Conservation Assessment
for

Appalachian Jacob's Ladder (Polemonium van-bruntiae) Britton

USDA Forest Service, Eastern Region

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessement for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service- Threatened and Endangered Species Program at 310 West Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

Appalachian Jacob's ladder (*Polemonium vanbruntiae* Britton) is an herbaceous perennial in the phlox family (Polemoniaceae). Although it is sometimes cultivated, in the wild it is rare range-wide. In the United States, it is extirpated in New Jersey, endangered in Maine and Pennsylvania, and threatened in Maryland, New York, Vermont, and West Virginia; in Canada, it is threatened in Quebec and historic in New Brunswick.

Appalachian Jacob's ladder in the wild is generally found in seepy areas, often where the soil is circumneutral. Its habitats include seepy woods and stream banks, many kinds of wetlands, and even wet roadside ditches; it often occurs at high altitudes (above 300 meters or 1000 ft). While these plants do reproduce vegetatively and can form large clones interconnected by rhizomes, bees visit flowers, and may serve as pollinators. Out-crossing may be encouraged by its protandrous flower development. Seeds apparently require winter dormancy, and are reportedly dispersed by winter winds and spring floods.

The most recent Element Occurrence Records estimate 84,000 plants in 77 native and two introduced populations in North America. The species' stronghold is in New York, Maryland, and West Virginia. Many populations have not been visited for nine or more years; substantial changes may have occurred during this time. Since this report is for both the New England Wildflower Society and the Eastern Region[1] of the USDA Forest Service, information presented pertains to both New England and any National Forest within the Region that has documented occurrences of Appalachian Jacob's ladder.

Although the number of plants may seem high, they are rare everywhere that they occur, and many populations have disappeared. Threats include habitat loss due to succession, flooding, road building and maintenance, off-road vehicle use, and other activities that change the hydrology or water quality. Other threats include grazing by domestic and wild animals, and mowing roadside populations. In addition, data trends within and across sites are not easily quantified, because of inconsistent and unclear monitoring units (stems versus plants versus clumps) and a lack of data for some sites.

The overall conservation objective is to maintain the current number and size of populations at or above the current level. Management needs include: 1) protection of sites; 2) further investigation of the species' biogeography; 3) standardized of monitoring methods, followed by an update of distribution information; and 4) refined studies of species biology and habitat, followed by development of management plants.

[1] The Eastern Region (U. S. Forest Service Region 9) includes Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin. The only National Forest within these states where this species is documented, extant or historic, is West Virginia. While it occurs elsewhere in the region, it does not have habitat on the National Forests in those states (USDA Forest Service 2000).

ACKNOWLEDGMENTS

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Elizabeth Farnsworth of the New England Wildflower Society (NEWFS) patiently answered innumerable questions as this document progressed. Bill Brumback, also of NEWFS, answered questions about seed germination and plant introductions. Diane Burbank of the Green Mountain National Forest also provided occasional guidance.

Laura Hutchinson, Library Services Leader North Central Research Station of the USDA Forest Service performed numerous literature searches and arranged for pertinent articles to be photocopied and mailed to me.

PREFACE

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda:* New England," which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of Flora Conservanda species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection.

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INTRODUCTION

Polemonium vanbruntiae Britton (Polemoniaceae) - Appalachian Jacob's ladder - is a perennial that grows in a variety of wet habitats, including seepy woods, wet roadside ditches, and several types of wetlands. These plants reproduce both vegetatively, by means of rhizomes that send up new shoots, and sexually, through the production of flowers and fruits. While bees have been observed visiting flowers, and the plant's floral structure is thought to promote outcrossing, little is known about its pollination biology. Flowers and fruits are common in most populations. Seeds can be germinated artificially, and at least one reintroduced population has been very successful. However, seed set and germination rate have not been studied in the wild. Likewise, although grazing by deer and cattle reportedly threaten some populations, little has been reported regarding interactions with other species.

Appalachian Jacob's ladder is known only from northeastern North America, and has a global rank of G3. Within the United States, Appalachian Jacob's ladder is listed as extirpated in New Jersey, endangered in Maine and Pennsylvania, and threatened in Maryland, New York, Vermont, and West Virginia. In Canada, it is listed as historic in New Brunswick and threatened in Quebec. The historic New Brunswick population may have been introduced (Hinds 1983). Where extant, its rank is S1, S2, or S3 (See Table 1 for more detail). While populations are secure in some places, others are not, and some have already been destroyed. In New England, the major threats are road maintenance,

logging activities, periodic flooding, beaver activity, canopy closure, and grazing. Elsewhere, proposed power projects, recreational development, adjacent off-road vehicle trails, flooding, and grazing are the major threats. Threats to individual populations are described below, and are also listed on Element Occurrence Records.

The global G3 rank assigned to Appalachian Jacob's ladder indicates that it is "threatened globally: rare and/or local" (Vermont Nongame and Natural Heritage Program 2001). This, in combination with its listing as endangered or threatened in all states or provinces where it occurs, suggests that a plan for the conservation of this species is greatly needed. While all populations of Appalachian Jacob's ladder in New England (only Maine and Vermont) are extant, many populations in nearby states are now listed as historic, and some have been destroyed; this places increasing significance on the survival of the New England populations. In addition, management decisions are hampered by the lack of information regarding this species' biology and specific habitat requirements.

The first part of this conservation plan assesses what is currently known about Appalachian Jacob's ladder. It describes the plant, its taxonomic relationships, history, and synonymy; it covers the species' biology, habitat/ecology, threats, distribution and status, and current conservation measures. The second part discusses conservation objectives and recommended actions. Because this conservation plan is written not only for the New England Plant Conservation Program, but also for the U.S.D.A. Forest Service, it includes detailed information about sites in West Virginia, where Appalachian Jacob's ladder is on the list of Regional Forester Sensitive Species for the Monongahela National Forest. It also includes some more general information for other states and provinces throughout the plant's range; two of these states, New York and Pennsylvania, also have National Forests, but there are no known extant or historic occurrences of Appalachian Jacob's ladder on National Forest land.

DESCRIPTION

The following description is a composite of information from Fernald (1950), Newcomb (1977), Gleason and Cronquist (1991), Zomlefer (1994), Magee and Ahles (1999), and Crow and Helquist (2000). Appalachian Jacob's ladder is a flowering, herbaceous perennial, with an erect stem ranging in height from 0.4 - 1.0 m. Its leaves are alternate, pinnately compound, and consist of 15 to 21 leaflets. Leaflets are well separated, the space between them generally 1 – 2 cm, or rarely up to 3.5 cm. They are narrowly ovate, with acute leaf-tips. Flowers are terminal, arranged in a raceme, which is sometimes compact, and each inflorescence is generally few-flowered. Individual flowers are bell-shaped, with five blue to purple united petals. The resulting corolla is lobed to about the middle. When the flower is fully expanded, the petals are 14 – 20 mm long and often have irregular margins, and the sepals are 8 – 10 mm long and are generally longer than the pedicels. Calyx lobes are longer than wide, and continue to grow as the fruit develops. Stamens protrude from the flower, surpassing the corolla by 5 – 7 mm. The fruit consists of a capsule with three locules and one to ten seeds per locule (Thompson 1991). The capsule is surrounded by the calyx, which becomes papery as it matures.

Appalachian Jacob's ladder is distinguished from a closely related species, Greek valerian (*Polemonium reptans*), with which it overlaps in range, by the following differences:

- **stamen position** (protruding in Appalachian Jacob's ladder versus not protruding in Greek valerian)
- **habit** (erect in Appalachian Jacob's ladder versus weak and reclining in Greek valerian) number of leaflets per leaf (15 – 21 in Appalachian Jacob's ladder versus 11 – 17 in Greek valerian)
- **phenology** (summer bloom for Appalachian Jacob's ladder versus spring bloom for Greek valerian)
- **habitat** (a variety of wetlands or seepy places for Appalachian Jacob's ladder versus rich woods for Greek valerian).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Nathaniel Lord Britton first published the name *Polemonium vanbruntiae* in the *Bulletin of the Torrey Botanical Club* in 1892. He named the plant after Mrs. Cornelius Van Brunt, of Ulster County, New York, who supplied him with "…such fine and numerous specimens by means of which the marked differences between it and the European plant may be pointed out" (Britton 1892: 224-225). He described it as a species of cold, wet places, found in New York, Vermont, New Jersey, and Maryland. It has since been found in other states in the U. S., and in two Canadian provinces.

