Act of 1973 provides for possible land acquisition in cooperation with the states and requires that recovery actions be carried out for all listed species. The protection required of Federal agencies and the prohibitions against certain activities involving listed plants are discussed below.

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as Federally endangered or threatened. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR Part 402. Section 7(a)(4) requires Federal agencies to confer with the U.S. Fish and Wildlife Service on any action that is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, Section 7(a)(2) requires Federal agencies to ensure that any activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the U.S. Fish and Wildlife Service. Because *A. virginica* occurs in wetland habitat, many projects potentially affecting it (e.g., the water supply, shoreline stabilization, and wetland development projects mentioned earlier) would be within the permitting authority of the Corps.

Section 9(a)(2) of the Act sets forth the prohibitions that apply to listed endangered plants. In general, it is unlawful to: (a) import and export such species; (b) remove and reduce to possession any such species from areas under Federal jurisdiction; maliciously damage or destroy any such species on such areas; or remove, cut, dig up or damage or destroy any such species on any other area in knowing violation of any law or regulation of any state or in the course of any violation of a state criminal trespass law; and (c) deliver, receive, transport,

carry, ship or sell or offer for sale in interstate or foreign commerce such species. The prohibitions apply equally to live or dead plants, their progeny, and parts or products derived from them. These same prohibitions apply to plants listed as threatened, except that the seeds of artificially propagated threatened plants, accompanied by a statement as to their cultivated origin, are exempt from the above-listed prohibitions. For endangered and threatened plants, permits from the Service may be issued for scientific purposes, enhancement of propagation or survival of the species, or economic hardship. In addition, for threatened plants, permits may be issued for botanical or horticultural exhibition, education, or other activities consistent with the purposes and policy of the Act.

Aeschynomene virginica is listed as endangered by the States of Maryland, New Jersey, and North Carolina. The Maryland Threatened and Endangered Species Regulations (COMAR 08.03.08) prohibit taking of endangered plant species from State property except by special permit, and further prohibit taking from private property without the written permission of the landowner. However, these regulations do not prohibit alteration of the habitat in which these species occur. Habitat protection is a component of Maryland's Critical Areas legislation. Any activity that may adversely affect any endangered or threatened species or its habitat within 100 feet of the upper limit to a tidal wetland is prohibited (COMAR 14.15.09).

Numerous laws provide protection for the species in New Jersey. The Pinelands Protection Act (NJ AC 7:50-6.24) prohibits any development that would adversely affect the survival of any local populations of an endangered or threatened species. The Manumuskin River is the western-most boundary for lands protected by this Act. Therefore, within New Jersey's single extant population, plants east of the river are protected by this Act, while plants located on the western bank are not. The regulations pursuant to the Coastal Area Facility Review Act (N.J.S.A. 13:19-1 *et seq.*) also protect this population and state that habitat for endangered and threatened species on Federal or State lists or under active consideration for inclusion on either list will be considered "special areas." Development in these areas is prohibited unless it can be shown that the rare species' habitat would not be adversely affected. The New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 *et seq.*) prohibits regulated activities from jeopardizing threatened or endangered species or adversely modifying historical or documented habitat, but this protection extends only to Federally listed plants. The New Jersey Endangered Plant Species List Act (N.J.S.A. 13:1B-15.151-158) only provides for the creation of a list of rare plants and offers no protection from take or

habitat alteration. In October 1994, the Maurice River and its tributaries (including the portion of the Manumuskin River supporting the *A. virginica* population) were designated as part of the National Wild and Scenic River System. The pristine water quality and of the Manumuskin River and the sensitive joint-vetch population were listed as outstanding national resources. Local ordinances also protect this population. The local municipalities have a Township Zoning Ordinance that identifies a River Management Overlay Zone. This ordinance establishes a minimum lot size and the amount of clearing allowable near the river and a 300-foot setback for buildings and septic systems and requires that a 50-foot buffer of natural vegetation be maintained along the river.

In North Carolina, the sensitive joint-vetch is protected by North Carolina general statutes Sections 106-202.122, 106-202.19 [CUN.SUP.1985], which prohibit interstate trade without a permit, prohibit taking without written permission of landowners, and provide for monitoring and management of State-listed species. However, this legislation provides no habitat preservation for listed species.

