Banisteria, Number 27, 2006

Aeschynomene virginica (Fabaceae) Habitat in a Tidal Marsh, James City County, Virginia

David E. Bailey[1], James E. Perry, and Douglas A. DeBerry

Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

ABSTRACT

The federally threatened *Aeschynomene virginica* (L.) B.S.P. is a rare, bushy, annual member of the Fabaceae occurring in mid-Atlantic tidal wetlands. We documented the size and associated species of an *Ae. virginica* population (control plot) and used a simulated grazing experiment to test for *Ae. virginica* seed bank occurrences adjacent to the potential source population in Colonial National Historical Park in southeastern Virginia. Importance values, calculated from percent cover and density estimates, were used to quantitatively determine species dominance in the control and test plots. By late August 2004, the control plot supported an estimated 458 *Ae. virginica* plants within a 10.1 m^2 area. Dominant vegetation in the test plots varied with elevation, with lower elevation plots (n=4) dominated by *Peltandra virginica*, and the higher elevation plot co-dominated by *Leersia oryzoides* and *Spartina cynosuroides*. No *Ae. virginica* stems were found in the test plots, possibly due to prolonged tidal inundation and associated anoxic sediment conditions in the lower elevation plots, or inadequate primary and secondary seed dispersal from the control plot to the higher elevation plot. The data suggest a relationship between high summer precipitation and the occurrence of *Ae. virginica* at the study site from 2000 to 2004. In September 2005, we noted six individuals present in the control plot and adjacent areas. Further studies should consider the response of *Ae. virginica* seed germination and seedling establishment to climate variations, as well as seed dispersal from source populations to suitable habitat patches.

Key words: *Aeschynomene virginica*, threatened vascular plants, tidal marsh, Virginia.

INTRODUCTION

Aeschynomene virginica (L.) B.S.P. is a bushy, annual member of the Fabaceae. Endemic to mid-Atlantic tidal wetlands, this species occurs from southern New Jersey to central North Carolina (Ware, 1991). The Virginia Natural Heritage Program ranks the species as very rare and imperiled both globally and statewide (G2, S2) (Townsend, 2004), and it is currently on the federal list of threatened species (FR 50 CFR Part 17). Although the distribution and associated flora of *Ae. virginica* have been relatively well documented (Ware, 1991), information is still lacking on some of the physical environmental needs necessary to define available habitat.

Past work in tidal wetlands suggests that standing vegetation and wetland elevation affect the abundance and distribution of many wetland species (Parker & Leck, 1979, 1985; Simpson et al., 1983). Griffith & Forseth (2003) found evidence that standing vegetation decreases seedling establishment, seedling survival to maturity, and seed production of *Ae. virginica*. They found that plants growing in plots with standing vegetation were smaller and had fewer seeds per plant than individuals growing in plots with vegetation removed. Field experiments supported by a greenhouse study suggest that lower average wetland elevations decrease germination and seedling establishment (Griffith & Forseth, 2003).

Seed germination studies showed that NaCl concentrations >1.0% caused significant decreases in *Ae. virginica* seed germination percentages (Baskin et al., 1998, 2005), and that non-dormant seeds can only tolerate soaking in a 2.0% NaCl solution for less than

[1] Corresponding author: debailey@vims.edu

one week before exhibiting significantly reduced viability (Baskin et al., 1998). These studies support the ostensible low salinity tolerance of *Ae. virginica* and confirm that this species is a non-halophyte.

Aeschynomene virginica has been known to occur at the Colonial National Historical Park (COLO) site (James City County, Virginia) since at least 1938 (Fernald, 1939), and specimens were collected from this location in 1938 and 1939 by Fernald & Long [11052 (US)]. In 2000, the Virginia Department of Conservation and Recreation discovered an *Ae. virginica* population of 13 plants within the COLO management area in Back River marsh, in a location historically known to support this species (Chazal & Van Alstine, 2001; Erdle & Heffernan, 2002). As this population was documented during a wet growing season (2000), Chazal & Van Alstine (2001) hypothesized that *Ae. virginica* may respond positively to wetter summer precipitation patterns.