Previously, this species had been thought to be the same entity as the European *Polemonium caeruleum* L., but Britton described it as differing from this species in having a horizontal rootstock, leafier stem, broader and fewer leaflets, exserted stamens, rounded petal lobes, a calyx that continues to grow with age, and fewer ovules. For plants recorded as *P. caeruleum* from sites in the eastern U. S. and adjacent Canada, *P. caeruleum* is considered a synonym for *P. van-bruntiae* (also spelled *vanbruntiae* and *Van-bruntiae).* For plants recorded as *P. caeruleum* from the Rocky Mountains, *P. caeruleum* is not a synonym for *P. van-bruntiae*. These Rocky Mountain plants are now recognized as a separate species, *Polemonium occidentale* Greene. Although primarily a western species, *P. occidentale* is also known from bogs in northern Minnesota (Gleason and Cronquist 1991). One other synonym for *P. vanbruntiae* is *P. caeruleum* ssp. *vanbruntiae* (Britt.) J. F. Davids., listed by Kartesz and Meacham (1999). Davidson (1950) recommended division of *P. caeruleum* into this and three other subspecies, but other botanists have not concurred. A final note by Gleason and Cronquist (1991) is that the European *P. caeruleum* occasionally escapes from cultivation in this country, and thus there is the possibility of encountering plants in the field that should still be given this name, and not *P. van-bruntiae*. The cultivated and wild species are apparently easily confused in the field, and a 1919 record of *P. van-bruntiae* from Knox County in Maine was later determined to be a specimen of *P. caeruleum* that had escaped from a nearby cemetery (Fernald 1949 in Johnson and Murray 1988).

The range of *Polemonium vanbruntiae* overlaps with *P. reptans*, and although some botanists may have confused the two species, there are clear morphological differences between them, as described in the previous section. *Polemonium reptans* also includes a variety that is local to Ohio and Kentucky (Gleason and Cronquist 1991). The *Synthesis of the American Flora* (Kartesz and Meacham 1999) lists numerous other species of *Polemonium*, most of them either northwestern or southwestern species; none of these is listed as a synonym of either *P. vanbruntiae* or *P. caeruleum*.

Common names for *Polemonium vanbruntiae* are varied. Gleason and Cronquist (1991) list it as Appalachian Jacob's ladder, Kartesz and Meacham (1999) list it as bog Jacob's-ladder, and most authors list it as simply Jacob's ladder (NatureServe 2001), sometimes written as "Jacob's-ladder." The "ladder" portion of the name refers to the well-separated, parallel, ladder-like arrangement of leaflets in a leaf.

SPECIES BIOLOGY

Appalachian Jacob's ladder reproduces both vegetatively and sexually. Factors influencing rates and limitations of both are unknown (Farnsworth in press). Many aboveground stems may be clones (ramets) connected by underground rhizomes, forming one large clump (genet). One genet may occupy as much as "several tens of square feet", and may consist of as much as hundreds of stems (Thompson 1991). No data have been found that estimate the lifespan of an individual plant.

Plants will often flower and fruit in their second year. Flowers open in mid- to late summer, with fruits developing in late summer to early fall. Flowers in the phlox family are often protandrous (Zomlefer 1994); the pollen is produced within a flower prior to when the stigma is receptive, which can facilitate out-crossing within a population (Popp 1990). Small and large bees have been observed visiting the flowers in Vermont populations (Popp 1990, Engstrom 1993 in a Vermont Element Occurrence Record), and other insects, butterflies, and hummingbirds have been observed visiting populations in Quebec (Sabourin and Paquette 1994). While bees have been confirmed as pollinators for this species (Grant and Grant 1965 in Harborne and Smith 1978), no thorough studies have been done that list all the pollinators and/or their effectiveness in terms of seed set. Galen and Newport's (1988) research on the alpine sky pilot (*Polemonium viscosum*) suggested that pollen impurity negatively effected seed set. It is certainly possible that this is a limiting factor in other species of *Polemonium*, as well.

Flowering and fruiting within a population appear to be common; most Element Occurrence Records (EORs) — Vermont records, the one Maine record, and about half of the West Virginia records — indicate that populations visited were budding, flowering, or fruiting whenever they were visited. While seed set has been studied extensively in two closely related species, towering Jacob's ladder (*Polemonium foliosissimum*) and alpine sky pilot (*Polemonium viscosum*), no studies have been documented for Appalachian Jacob's ladder.

Likewise, while insect herbivory of either reproductive or vegetative plant parts has not been documented for Appalachian Jacob's ladder, it is well known in towering Jacob's ladder. In this western mountain species, pre-dispersal seed predation by flies in the genus *Hylemya* is common, and removes a substantial number of seeds from the seed bank (Zimmerman 1979, 1980). In alpine sky pilot, also a western species, nectar-thieving ants reduce the reward available to pollinators, damage the style, and significantly reduce seed set (Galen 1999). These studies on closely related species suggest some possible avenues of research with populations of Appalachian Jacob's ladder.

While wind and water are the most likely seed dispersers of Appalachian Jacob's ladder (Sabourin and Paquette 1994), it is possible that animals are also involved, although there is no documentation of this. One study of ant-dispersal of seeds in a community that included Appalachian Jacob's ladder did not reveal any such dispersal of Appalachian Jacob's ladder seeds (Beattie and Culver 1981). However, this study was not conclusive for this species.

Results of seed germination experiments, in which seeds refrigerated at 1^{o}-5^{o} C had a higher germination rate than those that weren't refrigerated, suggest that Appalachian Jacob's ladder seeds require winter dormancy at a cold temperature in order to germinate (Brumback 1989; W. Brumback, New England Wild Flower Society, personal communication). Davidson (1947) describes the entire genus as having seeds that are relatively easily cultivated.

HABITAT/ECOLOGY

Appalachian Jacob's ladder is found in a variety of wet habitats, including: several types of wetland; seepy woods of varied composition (mostly in openings); and wet roadside ditches. Sabourin and Paquette (1994) suggest that, for some Quebec populations, road construction may have contributed to decline, with roadside ditches being the only remaining suitable habitat where the plants can still hold on. In New England, sites where Appalachian Jacob's ladder occurs vary in elevation from 67 m to 549 m (220 ft to 1800 ft). Outside of New England, elevation is often higher. In West Virginia, at the southern edge of the species' distribution, elevation ranges from 604 m to 1042 m (1980 ft to 3420 ft), with most sites occurring above 960 m (3150 ft). The Cranberry Glades of West Virginia, which house one population of Appalachian Jacob's Ladder, have a climate that is similar to northern New England (Anonymous 2002), due to an elevation of 1037 m (3400 ft) and cold air draining from the surrounding taller mountains. In New York State, Appalachian Jacob's ladder populations occur in the Catskill High peaks region, which is higher in elevation and receives more rainfall than the surrounding area.

Soils data, documented in EORs for only a few sites in Vermont and West Virginia, suggest that Appalachian Jacob's ladder usually prefers soils that are circumneutral. Maryland data supports this hypothesis - soil pH is 6.7 and 6.8 at the two sites where measurements have been taken (Ed Thompson, Maryland Department of Natural Resources, personal communication). Populations in Pennsylvania are all in wetlands;

while soil data have not been recorded, flora in two of these sites suggests circumneutral soil, but elsewhere, associated species are less easily interpreted (J. Kunsman, Eastern Pennsylvania Nature Conservancy, personal communication). In contrast, soil in the Cranberry Glades community has a pH of 4.4, apparently due to the large amount of *Sphagnum* present (Darlington 1943), and soil pH averages 5.0 in the Catskill High Peaks region (USFWS 2001). Additional descriptors include: organic (including muck, which is well decomposed); gleyed (having lost iron due to permanent soil saturation); not gleyed, mottled (indicative of seasonal water fluctuation); not mottled; and minerotrophic — suggesting heterogeneity between sites with regard to soil characteristics.

Throughout their range, the majority of known Appalachian Jacob's ladder populations grow in sites with a canopy that is at least partially open, and in many sites, there is little to no canopy cover. In Canada, habitat for this plant includes bogs, marshy alder thickets, and very wet mixed woods (Bouchard et. al. 1983). Sabourin and Paquette (1994) suggest that the species has problems spreading in habitats where competition from grasses is strong, but that it tolerates the shade of willows and alders. In Vermont, Thompson and Sorenson (2000) list [Appalachian] Jacob's ladder as a rare plant of seeps and red maple-northern white cedar swamps. The Maryland populations are in open or partially open wet meadows, with the sunniest sites having the most vigorous plants (Thompson, personal communication). Pennsylvania plants are all in wetlands. Comments on many EORs suggest that plants in sites receiving the most shade appear less vigorous and produce fewer flowers. General descriptions of habitat documented in EORs (for Maine, Vermont, and West Virginia) indicate that Appalachian Jacob's ladder grows in a variety of natural communities. Forested swamps where Appalachian Jacob's ladder occurs are described in these records as hardwoods-northern white cedar, calcareous seepage, circumneutral seepage, and spruce-fir. Other forested sites are described as floodplain woods, swales, springs, and seeps, and these are sometimes very open. Other communities dominated by woody vegetation and providing habitat for Appalachian Jacob's ladder include a spruce bog, alder thickets, and shrub swamps, often with alder. Appalachian Jacob's ladder also grows in wet meadows, graminoid marshes, riverside seeps, and wet roadside ditches. More specific soil and water chemistry requirements of this species are unknown (Farnsworth in press).