In Virginia, the species is proposed for State listing as endangered. If the species is listed under Virginia's Endangered Plant and Insect Species Act (Title 3.1, Chapter 39), it is protected from take, except by the private property owner, unless landowner permission and a State permit are obtained; however, destruction or alteration of its habitat remains unregulated. The Chesapeake Bay Preservation Act (Sections 10.1-2100 to 10.1-2115 of Chapter 21, Title 10.1 of the Code of Virginia) may provide some protection for *A. virginica*. The Chesapeake Bay Preservation Act regulations are mandatory for the cities, counties, and towns within tidal sections of the Chesapeake Bay Watershed and may be adopted by other local governments outside of these areas. The purpose of the regulations is to protect water quality by establishing two sets of criteria to be used by localities during the land use planning process. Tidal wetlands, nontidal wetlands that are adjacent to tidal wetlands and tributary streams, and tidal shores must have a 100-foot buffer area located landward of sensitive habitats. Other sites can be included as necessary to protect water quality. The 100-foot buffer may be reduced through the use of best management practices, soil and water conservation plans, etc. In addition, redevelopment and water-dependent activities may be allowed within the buffer area.

SITE PROTECTION

Currently, only two *Aeschynomene virginica* sites across the entire range of the species are afforded land protection. The Nature Conservancy owns one site on the Pamunkey River in New Kent County, Virginia and a portion of the extant site in New Jersey is located within their Manumuskin River Preserve. These protected sites are still subject to off-site threats such as sedimentation and water withdrawal projects.

SURVEYS TO LOCATE ADDITIONAL POPULATIONS

Survey efforts to date have confirmed a total of 26 extant sites throughout the species' range, as detailed under *Distribution and Status*. The possibility of finding additional sites along streams not previously searched has been suggested as a more promising undertaking than re-surveying historical habitats (see recommended search locations under Task 3.2), but both need to be included in recovery efforts.

The Delaware Natural Heritage Program is conducting surveys for the sensitive joint-vetch during the 1995 field season. Searches are planned in Kent County on the Mispillion, Murderkill, Leipsic, and Smyrna Rivers; in New Castle County on Blackbird and Dragon Creeks and Christiana and Appoquinimink Rivers; and in Sussex County on the Nanticoke River.

The Virginia Department of Conservation and Recreation, Division of Natural Heritage, is conducting surveys for the sensitive joint-vetch in previously unchecked areas during the 1995 field season.

RESEARCH EFFORTS

In 1994, the Virginia Chapter of The Nature Conservancy conducted a brief study of the *A. virginica* population on the Pamunkey River at Holts Creek Marsh to determine where plants occur within the marsh. Individual plants in the area owned by The Nature Conservancy will continue to be counted on an annual basis until such time that the area is secure enough that annual monitoring of every plant is no longer necessary (J. Dunscombe,

The Nature Conservancy, pers. comm. 1995) A water quality monitoring station may be installed at this site (J. Dunscombe, pers. comm. 1995).

Dr. J. Baskin and Dr. C. Baskin at the University of Kentucky are examining the parameters affecting germination, including apparent impermeability of fresh seeds, effects of moisture on permeability and germination of buried seeds, and effects of salinity on germination *in vitro*. The study should be completed this year.

RECOVERY STRATEGY

The primary thrust of the sensitive joint-vetch recovery program will be toward maintaining the integrity of the dynamic river systems upon which the species depends. This will amount to a long-term, landscape-level protection strategy. This plan emphasizes the early stages of recovery, as described below.

During the initial phase of recovery, the focus will be on assessing and ameliorating imminent threats to the species. The activities that may present the most immediate and serious risk to the sensitive joint-vetch are the water withdrawal proposals described under Threats to the Species. If and to what extent these projects could result in widespread decline of sensitive joint-vetch populations must be determined in the near future in order to frame an appropriate response to the project proposals. As needed, other system-wide or site-specific threats to the survival and recovery of *Aeschynomene virginica* will be identified and monitored. Their resolution will likely involve working cooperatively with landowners, planners, and managers as well as providing for technical assistance to minimize impacts to and restore the ecological integrity of sensitive joint-vetch sites.

Searches for additional populations should also be undertaken during the early phase of recovery, so that these populations, if any, will not be lost through inadvertent impacts. Further, it should be possible to approach habitat protection more effectively if a relatively complete picture of the plant's distribution is known.