The purpose of the current study was to monitor the number, density, and areal extent of the 2004 population, describe its habitat, and test for *Ae. virginica* in the adjacent seed bank by means of a grazing experiment. We hypothesized that removal of competitive vegetation from plots adjacent to the source population would yield viable *Ae. virginica* plants given adequate propagule dispersal and growth conditions. A follow-up survey was conducted in September 2005 to reevaluate the *Ae. virginica* population in the control and test plots.

SITE DESCRIPTION

Due to its rare status, the National Park Service has requested that the exact location of this *Ae. virginica* population not be disclosed. The research site has been described as an oligohaline tidal marsh (Chazal & Van Alstine, 2001; Erdle & Heffernan, 2002) with a semi-diurnal tidal regime and a range of 0.7 m (2.0 ft) (NOAA, 2004a). Moore (1980) noted that areas of the James River near Jamestown Island, including Back River and its marshes, are in a zone that marks the upper reaches of saltwater. Vegetation in the marsh is comprised mostly of mixed broad-leaved herbaceous and graminoid wetland species, characteristic of a transitional tidal freshwater/oligohaline marsh community (Perry & Hershner, 1999). The 2004 *Ae. virginica* population (control plot) was located within a wash-over area of an old roadbed running north to south through the marsh. A preliminary survey in early June 2004 found over 100 healthy *Ae. virginica* plants present in the control plot. There were no signs of fruit or refractive structures of *Ae. virginica* from the previous year.

METHODS

Grazing Experiment

Five randomly located, circular, 5 m diameter test plots, each at least 5 m removed from the *Ae. virginica* control plot, were established on 9 June 2004. "Grazed" conditions were created in each test plot by cutting back all vegetation to within 15 cm of the soil level with a commercial weed-cutter. Cut vegetation was either piled in the middle of the plot or cast to the side. The position and extent of the control and test plots were mapped in late August 2004 using a Trimble® GeoXT™ handheld GPS and the ESRI® ArcView 3.3 GIS system.

Vegetation

Perry & Atkinson (1997), Perry & Hershner (1999), and others have found that mid-August represents peak growing season in mid-Atlantic tidal marshes. Therefore, vegetation measurements including percent cover, density, and height of vegetation were estimated within the control and test plots on 11 and 28 August 2004. Cover estimates were obtained from three randomly placed but uniformly oriented 1 m x 1 m quadrats in each of the six plots. Cover data were visually estimated in the field as a value of 1 to 100% or trace (<1%). Mid-class cover ranges were estimated using a modified Braun-Blanquet cover scale (Daubenmire, 1966, 1968; DeBerry & Perry, 2004) where: <1% = 0.5, 1 to 5% = 3%, 5 to 25% = 15%, 25 to 50% = 37.5%, 50 to 75% = 62.5%, 75 to 95% = 85%, and 95 to 100% = 97.5%.

Density counts were made in 0.5 m x 0.5 m sub-quadrats systematically arranged in the southwest corner of each 1 m^2 quadrat. This corner was randomly chosen prior to arriving at the site on the basis of two coin flips. Density was estimated by counting the number of individual plants (separated by soil) of each species in the sub-quadrat. These data were extrapolated for the entire 1 m^2 quadrat by multiplying the results by four. Importance values (IV) were calculated as the average of the relativized sum of percent cover, density, and frequency values of each species in each quadrat using formulas found in Mueller-Dombois & Ellenberg (1974) and Perry & Hershner (1999).

Vegetation adjacent to each plot was visually surveyed for dominant/subdominant species and height of vegetation. A visual resurvey of the control and test plots was performed on 14 and 23 September 2005 to examine the density of the *Ae. virginica* population.

Elevation

Relative elevations were measured in test plots 1-4 and the control plot on 28 August 2004 using a Topcon® AT-G7 Autolevel and a standard stadia rod. A minimum of three readings were taken to determine the average relative elevation of each plot to the control plot. Test plot 5 was omitted from the August 2004 survey and relative elevation was established by hypsometric data on 26 October 2004.

RESULTS AND DISCUSSION

Current *Aeschynomene virginica* Population

The densest portion of the *Aeschynomene virginica* population (control plot) covered a semi-rectangular (approximately 5 m x 2 m) area of 10.1 m^2 and contained an estimated 458 individual plants (mean density of 45.3 plants m^{-2}) by 27 August 2004 (Table 1). Due to the density of the population, a direct count of plants could have potentially damaged some individuals to account for plants near the interior of the population; therefore, we chose to estimate total population size. Several isolated *Ae. virginica* individuals extended 15 m both north and south of the control plot along the roadbed. Flowers and mature fruit were observed on more than 200 *Ae. virginica* plants during the August site visits.