Associated plant species listed in EORs from Vermont and West Virginia vary depending on the type of natural community in which Appalachian Jacob's ladder is growing. Only eleven out of 20 EORs from West Virginia and five out of nine from Vermont list any associated species. The Maine population is described in the EOR as a seasonally moist sedge/fern meadow, with no specific details. For a complete list of associated species listed in EORs, see Appendix 2. All scientific and common names used come directly from EORs and may not be the most widely accepted names. When only a common or a scientific name was given, the corresponding common or scientific name is that used by Kartesz and Meacham (1999). At forested sites, some of which may be quite open, various combinations of tree species are listed, as described below. In both Vermont and West Virginia, red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), and trembling aspen (*Populus tremuloides*) are commonly associated tree species. Other tree species associated with at least two Vermont populations include red maple (*Acer rubrum*),

yellow birch (*Betula alleghaniensis*), black ash (*Fraxinus nigra*), northern white cedar (*Thuja occidentalis*), and hemlock (*Tsuga canadensis*). Five other tree species are each mentioned once at Vermont sites; no additional tree species are mentioned for West Virginia sites. Shrubs associated with both Vermont and West Virginia populations include alder-leaved buckthorn (*Rhamnus alnifolia*) and willows (*Salix* spp.). One other shrub species associated with at least two Vermont populations is poison sumac (*Toxicodendron vernix*); three other species are mentioned only once. Smooth alder (*Alnus rugosa*), and possibly other alder species (*Alnus* spp.) are known from three West Virginia populations. Another six shrub species are noted from West Virginia, each of them from only one site. Among the 36 flowering herbaceous plants noted on EORs, only one, manna-grass (*Glyceria melicaria*) is mentioned for both Vermont and West Virginia; it is the dominant herbaceous plant at a West Virginia site. However, six other herbaceous species listed are dominant in the communities in which they occur. In Vermont, these are bluejoint (*Calamagrostis canadensis*), fringed sedge (*Carex crinita*), spotted touch-me-not (*Impatiens capensis*), tall meadow rue (*Thalictrum pubescens*), and wood-nettle (*Laportea canadensis*); in West Virginia, they are fowl manna grass (*Glyceria striata*) and rice-cut grass (*Leersia oryzoides*). Another rare plant, rough avens (*Geum laciniatum*) is documented to occur in association with one of the Vermont populations. A total of six species of ferns and horsetails are listed in EORs; of these, royal fern (*Osmunda regalis*) is dominant at one Vermont site, and cinnamon fern (*Osmunda cinnamomea*) is dominant at one West Virginia site. None are listed for both Vermont and West Virginia. Two moss genera, *Polytrichum* and *Sphagnum*, are listed for West Virginia sites; none are mentioned for Vermont sites, although they may be there.

In Maryland, some herbaceous plants commonly associated with Appalachian Jacob's ladder are bluejoint (*Calamagrostis canadensis*), tussock sedge (*Carex stricta*), brome-like sedge (*Carex bromoides*), brown bog sedge (*Carex buxbaumii*), lakebank sedge (*Carex lacustris*), eastern swamp saxifrage (*Saxifraga pensylvanica*), and simpler's-joy (*Verbena hastata*), and shrubs include speckled alder (*Alnus incana*) and smooth arrow-wood (*Viburnum recognitum*) (Thompson, personal communication). In Pennsylvania, two of the wetland sites are described as having "circumneutral-like flora," but no specifics are given (Kunsman, personal communication). In Canada, associated species include: virgin's bower (*Clematis virginiana*); meadowsweet (*Spirea latifolia*); flat-topped aster (*Doellingeria umbellata*); and spotted joe-pye weed (*Eupatorium maculatum*) and some sites are dominated by bluejoint (*Calamagrostis canadensis*) (A. Sabourin, Botanist, personal communication).

In New York, commonly associated vegetation includes: alder (*Alnus* spp.); willow (*Salix* spp.); red maple (*Acer rubrum*); eastern hemlock (*Tsuga canadensis*); cinnamon fern (*Osmunda cinnamomea*); meadowsweet (*Spirea alba*); sedges (*Carex* spp. [especially *C. stipita* and *C. stricta*] and *Scirpus* spp.); cattail (*Typha latifolia*); and sensitive fern (*Onoclea sensibilis*). Approximately another 70 associated species are listed in New York State Heritage Program records.

THREATS TO APPALACHIAN JACOB'S LADDER

Threats to Appalachian Jacob's ladder include succession, flooding, road maintenance or construction, off-road vehicles, and grazing. In addition, monitoring problems complicate our understanding of the species status. Although some of the threats to this species are the same throughout much of its range, others are specific to the location of the population. There are no data regarding threats for thirteen sites: the only known Maine population (ME .001), the two introduced Vermont populations (VT .012 and .013), and ten West Virginia populations (WV .004, .006, .007, .010 - .014, .017, and .022). Three of the West Virginia populations for which there are no data regarding threats are A-ranked populations. It is unclear whether there are no threats to these populations, or the threats are simply unknown and/or undocumented.

Succession

Two EORs (VT .005 [Ripton] and .007 [Lincoln]) list canopy closure, or conversion of habitat to forest, as a threat to a population. This concern is based on field observations of plants in full sun compared to those in the shade — those receiving more sunlight appear to be more vigorous and have a greater number of reproductive stems than those in shadier spots. Likewise, of the two experimental reintroductions, the population that was introduced into an area with no canopy cover (VT .012 [Ripton]) is reportedly thriving, compared to the population introduced into a site with closed canopy (VT .013 [Ripton]), which has not been as successful.

However, timber harvest is listed as a potential threat to three Vermont populations (VT .002 [Cornwall], .003 [Leicester], and .006 [Lincoln]). It is unclear whether timber harvest is listed as a threat to these latter populations because of the change in canopy that would result (which is in conflict with concerns about canopy closure), or because of potential direct impacts, or soil disturbance and changes in hydrology. If canopy closure is, indeed, a threat to populations of Appalachian Jacob's ladder, many populations may dwindle as sites change over time.

Flooding

Another common threat is flooding, either because of human activity (e.g., dams that are part of power projects), beaver activity, or heavy rains. Beaver activity is a potential threat to one of the Vermont populations (VT .001 [Ripton]) and has already destroyed part of one of the West Virginia populations (WV .002 [Osceola]), although it is apparently still a large population. Flooding of a river as a result of heavy rains is the suspected cause of loss of one Vermont subpopulation (VT .005 subpopulation B [Ripton]), although the rest of that population was unharmed (USDA Forest Service 1998). In West Virginia, the proposed Davis Power Project once threatened five populations (WV .016 and .018 - .021 [all in Davis]); one of these (WV .018 [Davis]) is an A-ranked occurrence. However, that proposed project is no longer viable, and is, therefore, no longer a threat to these five populations (B. Sargent, West Virginia Natural

Heritage Program, personal communication). In Pennsylvania, the impoundment of a wetland to form a recreational lake has already permanently destroyed one population of Appalachian Jacob's ladder (S. Grund, Western Pennsylvania Chapter of The Nature Conservancy, personal communication), along with other rare plants. While flooding due to beavers and heavy rains would be difficult — if not impossible — to prevent, flooding due to human activity does not have to occur. Temporary flooding, of any sort, may or may not destroy a plant population, and permanent flooding can destroy not only the plant population, but also the entire habitat.

Road Maintenance or Construction

Three of the Vermont populations (VT .004 [Lincoln], .005 [Ripton], and .006 [Lincoln]) are either immediately adjacent to roads, or are close enough potentially to be impacted by road widening or other construction, or by annual roadside mowing. In some cases, mowing during the growing season has been successfully averted by alerting the mower to their presence. However, questions remain regarding whether to mow around Appalachian Jacob's ladder plants, or to mow the entire roadside after the growing season. Untimely mowing may reduce the reproductive success of some plants, and other kinds of roadwork may harm individual plants and/or habitat. While no other specific kinds of roadwork are mentioned in EORs, presumably road widening, ditch cleaning, salt run-off, and herbicide use could occur and pose a threat to these plants.