A long-term research and monitoring program will be necessary to evaluate the sensitive joint-vetch's recovery progress, but before this can be undertaken, monitoring priorities and

reliable and consistent monitoring techniques for the species need to be defined. Initial research efforts will focus on determining the effects of various natural and anthropogenic influences on the species' status, and, in turn, determining the species' ecological requirements.

The overall protection of *A. virginica* populations and their habitat will involve a two-pronged effort: (1) in concert with other watershed-wide efforts to protect riverine ecosystems and ongoing protection of the sensitive joint-vetch as a listed species via the regulatory process, consideration will be given to the dynamic habitat requirements of *A. virginica* when formulating water use and shoreline protection standards; and (2) at the more site-specific scale, delineation of the essential habitat for the species and a better understanding of on- and off-site impacts will lead to land conservation efforts. When this point in the recovery process is reached, it is likely that the recovery plan will undergo revision.

PART II: RECOVERY

RECOVERY GOAL

The goal of the *Aeschynomene virginica* recovery program is to protect, maintain, and increase the species and its habitat, thereby enabling eventual removal of the species from the Federal list of Endangered and Threatened Wildlife and Plants. This will be accomplished through habitat protection at the landscape scale and possibly by finding additional populations.

RECOVERY OBJECTIVE

The objective of this recovery plan is to remove *A. virginica* from the Federal Endangered and Threatened Wildlife and Plants list. **Delisting** will be considered when the following conditions (subject to revision if warranted by new data) have been met:

1. The sensitive joint-vetch and the ecosystem upon which it depends are fully protected – including conservation of all extant sites (or a combination of extant and future sites identified as viable that is commensurate to at least the current known status of the species) – within the following six watersheds: Manokin Creek in Maryland; Manumuskin River in New Jersey; Rappahannock, Pamunkey, Mattaponi, and Chickahominy Rivers in Virginia. These systems must be protected from present and foreseeable anthropogenic and natural threats that may interfere with the survival of the species. Adequate protection measures comprise protection of wetlands where the plant occurs, protection of water quality and quantity, and protection of an adequate upland buffer.

2. Annual monitoring over a 10-year period indicates that the populations in the six river systems are stable or increasing (expanding) and that threats have been alleviated and/or

removed. General population, reproductive, and habitat trends should indicate a capacity for being self-sustaining in the wild over the long term with minimal management intervention.

3. Life history and ecological requirements of the species are understood sufficiently to allow for effective protection, monitoring, and, as needed, management.

RECOVERY TASKS

1. **Maintain the integrity of the tidal wetland systems upon which the sensitive joint-vetch depends.** This will entail resolution of near-term questions that could have ramifications for the long-term survival of the species. It will also involve comprehensive evaluation and conservation of these ecosystems through landscape-level assessment and planning processes.

   1.1 Determine the effects of water withdrawal on the sensitive joint-vetch and its habitat. The effects of the multiple water withdrawal proposals within Virginia may constitute one of the most serious threats to the survival and recovery of *A. virginica*.

   1.11 Determine salinity and inundation tolerances of the sensitive joint-vetch at all life history stages. Salinity and inundation tolerances need to be determined to answer questions regarding effects of water withdrawal. Controlled laboratory experiments should be conducted to determine these tolerances during different life history stages. In addition, controlled germination of *A. virginica* at different mixes of salinity and inundation needs to be conducted.

   1.12 Refine the existing salinity model in order to more accurately predict the effects of water withdrawal projects. The Virginia Institute of Marine Science has conducted modeling to examine the effects of water withdrawal on *A. virginica* for the Regional Raw Water Study Group. These results indicate that a more comprehensive salinity model is

needed. A group of knowledgeable experts should be convened to review the existing VIMS model and its applicability to *A. virginica*. The group should then make recommendations as to additional information and/or changes needed, if necessary, to more accurately predict effects of water withdrawal projects on *A. virginica*.

1.2 **Identify and resolve other issues pertaining to ecosystem protection.** Activities that could affect water quality or other resource values on a system-wide basis should be identified. Possible issues include, for example, pervasive water quality impacts, runoff from development projects, significant changes in surrounding land use patterns, use of pesticides or herbicides, or other events affecting the ecological balance within the six priority watersheds. If any issues are found to be of immediate concern, they should be extended the same priority as that currently assigned to the water withdrawal question (see Implementation Schedule).