A total of 15 species was identified within the control plot; *Ae. virginica* dominated (IV=29.6), with *Leersia oryzoides* (IV=13.1) and *Ludwigia palustris* (IV=11.2) as sub-dominants (Table 2). Mean percent cover was high at 119% (Table 2). The largest *Ae. virginica* specimens were ≤1 m tall, many of which showed signs of grazing. All sub-dominant vegetation was <0.5 m in height. Percent cover of vegetation >1.5 m tall was <5% and was represented by a few individuals of *Spartina cynosuroides* (IV=3.8), *Schoenoplectus tabernaemontani* (IV=2.3), and *S. robustus* (IV=1.7). This is similar to other communities containing *Ae. virginica* in Tidewater Virginia (Belden & Van Alstine, 2003).

Vegetation within the old roadbed and immediately adjacent to the *Ae. virginica* plot was dominated by *S. cynosuroides* (98-100% cover) with no co-dominants. Nearly all of the *S. cynosuroides* was >2 m tall with >90% cover in the canopy at 1.5 m high.

A return visit to the site in September 2005 found only six *Ae. virginica* individuals in the study area (Table 1): four of these plants were within the 2004 control plot boundary, another was approximately 10 m southwest of the control plot along the old roadbed, and the sixth plant was within the boundaries of plot 5. None of the lower elevation plots (1-4) contained *Ae. virginica* specimens. Each individual was approximately 1 m tall, bore flowers and seedpods ($\bar{x}$ = 4.5; range = 1 to 11), and showed signs of stem grazing by 23 September 2005. All specimens were adjacent to dense stands of *S. cynosuroides* >2 m tall, and both specimens outside of the 2004 control plot were somewhat entangled with *Mikania scandens*.

Table 1. Number of *Aeschynomene virginica* individuals observed during surveyed years at COLO site and corresponding seasonal precipitation totals for spring (March-May) and summer (June-August). Values in parentheses are departures from seasonal average precipitation ($\bar{x}$).

Year [a]	Number of *Ae. virginica* individuals	Spring Precipitation (cm) [c] $\bar{x}$ = 26.9	Summer Precipitation (cm) [c] $\bar{x}$ = 37.8
2000	13 [b]	25.8 (-1.1)	61.4 (+23.6)
2001	0 [b]	23.1 (-3.8)	39.4 (+1.6)
2003	0	35.5 (+8.6)	45.9 (+8.1)
2004	>458	24.3 (-2.6)	68.2 (+30.4)
2005	6	22.0 (-4.9)	40.2 (+2.4)

[a] No survey conducted in 2002.
[b] Data from Chazal & Van Alstine (2001).
[c] Data from NOAA (2004b).

The occurrence of *Ae. virginica* during this study, and its absence over the past several years, may be related to precipitation levels during the growing season in the respective years. For example, approximately 458 plants were documented in 2004, which was the 3rd wettest summer (June-August) on record with 68.2 cm (26.9 in) (NOAA, 2004b). The site also supported a population in 2000 (13 plants) (Chazal & Van Alstine, 2001; Erdle & Heffernan, 2002), which was the 4th wettest summer on record with 61.4 cm (24.2 in) (NOAA, 2004b). Visits to the COLO site in 2001 (Chazal & Van Alstine, 2001) and 2003 (J.E. Perry, pers. obs.) failed to detect any *Ae. virginica* specimens. Meteorological records show summer precipitation amounts of 39.4 cm (15.5 in) in 2001 and 45.9 cm (18.1 in) in 2003 (NOAA, 2004b). Both years were within one standard deviation of the mean [$\bar{x}$ = 37.8 cm (14.9 in.), SD = 12.3 cm (4.8 in)] for the period of record (1895-2005), and are therefore considered normal precipitation summers (NOAA, 2005) (Table 1).

The COLO site supported a population of *Ae. virginica* in 2005 (6 plants), a period of normal summer precipitation similar to 2001 and 2003, although the population was substantially reduced from 2004 (Table 1). Based on these observations, it is possible that the persistence of the population in 2005 was related to the presence of propagules from the population during the previous year, and that the substantial reduction in plants may have been related to the normal (i.e., non-wet) summer rainfall conditions.