Off-Road Vehicles

Trails, especially those used by off-road vehicles, including all-terrain vehicles, are cited as threats to five West Virginia populations (WV .001, .003, and .019 - .021). The threat to these populations is the potential for direct loss of any plants that are trampled, in addition to changes in hydrology as a result of soil compaction due to vehicle use.

Grazing

Herbivory can also be a threat to Appalachian Jacob's ladder. Deer browsing is listed as a threat to one Vermont population (VT .005 [Ripton]), and cattle grazing is listed as a threat to another population in Vermont (VT .007 [Lincoln]) and two in West Virginia (WV .002 and .005 [towns unknown]). While none of the EORs lists insects as problematic herbivores, there is substantial documentation of damage, especially to seeds, in populations of a related western species, *Polemonium foliosissimum* (Zimmerman 1980). It is possible that a similar problem exists for *P. van-bruntiae*, and has not yet been documented or studied. The threats posed by grazing are damage to the photosynthetic capabilities of individual plants and loss of seed viability. In *P. foliosissimum*, defoliation led to a reduced end-of-season biomass (Zimmerman and Pyke 1988); this, in turn, may result in reduced reproductive success in subsequent years, or even complete loss of individuals or populations. Grazing, in combination with monitoring problems (discussed below), could result in undetected downhill trends in a population.

Monitoring Problems

A final category of problems has to do with complications encountered when monitoring Appalachian Jacob's ladder. In one instance, the landowner has denied access to the site. More complicated is the lack of consistency in units of measurement used to monitor populations. These inconsistencies stem, at least in part, from the habit and morphology of the plants. Appalachian Jacob's ladder plants are notoriously difficult to quantify. First, because they reproduce vegetatively, and also because there is often little space between one genet and the next, it is difficult to count plants (genets). Even a count of stems (ramets) is not simple, since it is difficult to tell the difference between new stems versus basal leaves of an established stem. Second, because the stems and leaves of these plants become tangled with each other and with associated species, and they are generally too fragile to untangle, an accurate stem count may be unrealistic. Fruiting stems are, however, somewhat less difficult to count, since they stand tall within the rest of the vegetation. The result of these complications is that EORs for this species are based on a number of different units of measure (genet, ramet, stem, plant, clone, clump), that make comparison, either within one population over time or between different populations, difficult. Without consistent and practical methodology for monitoring their populations, trends may go unnoticed.

DISTRIBUTION AND STATUS

General Status

Appalachian Jacob's ladder has a global rank of G3, and is a narrow endemic that occurs only in eastern North America. In the United States, it has a national rank of N3 (1994). It is Endangered (E) in Maine (S1) and Pennsylvania (S1; PE denotes Pennsylvania Endangered); Threatened (T) in Maryland (S2), New York (S3), and Vermont (S2); rare in West Virginia (S2; West Virginia has no state T or E categories); and extirpated (SX) in New Jersey (SX.1 denotes one extirpated occurrence.) In Connecticut, a specimen was allegedly reported in error (SRF) from Salisbury (N. Murray, Connecticut Department of Environmental Protection, personal communication). Les Mehrhoff of the University of Connecticut Herbarium has suggested that this specimen, which was annotated to *P. reptans*, be reexamined; however, the herbarium is currently being moved to a new building, and specimens will not be accessible until at least mid August, 2002. In addition to the Heritage Program records for Vermont, Jenkins (1982) lists six historic records. Three of the extant populations are from the same towns as three of these historic records; thus records from these towns may not be historic. In Canada, Appalachian Jacob's ladder has a national rank of N1 (1989). It is threatened in Quebec (S1) and historic (SH) in New Brunswick. *Flora Conservanda:* New England (Brumback and Mehrhoff et al. 1996) categorizes Appalachian Jacob's ladder in Division 1, for globally rare taxa occurring in New England. Table 1 and Figure 1 summarize the status of Appalachian Jacob's ladder throughout its range. Explanations of G, N, and S ranks are in Appendix 3.

Table 1. Occurrence and status of *Polemonium vanbruntiae* in the United States and Canada based on information from Natural Heritage Programs.		
OCCURS & LISTED (AS S1, S2, OR T &E)	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
Maine (S1, E) 1 extant occurrence	Connecticut (SRF)	New Brunswick (SH)
Maryland (S2, T) 9 extant occurrences and 6 historic occurrences (2 of which are questionable)		New Jersey (SX.1)
New York (S3, T) 30 extant and 14 historic occurrences		
Pennsylvania (S1, PE) 3 extant, 2 historic, 1 failed, and 2 destroyed occurrences		
Vermont (S2, T) 9 extant occurrences and at least 3 historic		
West Virginia (S2) 18 extant and 2 historic occurrences		
Quebec (S1, T) 9 extant occurrences and 2 historic occurrences		

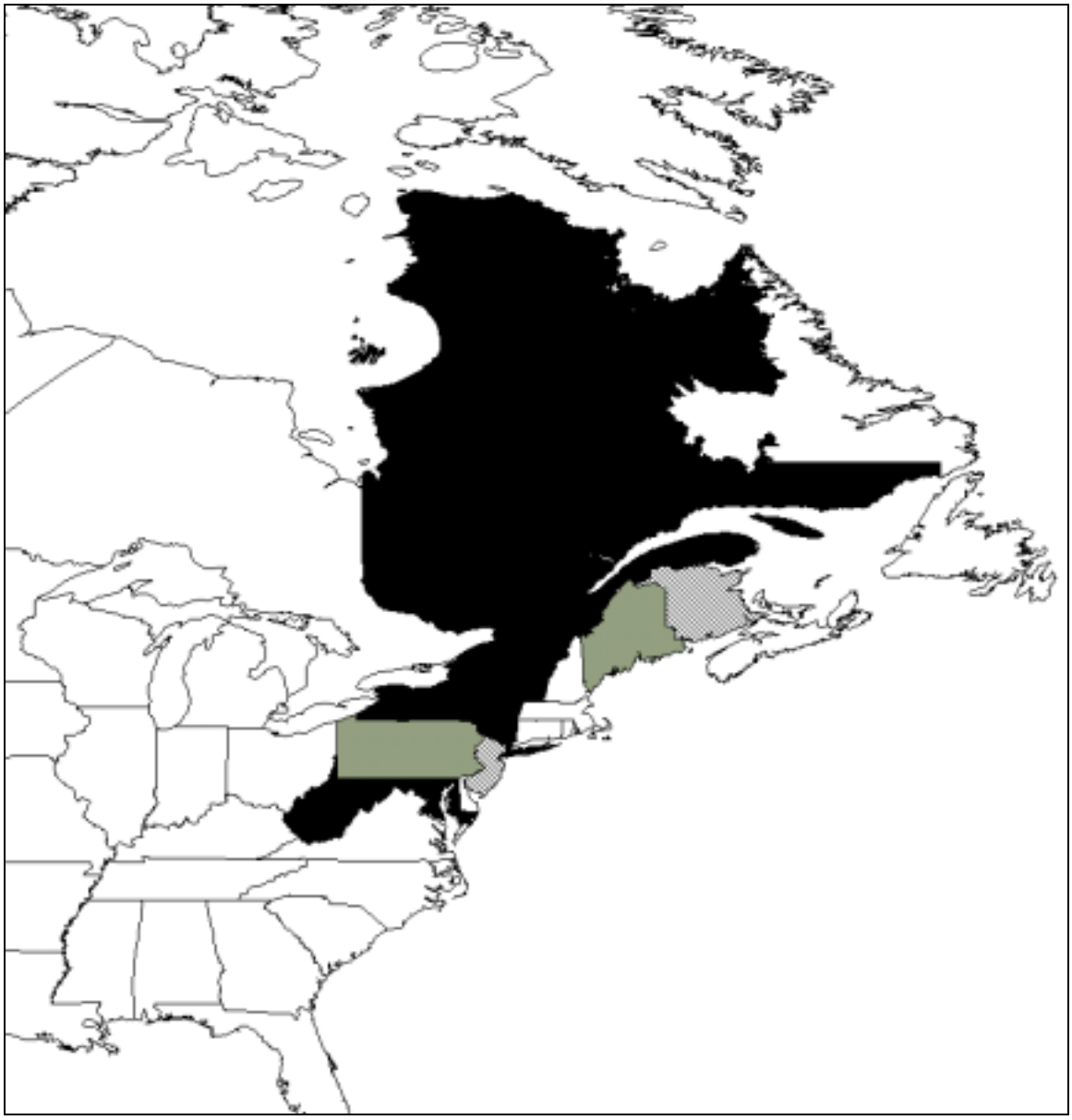

Figure 1. Occurrences of *Polemonium van-bruntiae* in North America. States and provinces shaded in gray have one to five current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. See Appendix 3 for explanation of state ranks).