1.3 **Actively participate in large-scale land use planning efforts throughout the species' range.** Municipal and county planning boards, water quality and other environmental councils, and other decision-making bodies that are examining watershed-wide or landscape-level needs and opportunities could provide an ideal forum for integrating protection of *A. virginica* into comprehensive land use strategies. Opportunities for becoming engaged in these processes should be identified and acted upon. Where such opportunities are lacking, state and Federal agencies and other organizations should take the initiative to meet this need. Coordination among various planning efforts should be sought in order to achieve consistency and effectiveness of ecosystem protection across administrative and other boundaries. As a first step, landscape-scale assessments and planning efforts that are currently underway should be identified, and a course of action for participating in these processes should be defined.

2. **Protect extant sensitive joint-vetch populations and sites.** Almost all known populations occur on private lands and are currently threatened by water withdrawal and/or habitat degradation or loss. Until issues regarding water withdrawal are better understood and resolved, on-site protection will remain a partial, but still vital, component of *A. virginica*

recovery. Nevertheless, site protection should be initiated as an ongoing effort from the outset of the recovery process.

2.1 Delineate essential habitat. Using known habitat characteristics and requirements, the area needed to support each extant sensitive joint-vetch population and the area within which the sensitive joint-vetch may be susceptible to on- or off-site impacts should be identified. Land status should also be identified as a component of essential habitat data. This is necessary for the initiation of on-site protection strategies. The information should be documented and maintained in map and text files, and will be subject to revision as new data become available.

2.2 Identify, monitor, and alleviate site-specific threats to each population. In addition to assessing threats to the river/marsh systems upon which the sensitive joint-vetch depends, each population should be carefully monitored to assess potential threats and identify any new or unforeseen threats to the population or its habitat. The magnitude and immediacy of these threats should be monitored on a site-specific basis to implement proactive management and protection strategies.

2.21 Identify and monitor site-specific threats.

2.211 Determine the effects of exotic, invasive plant species. *Phragmites australis* and *Murdannia keisak* have been documented within and adjacent to *A. virginica* sites. Competition or other threats from exotics should be ascertained and tracked.

2.212 Investigate the effects of boat use and marinas on the sensitive joint-vetch. It has been stated that boat wakes adversely affect *A. virginica* through erosion of habitat; the validity of this needs to be determined. The effects of oil and gas and any other pollutants related to boats and marinas on *A. virginica* need to be quantified.

2.213 Determine the effects of seed predation. Predation by the corn earworm and tobacco budworm appears to be severe in some years.

The effects of these pests on the persistence of *A. virginica* at a particular site should be determined.

2.214 **Determine the effects of herbivory.** White-tailed deer and muskrats have been reported as predators on *A. virginica*. The validity of these reports should be determined. The impacts from this type of predation should be quantified and documented.

2.22 **Alleviate site-specific threats to each population as the need and opportunity arise.** Management and protection strategies should be formulated to prevent potential threats and offset ongoing impacts to sensitive joint-vetch populations. These strategies should then be implemented in a timely fashion, with adequate monitoring of the situation both before and after implementation.

2.3 **Seek permanent protection for known habitats.** Opportunities for land acquisition or conservation easements for populations on private property should be identified and acted upon by private and public conservation organizations. Voluntary cooperative agreements should be sought. It should be noted, however, protection from water withdrawal will not be accomplished through any of these methods. Until the effects of water withdrawal on *A. virginica* are determined (see Task 1) and, as possible, alleviated, full protection of the species and its habitat will not be achieved.

2.4 **Seek the cooperation and active support of private landowners and local governments.** Landowners should be informed about the presence of *A. virginica* on their property, and apprised of the biological, ecological, and legal status of the species. Landowners and local governments will be provided an information packet, as developed in Task 8. Voluntary support in protecting and managing populations should be solicited.

2.5 **Coordinate with Federal, state, and local regulatory agencies to ensure compliance with laws protecting the species.** *A. virginica* is protected by the Federal Endangered Species Act of 1973, as amended, and under individual state

endangered and threatened species laws and regulations (see *Conservation Measures*). The wetland habitat occupied by *A. virginica* receives some degree of protection under Federal and state wetland laws and regulations. However, in some areas in, for example, Virginia, many areas of potential habitat have not been surveyed. Surveys need to be completed (see Task 3), and any information on new locations should be provided to local, state, and Federal regulatory agencies for use during their permit review process.