The relationship between *Ae. virginica* occurrence and heavy precipitation during summer months is potentially linked to survivorship of germinated plants, rather than to germination itself. For instance, germination of *Ae. virginica* seeds occurs from late May to early June (Baskin & Baskin, 1997). There was no obvious relationship between spring (March-May) precipitation and *Ae. virginica* occurrence during 2000 [25.8 cm (10.2 in), the 56^{th} wettest spring on record] or 2004 [24.3 cm (9.6 in), the 67^{th} wettest spring on record] (NOAA, 2004b) (Table 1). However, as it is plausible that salinity also negatively affects *Ae. virginica* seedling survival (Baskin et al., 2005), wet summers are a possible mechanism to enhance survival throughout the growing season by reducing *in situ* porewater salinity through direct precipitation inputs, and by dilution from increased freshwater subsidies upriver.

Grazing Experiment

Test plots 1-4 were 16 to 20 cm lower, and plot 5 was 7 cm higher, in elevation than the control plot. Lower elevation plots were dominated by *Peltandra virginica* (IV range = 33.0 to 71.4, $\overline{x}$ =54.3), while plot 5 was dominated by *L. oryzoides* (IV=39.1) with *S. cynosuroides* (IV=30.0) as a sub-dominant (Table 2). All vegetation in the test plots was <1.5 m tall ($\overline{x}$=0.5 m). Mean cover in the test plots was lower (47.5%) than in the control plot (119.2%) (Table 2).

Even with an open canopy and similar vegetation height to the control plot, no *Ae. virginica* specimens were found in the test plots in 2004. One specimen was noted adjacent to plot 5 prior to clipping, but it was grazed to the ground prior to 11 August and completely missing on 28 August 2004. The lower elevations of plots 1-4 may have rendered those areas non-conducive to *Ae. virginica* growth via prolonged tidal inundation. Although Baskin et al. (2005) showed that seeds of *Ae. virginica* can germinate while submerged, Griffith & Forseth (2003) reported that seeds of this species germinated significantly less frequently in submerged or waterlogged soil than in wet soil, possibly due to resulting anoxic conditions. The absence of *Ae. virginica* in plots 1-4 is consistent with the known distribution of this species on levee areas and other local topographically higher elevations within tidal freshwater marshes (U.S. Fish and Wildlife Service, 1995).

In contrast, the elevation of test plot 5 was only slightly higher than the control plot. The absence of *Ae. virginica* within plot 5 during 2004 may have been due to a lack of *Ae. virginica* seed in the seed bank. Perhaps *Ae. virginica* seeds are not distributed >5 m from the parent source. Griffith & Forseth (2002) reported short primary seed dispersal distances for *Ae. virginica*. However, secondary dispersal by water (hydrochory) is thought to play a significant role in dispersing seeds from source populations to new suitable habitat patches. The stand of *S. cynosuroides* separating our control and test plot 5 may have been too dense for *Ae. virginica* seeds to penetrate, although Griffith & Forseth (2002) found no effect of surrounding vegetation and its removal on secondary seed dispersal by water. Apparently, water as a secondary dispersal mechanism operates to facilitate dispersal over broader distances than within an immediate population. The 2005 occurrence of one *Ae. virginica* individual within plot 5 suggests that seeds from the 2004 control population may have used this mechanism to disperse to adjacent areas, albeit with limited germination success and/or seedling establishment. This explanation, however, is speculative and warrants further study.

CONCLUSIONS

The re-occurrence of *Ae. virginica* on the COLO site in 2004 may have been due to heavy precipitation during the growing season. This population is limited to a narrow elevation zone with little to no overstory >1 m. *Ae. virginica* did not take root in the clipped test plots during the 2004 growing season, perhaps due to differences in elevations and/or lack of seeds in test plot seed banks. Relative to 2004, the 2005 *Ae. virginica* population was much smaller (6 vs. 458 plants) and coincided with a drier summer (40.2 vs. 68.2 cm precipitation). Therefore, it is plausible that the 2005 population is less a reflection of high summer precipitation, and more a remnant of the strength of the 2004 population. The occurrence of an *Ae. virginica* specimen within plot 5 during the 2005 growing season indicates the potential of successful, although limited, seed dispersal from the 2004 parent population. Future experimental studies should consider clipping test plots earlier in the growing season and possibly adding a seed source to the plots. Further data are needed on the response of *Ae. virginica* seed germination to climate variations, particularly precipitation, *Ae. virginica* seed distribution from source populations to suitable habitat patches, and the potential for formation of a viable seed bank at those locations.