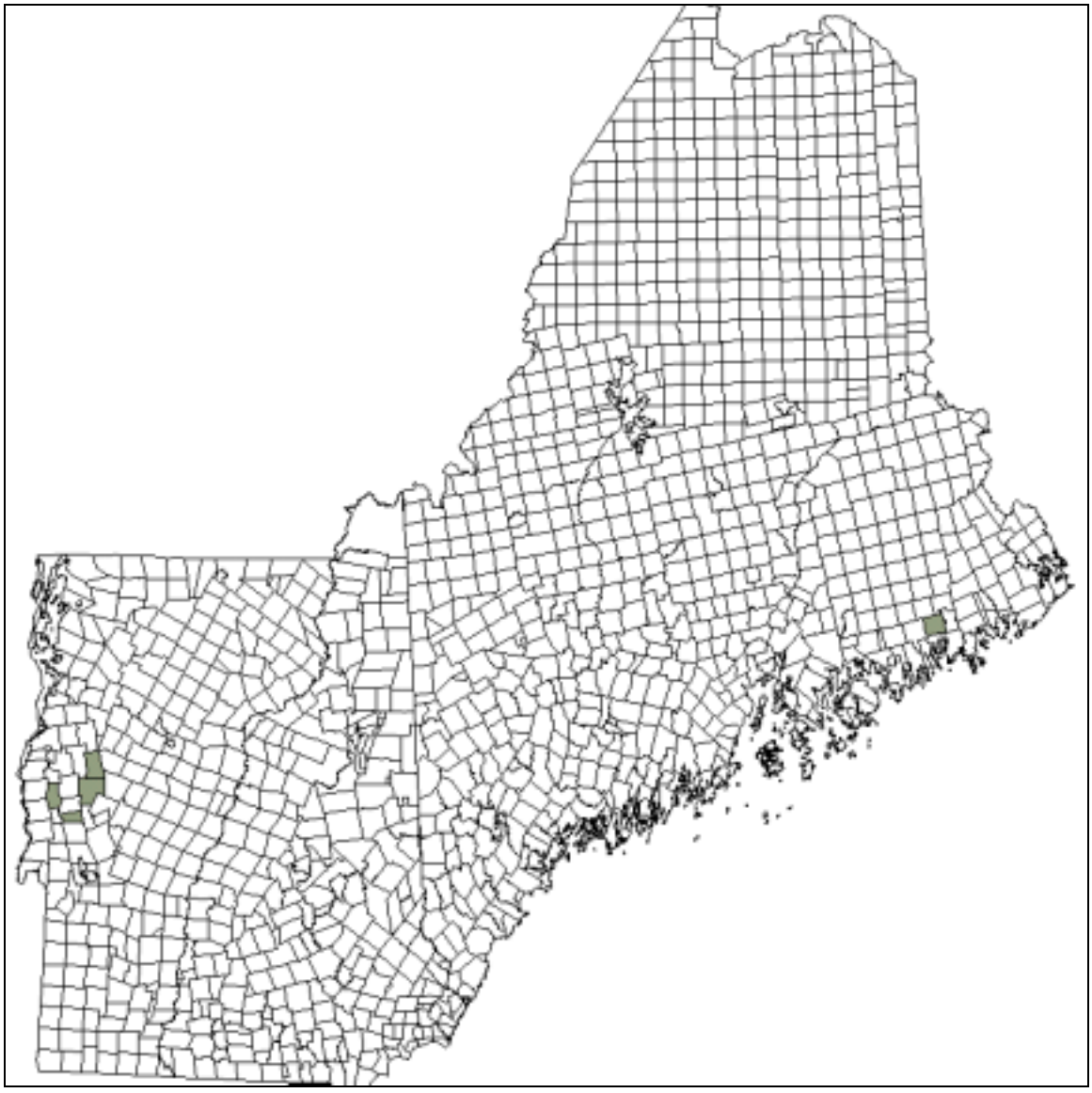

Figure 2. Extant occurrences of *Polemonium van-bruntiae* in New England. Town boundaries for Maine, New Hampshire, and Vermont are shown. Towns shaded in gray have one to five extant occurrences of the taxon. All occurrences in New England are considered extant, so a map of historic records is not shown.

Status of Region 9 Occurrences — Current and Historical

Below is a detailed description of each Element Occurrence (EO) of Appalachian Jacob's ladder, in narrative form. Immediately following these narratives in Table 2 is a summary of information on each of the New England occurrences of Appalachian Jacob's ladder, followed by a summary for occurrences in West Virginia (Table 3). The Tables list the state, county, town, and site ownership, followed by the first and last observation dates, site description, element occurrence rank, population size, comments, and threats; current occurrences are in bold. Element Occurrence Records provided by State Natural Heritage Programs are the source for all information in this section.

Status of Maine Occurrences

ME .001 (Columbia) — The one population known from Maine occurs in a seasonally moist sedge/fern meadow. It was first documented in July 1988, with one to ten genets seen; at least some plants were either in flower or in fruit. Approximately 14 individual plants, with 30 fruiting capsules, were observed in August 1993. If these 14 individuals represent 14 genets, the population increased between 1988 and 1993. However, it has an EO rank of C. Ownership of the site is not known, and no threats have been documented.

Status of Vermont occurrences

VT .001 (Ripton) — Within a pond/wetland complex in Ripton, this population is in a graminoid marsh near an incoming stream. It was first observed well over one hundred years ago, in 1878. The site was visited in 1982, 1985, 1993, 1995, and 1999, with an apparent increase in population size at each visit (although no data were collected in 1982 or 1995); however, the different terminology used in measuring the population size — plants vs. genets vs. fruiting culms — renders the data not fully comparable. In August 1999, two patches were observed: one with over 100 fruiting culms, and the other with over 200 fruiting culms. The EO has a C rank. This site is now owned by the Green Mountain National Forest, and is part of a Research Natural Area. The main threat to the population is flooding of the site as a result of beaver activity.

VT .002 (Cornwall) — This population is in a natural community that is predominantly a hardwood-northern white cedar swamp. It was first observed in 1983, and was visited again in 1985, 1993, and 1996. Although the terminology used in measuring the population has not been consistent — clumps vs. plants — the population appears to have declined substantially from 51 – 100 vigorous plants (half of them flowering) in 1985, to one clump with four to five flowering stems in 1996. The EO rank is C. Ownership at the site is a combination of public (Fish and Wildlife) and private. The habitat was described in 1985 as a cut over cedar swamp in open hollows, and cutting is still listed as a threat.

VT .003 (Leicester) — This small population occurs in a large calcareous seepage swamp in a limey valley. The plants were found in a disturbed area along a logging road that allowed in light to about half the population. It has apparently been visited only once, in 1983, and at that time, consisted of ten plants, half of them flowering. Its EO rank is B. Ownership of the site is not known, and no threats have been documented, although ongoing logging is a possibility.

VT .004 (Lincoln) — This population, consisting of six subpopulations, occurs along a one-mile stretch of a rural road. One of the subpopulations was first observed in 1955, and the EOR documents visits for at least some subpopulations in 1987, 1988, 1991, 1992, 1993, and 1994. Forest Service files on the Green Mountain National Forest record more recent visits, including 2001. In 1993, the stem count for the entire population was estimated at more than 800, and the EO is ranked at B. A few of the smallest sub-populations have not been located in recent years. In 2001, five of the six subpopulations were not relocated, but the one that was appeared to have flourished, with an estimated 1000 flowering stems (U. S. Forest Service 2001). The habitat for the entire population is a wet, seepy, roadside ditch, with some tall herbaceous and some young woody vegetation. Ownership of the roadsides is a mix of public (Green Mountain National Forest) and private. Roadside mowing is a threat when it occurs in the growing season, but if it occurs in early autumn when the flowers have already set seed, it may be a good means of holding competition from other plants in check.

VT .005 (Ripton) — Another population of 10 colonies, or subpopulations, occurs along a river, in forest seeps, springs, riverside seeps, and seepy roadside ditches. The plants were first observed in 1992, and were visited again in 1993, 1994, and 1996. In 1993, the total population size was estimated at approximately 800 stems, and its EO rank is AB. Ownership is a combination of public (Green Mountain National Forest) and private. Browsing by deer, canopy closure, road widening, roadside mowing during the growing season, and period flooding along the river are threats to some subpopulations. One small subpopulation immediately adjacent to the river has disappeared, possibly due to a flooding event.

VT .006 (Lincoln) — This population occurs in a roadside ditch and in an adjacent old pasture and alder-goldenrod thicket on the Green Mountain National Forest. The plants were first observed in July 1993, and have not been revisited since. At that time, four genets with 11 flowering/fruiting stems were observed in the wet ditch, and another 35 flowering/fruiting stems were observed several meters back from the road, in the thicket; the EO has a D rank. Threats to the EO include roadwork and potential logging.