2.51 **Coordinate with the U.S. Army Corps of Engineers to ensure that permits issued do not jeopardize any sensitive joint-vetch populations.** The Corps will be urged to take an active role to ensure that areas that have, or are likely to have, populations of *A. virginica* come under close scrutiny when permits for projects within these areas are reviewed. The Corps will be encouraged to maintain discretionary authority over nationwide and general permits in all areas known to support this species, and to closely coordinate permit reviews in these areas with the U.S. Fish and Wildlife Service.

2.52 **Coordinate with the Chesapeake Bay Local Assistance Department (CBLAD) and local planners to promote implementation of the Chesapeake Bay Preservation Act.** The Chesapeake Bay Preservation Act may provide some protection for *A. virginica* in Virginia. The CBLAD should be informed of known locations and sites with potential habitat. The U.S. Fish and Wildlife Service should work with the CBLAD to ensure aggressive enforcement of the Chesapeake Bay Preservation Act within the range of *A. virginica*.

2.53 **Coordinate with state agencies and Natural Heritage Programs to ensure that the sensitive joint-vetch receives the full protection of applicable state laws.** Individual sensitive joint-vetch plants receive some protection from take under most state endangered species laws; however, the primary threat is to the species' habitat. In some states, its habitat may receive a degree of protection indirectly through state wetland regulations. All appropriate regulatory avenues should be utilized to protect the species.

Regulatory agencies that review and/or issue permits that may adversely affect the sensitive joint-vetch should be familiar with the known occurrences and potential distribution of the species, and should, before permits are issued, recommend surveys by qualified individuals of those areas likely to support additional populations of the species.

3. ***Conduct a comprehensive survey for additional populations.*** Surveys should be conducted initially at sites where the sensitive joint-vetch has occurred but has not been or could not be recently relocated. This is needed because, as an annual, *A. virginica* has been documented as not re-occurring at known locations. In addition, sites with few individuals may be overlooked. Rangewide surveys of sites with potential habitat are also needed.

   3.1 **Resurvey sites thought to have suitable habitat.** All sites that appeared to have suitable habitat based on past surveys should be resurveyed.

   3.2 **Identify potential habitat and survey these sites for the presence of sensitive joint-vetch.** There are areas of potential *A. virginica* habitat that have not yet been surveyed. Surveys are needed in all three Delaware counties, and surveys in Maryland are needed on the Potomac River along the main stem and its tributaries and in a few tributaries on the Eastern Shore. The Wading River site in New Jersey also needs to be checked; in addition, Hill (1992) recommended that the Tuckahoe River, Raccoon Creek, and tributaries to the Maurice River be resurveyed. In North Carolina, natural habitats need to be surveyed, particularly in wetlands around Lake Mattamuskeet, in Brices Creek, and in the Pamlico, Tar, Trent, Cape Fear, and Little Washington Rivers. In Virginia, surveys need to be conducted on the tidal freshwater portion of tributaries located downstream of the main stem river distribution of *A. virginica*. Further survey work on the James River should also be conducted. Sites that appear to have suitable habitat, but where *A. virginica* has not been documented, will be resurveyed in successive years.

   3.3 **Document, monitor, and protect newly discovered populations.** To adequately protect and monitor *A. virginica*, information on additional populations (or new

locations within a known population) must be provided to all regulatory agencies (see Tasks 1, 2, and 4).

4. **Establish monitoring priorities, develop reliable monitoring techniques, and monitor populations accordingly.** Prioritization of sites that need to be monitored and methods that will allow investigators to accurately and consistently monitor sensitive joint-vetch sites throughout its range are needed.

   4.1 **Establish monitoring priorities.** A system should be devised to prioritize monitoring of known populations given funding and personnel constraints. Criteria should include, but not be limited to, known trends or current status of sensitive joint-vetch and associated plant communities, respresentativeness of populations and habitat, immediacy of threats, recovery potential, and conflicts with economic or land-use alternatives.

   4.2 **Develop and field test census techniques that are consistent rangewide.** Surveying from a boat versus on foot can yield very different results. Methodologies for both types of surveys should be developed to yield accurate results that can be used to monitor seasonal and annual trends.

   4.3 **Describe methods for determining the health of a site.** Information such as number of plants, flowering condition, fruiting condition, signs of predation, anthropogenic threats, and appearance of exotics should be noted at each site.