Table 2. Importance values (IV), mean percent cover (C), and mean density (D) of vascular plants from the *Aeschynomene virginica* control plot (Control) and five test plots. Importance values (IV) were calculated as the average of the relativized sum of percent cover, density, and frequency values of each species.

	Control			**Plot 5**			**Plot 4**			**Plot 3**			**Plot 2**			**Plot 1**		
Species	IV	C	D	IV	C	D	IV	C	D	IV	C	D	IV	C	D	IV	C	D
Aeschynomene virginica (L.) B.S.P.	29.6	61.7	45.3															
Aster sp.	2.3	0.2	4.0	4.6	1.2	1.3												
Cicuta maculata L.				9.1	1.8	5.3												
Cyperus strigosus L.				0.4	0.3													
Echinochloa walteri (Pursh) Heller	2.3	1.2	2.7															
Juncus effusus L.							13.0	5.0	9.3									
Leersia oryzoides (L.) Sw.	13.1	7.0	38.7	39.1	4.3	121.3												
Lobelia cardinalis L.				0.2	0.2													
Ludwigia palustris (L.) Ell.	11.2	12.5	36.0	4.4	3.3													
Murdannia keisak (Hassk.) Hand.-Maz.	10.6	6.2	25.3															
Panicum virgatum L.	0.6	2.0																
Peltandra virginica (L.) Schott	2.3	1.0	2.7				50.4	45.8	21.3	33.0	22.5	9.3	71.4	30.0	26.7	62.2	53.3	18.7
Polygonum arifolium L.	7.0	11.0	5.3															
Polygonum hydropiperoides Michx.	7.2	2.2	12.0				4.7	0.2	1.3	20.1	1.3	14.7	6.3	0.2	1.3	15.8	0.3	5.3
Polygonum punctatum Ell.				7.7	0.3	8.0	5.8	0.3	2.7									
Pontederia cordata L.							7.1	1.0	4.0							1.0	2.0	
Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller	6.1	1.2	16.0				0.5	1.0		16.3	6.2	6.7						
Schoenoplectus robustus (Pursh) M.T. Strong	1.7	6.0														0.5	1.0	
Schoenoplectus tabernaemontani (K.C. Gmel.) Palla	2.3	2.0	1.3							3.5	5.0		7.1	1.0	1.3	20.6	10.0	5.3
Spartina cynosuroides (L.) Roth	3.8	5.0	5.3	30.0	12.7	24.0	12.8	10.0	5.3	3.5	5.0							
Typha angustifolia L.	0.1	0.2		4.6	1.2	1.3				4.9	1.0	1.3	7.1	1.0	1.3			
Zizania aquatica L.							5.7	0.2	2.7	18.7	7.0	5.3	8.1	2.0	1.3			

ACKNOWLEDGMENTS

The authors wish to thank Mr. Charles Rafkind, Dr. Steve Roble, and two anonymous reviewers for their comments on this manuscript, Mr. David Fredrick for supplying the GIS data, and Ms. Keri Reyes, Dr. Robert Atkinson, and Mr. Adam Crary for their help with fieldwork. This project was funded in part by a grant from Colonial National Historical Park, National Park Service. This paper is Contribution No. 2726 of the Virginia Institute of Marine Science, The College of William and Mary.

LITERATURE CITED

Baskin, J. M., & C. C. Baskin. 1997. Seed germination studies of *Aeschynomene virginica.* Final report to the Virginia Department of Agriculture and Consumer Services. School of Biological Sciences, University of Kentucky, Lexington, KY. 21 pp.

Baskin, J. M., C. C., Baskin, & R. W. Tyndall. 2005. Studies on dormancy of the rare plant species *Aeschynomene virginica* (Fabaceae). Natural Areas Journal 25: 147-155.