VT .007 (Lincoln) — A few miles from Lincoln Gap, this population is in a swale in the woods; the swale consists of an opening in fir/birch woods, with saturated ground. It was first observed in 1985, and was visited again in 1988, 1991, and 1993. In July 1993, the population consisted of two colonies – one with an estimated 900 ramets within about 10 genets, and the other with about four genets. Most plants had flowers or immature fruit, although those in the shade were not flowering, and were the least vigorous. These 1993 population data suggest that the population is very similar to, or possibly slightly smaller

than, what was reported in 1985, and it has a B EO rank. The land at this site is privately owned, and shows evidence of wind-thrown trees and logging. The main threats described are succession to forest and cattle grazing. However, proximity to the road may mean that some roadwork also could cause problems.

VT .012 (Ripton) — One of the two introduced populations, this EO occurs in a small natural opening near a rural dirt road, and its EO rank is I. The site had 100% ground cover but minimal tree canopy cover, and was wet. Seeds were collected from a Lincoln population and grown at the Garden in the Woods, and 42 individuals were planted at the site in 1990. The site was monitored in 1991 and 1993; in 1993, 39 plants were counted, of which 30 were in fruit. In subsequent visits, recorded in Forest Service files, the population had expanded to the extent that the plants were almost too dense to count; in a partial count, 118 clumps were recorded, of which 41 were reproductive (USDA Forest Service 1998). Note, however, that difficulty in relocating stakes and/or discerning numbers on them, dense associated vegetation, heavy rain at the time of counting, debris deposited by recent flooding, and fragile *Polemonium* stems resulted in an incomplete count. However, this population appeared vigorous. The land belongs to the Green Mountain National Forest, and the only threat would be a storm significant enough to cause substantial flooding.

VT .013 (Ripton) — A second introduced population is in a small natural opening near a seasonal pond and intermittent stream, and its EO rank is I. The site has a mostly closed canopy, but less dense understory, and organic wet soil. Seeds were collected from a population in Lincoln and grown at the Garden in the Woods, and 42 individuals were planted in 1990. The population was monitored in 1991 and 1993; in August of 1993, the population had declined to 26 plants, with only three in fruit. The land belongs to the Green Mountain National Forest, and the only threats would be continued canopy closure, and a storm significant enough to cause substantial flooding.

In addition to the above EORs, Jenkins (1982) lists six historic occurrences in Vermont. Three of these are from towns where we now know there are extant occurrences, and may correspond to VT.001 (Ripton), VT.003 (Leicester), and VT.004 (Lincoln). Thus, there may only be three historic sites, from the towns of Randolph, Cavendish, and Brookline. These towns represent an expansion of at least the historic range of the species in Vermont. Since the latter are not on file with the Vermont Nongame and Natural Heritage Program, they are not included in Table 2.

Status of West Virginia Occurrences

WV .001 (Davis) — This population is in a wetland in the Cheat River watershed; the wetland consists of a spruce-fir swamp and wet meadow. *Polemonium van-bruntiae* was first observed there in 1941, and was visited again in 1985 and 1990. Population data suggest an increase over the years from 300+ plants in 1985 to more than 800 plants in 1990, within two subpopulations; the EO rank is B+. Land ownership is unknown, and the main threat is off-road-vehicles on a trail that is very close to both subpopulations.

WV .002 (Osceola) — In a high-elevation shrub swamp in the Greenbrier River watershed is another population; most of the plants are in a seepage area grazed by cattle. *Polemonium* was first observed here in 1941, and was visited again in 1983, 1993, and 1997. The population in 1997 consisted of hundreds of plants, although beaver activity has apparently wiped out a large portion of the population. The size of the population in 1997 appears to be greater than in previous years, but it is unclear whether the beaver activity occurred prior to or after the 1997 population count; the EO rank is BC. The land is privately owned, and the main threats appear to be beaver activity and cattle grazing.

WV .003 (Davis) — This population is in a minerotrophic shrub swamp in the Cheat River watershed. It was first observed in 1990, and visited again in 1993. No population count is listed for 1993, but in 1990 the population was estimated at over 300 individuals, (many?) in flower or fruit; the EO rank is B-. Landownership is unknown, and the main threat to the plants is an off-road vehicle trail that is very close. Buffering is needed to prevent disturbances that might change the soil moisture level.

WV .004 (Gladwin) — Also in the Cheat River watershed, this population of Appalachian Jacob's ladder was observed in 1996. No data are available regarding the size or health of the population, or the type of natural community in which it occurs. The U. S. Forest Service owns the land, and no threats are listed.

WV .005 (Davis) — Another Cheat River watershed population is in a wet meadow/shrub swamp. It was first observed in 1940, and revisited in 1990. The EO rank is D, but no plant count is listed. Land ownership is unknown, and the only documented threat to the site appears to be grazing, which is mentioned as a probable cause for lack of flowering or fruiting plants.

WV .006 (Wildell) — This population is in a spruce bog and "*Alnus*/*Glyceria*/*Sphagnum* swamp" within the Cheat River watershed, on the Potomac Ranger District of the Monongahela National Forest. *Polemonium* was first observed there in 1998, and has apparently not been visited since. In 1998, 30 rosettes were seen; the EO rank is E. The U. S. Forest Service owns the land, and no threats are listed.

WV .007 (Hartmansville) — First observed in 1952, this population is in a swamp in the North Branch Potomac River watershed. *Polemonium* was searched for again at this site in 1999, with no success. The area consists of numerous wetlands, mostly small and inaccessible. No other population or site data are available. Ownership is private, no threats are listed, and the only comment is that this record may be from nearby Glade County, instead of Mineral County.

WV .010 (Davis) — A very small population occurs in an open marshy area along a river in the Cheat River watershed, in Canaan Valley State Park. *Polemonium* was first observed there in 1985, and has apparently not been visited since. Three plants were

observed, flowering, and the EO rank is D. The West Virginia Department of Natural Resources owns the land, and no threats are listed.

WV .011 (Cranesville) — This population is in an alder swamp in the Youghiogheny River watershed. It was first observed in 1897, and was revisited in 1995. At that time, over 100 plants were seen, most of which had flowered and produced seed; the EO rank is BC. The Nature Conservancy owns the land, and no threats are listed.

WV .012 (Richwood) — Occurring in a shrub thicket in one of the glades in the Gauley River watershed on the Gauley Ranger District of the Monongahela National Forest, this population was first observed in 1909, and was visited again in 1983 and 1986. No population data are listed for 1986, but in 1983, 200 – 250 plants were seen; the EO rank is C. The U. S. Forest Service owns the land, and no threats are listed.

WV 0.13 (Cranesville) — Within the Youghiogheny River watershed, this population occurs near a road and out into a wet meadow. It was first observed in 1897, and was visited again in 1916, 1979, 1995, and 1996. Population size is apparently constant or growing, with over a hundred plants reported from earlier visits, and hundreds of flowering plants reported in 1996. The EO rank for this population is A. The Nature Conservancy owns the site, and no threats are listed.

WV .014 (Davis) — This population is in a wet open shrub and red spruce-balsam fir swamp forest in the Cheat River watershed. It was first observed in 1981, and was revisited in 1988, 1992, 1996, and 1998. The only population data are from 1986 and 1992, and both times the population was estimated at 10,000 (possibly more in 1992); the EO rank is A. The West Virginia Division of Commerce owns the land, and no threats are listed.

WV 0.15 (Davis) — At another site in the Cheat River watershed, this population is in a swamp with grasses and sedges. It was first observed in 1979, and was visited again in 1980 and 1997. In 1980, 15 – 20 plants were found, neither flowering nor fruiting. In 1997, the search was unsuccessful: no plants were found, the site had been destroyed, and no explanation is given. The EO rank is X. The West Virginia Department of Natural Resources owns the site.

WV .016 (Davis) — In a floodplain woods dominated by *Cinna* sp. and hawthorn, there is another population of Appalachian Jacob's ladder population within the Cheat River watershed, within one of the largest wetland complexes in this vicinity. It was first observed in 1990, and has apparently not been revisited since then. Only two plants were found, one of them in fruit, and the EO rank is D. The land ownership is unknown, and the main threat to the population, as listed on the EOR, is the Davis Power Project. However, that project is no longer planned for this valley (Sargent, personal communication).

WV .017 (Davis) — Another Cheat River watershed population occurs in a minerotrophic shrub swamp. It was first observed in 1990, and has apparently not been

visited since then. The only population or site information is "large number of individuals in a good habitat," and the EO rank is A. Land ownership is unknown, and no threats are listed.