   4.4 **Develop methods and techniques for detailed monitoring of the six priority systems.** The results of Tasks 4.1 and 4.2 should be incorporated into a monitoring program for the six priority systems identified in the recovery objective. Additional detailed information (e.g., threats and data under Task 4.3) should be specified and collected for these priority systems.

   4.5 **Monitor populations.** All populations should be monitored and information collected at least every other year. The six priority river systems should be monitored every year using the methods resulting from Tasks 4.1-4.3.

5. **Determine the ecological and distributional characteristics and requirements of the sensitive joint-vetch.** The stability of *A. virginica* at a particular site for many consecutive years and the disappearance of the species at a documented location have long been attributed to seed banking. In addition to investigating the effects of water withdrawal and other environmental perturbations upon the sensitive joint-vetch (see Task 1), research is needed to pinpoint the factors affecting long-term population stability at a given location.

   5.1 **Determine seed dispersal and banking capabilities.** Investigation is needed into how long and how far sensitive joint-vetch fruits can float; other methods of seed dispersal should also be examined. With regard to seed banking -- if it occurs -- many questions such as how long seeds remain viable and the size of the seed bank need to be answered.

   5.2 **Investigate the differences between occupied and unoccupied potential habitat.** Marshes above and below sites containing *A. virginica* need to be examined and characterized. This information will be useful in determining if other sites have the potential to support *A. virginica* populations.

   5.3 **Examine factors affecting sensitive joint-vetch distribution within a given site.** This species has been documented on the edges of and within marshes. Potential determinants include diurnal tidal fluctuations, ice scour, wave action, severe storm events, herbivory, and/or nutrient deficiencies. These factors need to be examined to determine how the sensitive joint-vetch is distributed and maintained within a marsh.

   5.4 **Investigate the relative potential of sites to support sensitive joint-vetch populations or subpopulations.** This information is needed to determine the relative importance of a given site. For instance, a marsh with only a few *A. virginica* plants may warrant protection if it is shown that the marsh contains high-quality potential habitat and could harbor a large number of plants in the future.

6. **Develop an informational brochure on the importance of the sensitive joint-vetch and the tidal wetlands upon which it depends.** This brochure will be used as a public

relations/education/ conservation document related to the species, freshwater tidal wetlands, and general wetland protection. The brochure should provide an easily understood explanation of threats to the species and applicable Federal and state laws. It should also include contact points for agencies that regulate the species. The brochure should be distributed to property owners and appropriate resource management agencies and made available to the interested public.

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PART III: IMPLEMENTATION

The Implementation Schedule lists and ranks tasks that should be undertaken within the next three years in order to implement recovery of *Aeschynomene virginica*. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in order of priority.

Key to Implementation Schedule Column 1

Task priorities are set according to the following standards:

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

Priority 2: Those actions that must be taken to prevent a significant decline in species population, or some other significant impact short of extinction.

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

Key to Agency Designations in Column 5

USFWS - U.S. Fish and Wildlife Service
R4 ES - Region 4 Ecological Services, U.S. Fish and Wildlife Service
R5 ES - Region 5 Ecological Services, U.S. Fish and Wildlife Service
EPA - U.S. Environmental Protection Agency
COE - U.S. Army Corps of Engineers
NBS - U.S. National Biological Service
SCA - State Conservation Agencies
TNC - The Nature Conservancy
CPC - Center for Plant Conservation and cooperating institutions
CO - Other conservation organizations
AI - Academic institutions

IMPLEMENTATION SCHEDULE

Sensitive Joint-Vetch Recovery Plan

September 1995

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimate ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
1*	Determine salinity and inundation tolerances of the sensitive joint-vetch at all life history stages.	1.11	2 years	R4/R5 ES	NBS SCA TNC CPC AI	2.5	2		
1*	Refine the salinity model in order to more accurately predict the effects of water withdrawal projects.	1.12	2 years	R5 ES	EPA COE SCA AI	20	10		
2	Identify and resolve other issues pertaining to ecosystem protection.	1.2	10 years	R4/R5 ES	EPA NBS SCA TNC CPC CO AI		10		Periodic funding as needed. 72K total in FY4-20.
2	Participate in large-scale land use planning efforts throughout the species' range.	1.3	20 years	R4/R5 ES	SCA	5		15	As allowed by opportunity. 100K total in FY4-20.
2	Delineate essential habitat.	2.1	2 years	R4/R5 ES	SCA TNC AI		5	5	Revise as necessary.
2	Determine the effects of exotic, invasive plant species.	2.211	2 years	R4/R5 ES	SCA TNC AI			2.5	+ 2K in FY4. Additional funding may be required in future.
2	Investigate the effects of boats and marinas on the sensitive joint-vetch.	2.212	2 years	R5 ES	SCA TNC AI		2		+ 2K in FY5.