Baskin, J. M., R. W. Tyndall, M. Chaffins, & C. C. Baskin. 1998. Effect of salinity on germination and viability of nondormant seeds of the federal-threatened species *Aeschynomene virginica* (Fabaceae). Journal of the Torrey Botanical Society 125: 246-248.

Belden, A, Jr., & N. E. Van Alstine. 2003. Status of the federally listed *Aeschynomene virginica* (L.) BSP. on the James River in Virginia. Castanea 68: 179-181.

Chazal, A. C., & N. E. Van Alstine. 2001. An inventory for rare, threatened, and endangered species in the Jamestown Island 400 Project Area, Colonial National Historical Park. Natural Heritage Technical Report 01-23. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 41 pp. plus appendices.

Daubenmire, R. 1966. Vegetation: identification of typal communities. Science 152: 546-547.

Daubenmire, R. 1968. Plant Communities. Harper and Row, New York. 300 pp.

DeBerry, D. A., & J. E. Perry. 2004. Primary succession in a created freshwater wetland. Castanea 69: 185-193.

Erdle, S. Y., & K. E. Heffernan. 2002. Biological assessment for proposed new construction and increased visitor use impacts at the Jamestown Island Project site. Cooperative Agreement 4000-8-9027, Supplemental Agreement 4. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 25 pp. plus appendices.

Fernald, M. L. 1939. Last survivors in the flora of Tidewater Virginia. Rhodora 41: 465-504, 529-559, 564-574.

Griffith, A. B., & I. N. Forseth. 2002. Primary and secondary seed dispersal of a rare, tidal wetland annual, *Aeschynomene virginica.* Wetlands 22: 696-704.

Griffith, A. B., & I. N. Forseth. 2003. Establishment and reproduction of *Aeschynomene virginica* (L.) (Fabaceae) a rare, annual, wetland species in relation to vegetation removal and water level. Plant Ecology 167: 117-125.

Moore, K. A. 1980. James City County Tidal Marsh Inventory. SRAMSOE #188. Virginia Institute of Marine Science, Gloucester Point, VA. 100 pp.

Mueller-Dombois, D. & H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons, New York. 547 pp.

National Oceanic and Atmospheric Administration (NOAA). 2004a. Tidal Station Location and Ranges. Center for Operational Oceanographic Products and Services. Silver Spring, MD. http://co-ops.nos.noaa.gov/tides04/tab2ec2c.html#58

National Oceanic and Atmospheric Administration (NOAA). 2004b. National Weather Service Center. National Climatic Data Center, Asheville, NC. http://lwf.ncdc.noaa.gov/oa/climate/research/cag3/y9.html

National Oceanic and Atmospheric Administration (NOAA). 2005. Climate Research. National Climatic Data Center, Asheville, NC. http://www.ncdc.noaa.gov/oa/climateresearch.html

Parker, V. T., & M. A. Leck. 1979. Seed dispersal and seedling survival in relation to zonation patterns in a freshwater tidal marsh. Bulletin of the Ecological Society of America 60: 133.

Parker, V. T., & M. A. Leck. 1985. Relationships of seed banks to plant distribution patterns in a freshwater tidal wetland. American Journal of Botany 72: 161-174.

Perry, J. E., & R. B. Atkinson. 1997. Plant diversity along a salinity gradient of four marshes on the York and Pamunkey rivers in Virginia. Castanea 62: 112-118.

Perry, J. E., & C. H. Hershner. 1999. Temporal changes in the vegetation pattern in a tidal freshwater marsh. Wetlands 19: 90-99.

Simpson, R. L., R. E. Good, M. A. Leck, & D. F. Whigham. 1983. The ecology of freshwater tidal wetlands. BioScience 33: 255-259.

Townsend, J. F. 2004. Natural Heritage resources of Virginia: rare plants. Natural Heritage Technical Report 04-06. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 56 pp. plus appendices.

U.S. Fish and Wildlife Service. 1995. Sensitive joint-vetch (*Aeschynomene virginica*) recovery plan. Hadley, MA. 55 pp.

Ware, D. M. E. 1991. Northern Joint-vetch, *Aeschynomene virginica* (L.) B.S.P. Pp. 119–121 *In* K. Terwilliger (Coordinator), Virginia's Endangered Species. McDonald & Woodward Publishing Company, Blacksburg, VA.

Sensitive Joint-vetch (*Aeschynomene virginica*), original drawing by Megan Rollins.