WV .018 (Davis) — This large, high-quality population is in an *Alnus-Spiraea* thicket along a river in the Cheat River watershed. It was first observed in 1990, and has apparently not been visited since then. The population consists of hundreds of plants along a river, and thousands along a tributary of that river; the EO rank is A. The Monongahela Power Company owns the site, and threats to it, as listed on the EOR, include the Davis Power Project, and possibly grazing. However, that project is no longer planned for this valley (Sargent, personal communication).

WV .019 (Davis) — One of the smaller populations in the Cheat River watershed is along a seepy run under an open fir canopy. It was first observed in 1990, and has apparently not been visited since then. The population, which consists of ten plants in a small area, has a D rank. Land ownership is unknown, and threats listed on the EOR are heavy ATV use nearby, plus the Davis Power Project. However, that project is no longer planned for this valley (Sargent, personal communication).

WV 0.020 (Davis) — This population is in three stands within in a circumneutral seepage swamp, in the Cheat River watershed. It was first observed in 1990, and has apparently not been visited since then. There are about 150 – 200 plants in the southern stand, 300 – 500 in the middle stand, and about 300 in the northern stand; the EO Rank is B. Land ownership is unknown, and the threats to the site, as listed on the EOR, are the Davis Power Project and off-road vehicle use. However, the Davis Power Project is no longer planned for this valley (Sargent, personal communication).

WV .021 (Davis) — Another population of Appalachian Jacob's ladder in the Cheat River watershed occurs in a *Populus tremuloides* grove with an understory of *Salix sericea*. It was first observed in 1990, and has apparently not been visited since then. The population consists of 200 – 300 plants, in fruit; the EO rank is C. Land ownership is unknown, and threats to the site, as listed on the EOR, are the Davis Power Project and ATV use. However, the Davis Power Project is no longer planned for this valley (Sargent, personal communication).

WV .022 (Davis) — One more small population is in a wet meadow – shrub swamp in the Cheat River watershed. It was first observed in 1991, and was revisited in 1995. No count is given for 1995, but in 1991, over one dozen plants were observed. None were flowering, and deer browse is listed as a possible reason. The EO rank is D. Canaan Valley State Park owns the land, and no threats are listed.

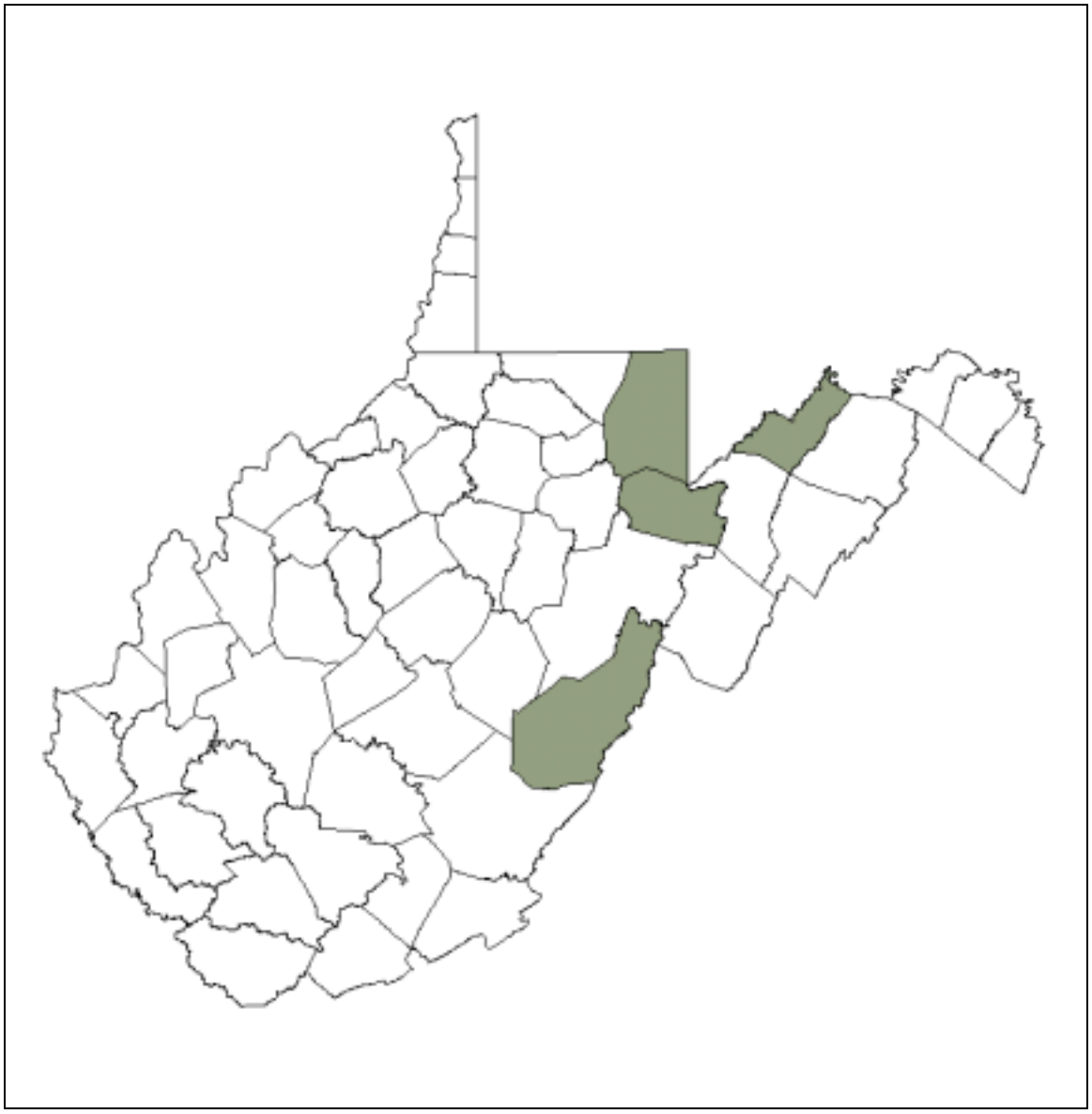

Figure 3. Occurrences of *Polemonium van-bruntiae* in West Virginia. County boundaries are shown. Preston, Tucker, Mineral, and Pocahantas Counties are shaded to indicate presence of the taxon.

Table 2. New England Occurrence Records for *Polemonium vanbruntiae.* Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
ME	.001	Washington	Columbia	Unknown	1988	1993	Seasonally moist sedge/fern meadow	C	14 individuals (not known if genets or stems/ramets) (1993)	None	None known
VT	.001	Addison	Ripton	GMNF	1878	1999	Plants are in a graminoid marsh near incoming stream; *Calamagrostis canadensis* in dominance here; area flat, open, and saturated	C	300+ (1999)	Only 9 plants recorded in 1982	Since site is a Research Natural Area, logging is not allowed; potential of flooding by beaver
VT	.002	Addison	Cornwall	Fish & Wildlife, & some private	1983	1996	Site is mostly a hardwood-northern white cedar swamp	C	1 clump: 4-5 flowering stems (1996); 51 – 100 plants observed in 1985		Cutting is a threat
VT	.003	Addison	Leicester	Unknown	No data	1983	Calcareous seepage swamp	B	10 (1983)	All plants are in small disturbed area	Evidence of past logging
VT	.004	Addison	Lincoln	GMNF	1955	2001	6 subpopulations along USFS FR 54 in open to semi-open swales, wet roadside ditches, and the wet bank of a densely forested ravine	B	Only C was relocated, and consisted of 800+ flowering stems (2001)	Plants need to be staked in early summer, w/ map given to mower; mowing should occur in autumn	Roadside mowing in growing season

Table 2. New England Occurrence Records for *Polemonium vanbruntiae.* Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
VT	.005	Addison	Ripton	GMNF & some private	1992	1996	10 colonies in forest seeps, springs, riverside seeps, and seepy roadside ditches	AB	Subpopulations (1993) A: 90 clumps B: 5 stems C: 17 stems D: 60+ stems E: 60 stems F: 73 stems G: 115 – 140 stems H: 58 stems I: 250+ stems J: 53 stems (USDA Forest Service 1998 field records indicate that B was apparently lost due to flooding)	Plants need to be staked in early summer, w/ map given to mower; mowing should occur in autumn; the rare *Geum laciniatum* occurs here, also	Deer browsing, roadside mowing in growing season and road widening, canopy closure, and periodic flooding of the river
VT	.006	Addison	Lincoln	GMNF	1993	1993	Small population in old pasture, wet woods (alder and hardwoods) adjacent to wet roadside ditch	D	46 flowering/fruiting stems (1993)	This site and an adjacent open seep need more survey work	Roadwork and timber harvest
VT	.007	Addison	Lincoln	Private	1985	1993	Population is in swale in opening in fir/birch woods, with saturated ground and dense undergrowth	B	South colony: approximately 900 stems (1993) North colony: 6 stems (1993)	Data (’85 – ’93) suggest that the population has been large and healthy over a period of several years	Forest invasion (canopy closure) and grazing cattle are possible threats
VT	.012	Addison	Ripton	GMNF	1990	1993	Introduced	I	39 plants	Needs ongoing	None known