Sensitive Joint-Vetch Implementation Schedule, September 1995

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimate ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
3	Determine the effects of seed predation.	2.213	4 years	R4/R5 ES	SCA TNC AI			3	+ 3K/yr in FY4-6.
3	Determine the effects of herbivory.	2.214	2 years	R5 ES	SCA AI		1.5	1.5	
3	Resurvey sites thought to have suitable habitat.	3.1	3 years	R4/R5 ES	SCA TNC AI		8	8	+ 8K in FY4.
3	Document, monitor, and protect any newly discovered populations.	3.3	ongoing	R4/R5 ES	SCA TNC AI				No special funding. Costs covered in other tasks.
3	Determine seed banking and seed dispersal capabilities.	5.1	2 years	R5 ES	SCA TNC CPC AI		1.5	1	
3	Investigate the differences between marshes with and without sensitive joint-vetch populations.	5.2	3 years	R4/R5 ES	NBS SCA TNC AI	7		7	+ 7K in FY5.
3	Examine factors affecting sensitive joint-vetch distribution within a given site.	5.3	2 years	R4/R5 ES	NBS SCA TNC CPC AI	5	5		
3	Investigate the relative potential of sites to support sensitive joint-vetch populations or subpopulations.	5.4	2 years	R4/R5 ES	NBS SCA TNC AI				5K/yr in FY6-7.
3	Develop a brochure on the importance of the sensitive joint-vetch and freshwater tidal wetlands.	6	1 year	R4/R5 ES	SCA		8		+ 6K total for 2 reprints.

* Priority 1 is assigned to these tasks because of the immediate need to resolve these questions in order to avoid potentially widespread impacts to the species. If study results indicate that resolution of water withdrawal issues is less urgent than now thought, the task priority will be downgraded to 2.

Sensitive Joint-Vetch Implementation Schedule, September 1995

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimate ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
2	Alleviate site-specific threats to each population as the need and opportunity arise.	2.22	ongoing	R4/R5 ES	EPA COE SCA TNC	10		10	+ 5K/yr periodically, 45K total.
2	Seek permanent protection for known habitats.	2.3	10 years	R5 ES	SCA TNC CO				Assuming conservation easements, 50K total.
2	Seek the cooperation and active support of private landowners and local governments.	2.4	ongoing	R4/R5 ES	SCA TNC CO				Standard operating costs.
2	Coordinate with the Corps of Engineers to ensure that permits issued do not jeopardize any sensitive joint-vetch populations.	2.51	ongoing	R4/R5 ES	EPA COE SCA				Standard operating costs.
2	Coordinate with the CBLAD and local planners to implement the Chesapeake Bay Preservation Act.	2.52	ongoing	R5 ES	SCA				Standard operating costs.
2	Coordinate with state agencies and Natural Heritage Programs to ensure that the sensitive joint-vetch receives the full protection of applicable state laws.	2.53	ongoing	R4/R5 ES	SCA TNC				Standard operating costs.
2	Identify potential habitat and survey for presence of sensitive joint-vetch.	3.2	3 years	R4/R5 ES	SCA TNC AI		15	10	+ 10K in FY4.
2	Develop and field test monitoring techniques that are consistent and reliable.	4.1-4.3	2 years	R5 ES	NBS SCA TNC CPC	4	3		
2	Monitor populations.	4.4	ongoing	R4/R5 ES	SCA TNC AI	10	7.5	10	Monitor all populations at least every other year (7.5K) + priority populations every year (2.5K).

APPENDIX: LIST OF REVIEWERS

The following individuals submitted comments on the draft *Aeschynomene virginica* recovery plan. All comments were considered during final plan preparation and incorporated into this document as warranted. Letters of comment are retained on file in the Virginia Ecological Services Field Office of the U.S. Fish and Wildlife Service.

The Service wishes to thank those who took the time to read and comment on the draft recovery plan. Effective recovery of *Aeschynomene virginica* ultimately hinges on the shared expertise and continuing interest of conservation professionals and concerned parties.

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