Table 2. New England Occurrence Records for *Polemonium vanbruntiae.* Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
							population; in natural opening w/ little canopy cover		(genets), w/ many stems (1993) (USDA Forest Service records show 118+ clumps, w/ 41+ flowering in 1998)	monitoring	
VT	.013	Addison	Ripton	GMNF	1990	1993	Introduced population; in natural opening, w/ mostly closed canopy	I	26 plants (genets) (1993)	Needs ongoing monitoring	This introduced population has not done as well as the other (.012)

Table 3: Occurrence Records Elsewhere in Region 9, in which *Polemonium vanbruntiae* is known from National Forest lands. Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
WV	**.001**	**Tucker**	**Davis**	**No Data**	**1941**	**1990**	**Spruce-fir swamp and wet meadow**	**B+**	**800+ plants (not known if genets or ramets) in 2 sub-populations (1990)**	**Off-road vehicle trail is close to both sub-populations**	**Off-road vehicles**
WV	**.002**	**Pocahontas**	**Osceola**	**Private**	**1941**	**1997**	**High elevation shrub swamp**	**BC**	**100s of plants (not known if genets or ramets) (1997)**	**Beaver activity has wiped out a large part of this population (1997); cattle have grazed most plants in seepage area**	**Cattle grazing and beaver activity**
WV	**.003**	**Tucker**	**Davis**	**No Data**	**1990**	**1993**	**Minerotrophic shrub swamp**	**B-**	**300+ individuals (1990)**	**Site needs to be buffered from soil disturbance so moisture level is maintained**	**Off-road vehicles**
WV	**.004**	**Tucker**	**Gladwin**	**USFS**	**1996**	**1996**	**No Data**	**E**	**No Data**	**No Data**	**No Data**
WV	**.005**	**Tucker**	**Davis**	**No Data**	**1940**	**1990**	**Wet meadow/shrub swamp**	**D**	**No Data**	**Plants not flowering or fruiting, probably because of grazing**	**Grazing**
WV	**.006**	**Randolph**	**Wildell**	**USFS**	**1998**	**1998**	**Spruce bog**	**E**	**30 rosettes seen**	**No Data**	**No Data**
WV	.007	Mineral	Hartmansville	Private	1952	1952	Swamp	H	0 (1999)	Numerous small, mostly inaccessible wetlands in this area; this record could be from Grant Co.	No Data
WV	**.010**	**Tucker**	**Davis**	**WVDNR**	**1985**	**1985**	**Open marshy area along river**	**D**	**3 plants (1985)**	**No Data**	**No Data**
WV	**.011**	**Preston**	**Cranesville**	**TNC**	**1897**	**1995**	**Meadow**	**BC**	**100+ (1995)**	**No Data**	**No Data**
WV	**.012**	**Pocahontas**	**Richwood**	**USFS**	**1909**	**1986**	**Alder shrub swamp around acidic fen**	**C**	**200 – 250 plants (1983)**	**No Data**	**No Data**
WV	**.013**	**Preston**	**Cranesville**	**TNC**	**1897**	**1996**	**Open wet meadow**	**A**	**100s (1996)**	**No Data**	**No Data**

Table 3: Occurrence Records Elsewhere in Region 9, in which *Polemonium vanbruntiae* is known from National Forest lands. Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
WV	**.014**	**Tucker**	**Davis**	**WV Div. of Commerce**	**1981**	**1998**	**Wet open shrub and red spruce-balsam fir swamp forest**	**A**	**10,000+ (1992)**	**No Data**	**No Data**
WV	.015	Tucker	Davis	WVDNR Canaan Valley SP	1979	1980	Swamp with grasses and sedges	X	0 (1997)	In 1980, 15 – 20 plants were found	Trail passes through site
WV	**.016**	**Tucker**	**Davis**	**No Data**	**1990**	**1990**	**Cinna-Hawthorn dominated floodplain woods**	**D**	**2 plants (1990?)**	**This is one of the largest wetland complexes in the valley**	**Davis Power Project[1]**
WV	**.017**	**Tucker**	**Davis**	**No Data**	**1990**	**1990**	**Minerotrophic shrub swamp**	**A**	**1000s (1990?)**	**Thousands of plants over acres**	**No Data**
WV	**.018**	**Tucker**	**Davis**	**Mononga-hela Power**	**1990**	**1990**	**Alder-Spirea thicket**	**A**	**100s in one location; 1000s in another**	**Very large population in undeveloped area**	**Davis Power Project[1]**
WV	**.019**	**Tucker**	**Davis**	**No Data**	**1990**	**1990**	**Under open fir canopy along seepy run**	**D**	**10 plants (1990?)**	**Heavy ATV use nearby**	**Davis Power Project[1] and ATV use**
WV	**.020**	**Tucker**	**Davis**	**No Data**	**1990**	**1990**	**Circumneutral seepage swamp**	**B**	**3 stands: Southern: 150 – 200 Middle: 300 – 500 Northern: 300 (1990?)**	**Eliminate off-road vehicles**	**Davis Power Project[1] and off-road vehicles**
WV	**.021**	**Tucker**	**Davis**	**No Data**	**1990**	**1990**	**In area of *Populus tremuloides* grove with understory of *Salix sericea***	**C**	**200 – 300 plants (1990?)**	**Eliminate ATV use**	**Davis Power Project[1] and ATV use**

Table 3: Occurrence Records Elsewhere in Region 9, in which *Polemonium vanbruntiae* is known from National Forest lands. Shaded occurrences are considered extant.

State	EO #	County	Town	Site Ownership	First Obs.	Last Obs.	Description	EO Rank	Population Size (date)	Comments	Threats
WV	.022	Tucker	Davis	WV Div. of Commerce	1991	1995	Wet meadow-shrub swamp	D	12+ plants (1991)	Integrity of wetland must be maintained; area needs to be surveyed to get better understanding of population size	No Data

CURRENT CONSERVATION MEASURES IN NEW ENGLAND AND WEST VIRGINIA

Site Protection

Five of the nine Vermont populations are on Green Mountain National Forest (GMNF) land, where their status as Sensitive Species affords them some protection in the Forest Land and Resource Management Plan (Forest Plan). In September 2001, a Decision Notice to amend the Forest Plan was signed. This amendment incorporates proposed changes as listed in the preceding Environmental Assessment, which states that "Management activities that might affect such species may occur only after Biological Evaluations have determined that such activities would not lead to loss of viability or a trend towards federal listing" (USDA 2001). An additional two of the Vermont populations are partially on public land (some Green Mountain National Forest [GMNF] and some Fish and Wildlife).

Of the 20 populations of Appalachian Jacob's ladder in West Virginia, three are on the Monongahela National Forest, where their status as Sensitive Species affords them some protection in the Forest Land and Resource Management Plan. Another two are on land owned by the Nature Conservancy, two others are on land owned by the West Virginia Department of Natural Resources, and two more are on land owned by the West Virginia Department of Commerce.

Monitoring

Although a formal monitoring protocol does not yet exist, populations on the GMNF are visited either yearly or every other year, and population parameters are estimated. A more formal protocol will be established on the GMNF within the next year.

Seed Collection, Germination, and Reintroduction of populations

Two of the Vermont populations are experimental reintroductions. New England Wildflower Society collected and germinated seeds, and a botanist from the Vermont Nongame and Natural Heritage Program planted these seedlings in natural openings on the GMNF. One of these populations has been extremely successful, and has expanded to fill much of the natural opening into which it was introduced. The other has been less successful.

CONSERVATION OBJECTIVES FOR TAXON IN NEW ENGLAND

Appalachian Jacob's ladder is a globally rare plant that is currently classified as Division 1 (Globally Rare) of the *Flora Conservanda* in New England (Brumback and Mehrhoff et. al 1996). It is Threatened (T) in Vermont, Endangered (E) in Maine, and not known from any of the other New England states. Five conservation objectives, listed in the

order of their priority, are proposed in support of an overall goal of increasing this species' security throughout its range in New England for the foreseeable future.

The first objective, which is, to some extent, dependent upon success in meeting the four other objectives, is to maintain the number of populations in New England, and number of individuals per population, at or above the level documented in this report: currently one population in Maine with about 14 individuals, and nine populations in Vermont with about 2300 - 3200 individuals. (Because of inconsistency in measurement units, total Vermont population can only be estimated within a fairly broad range.) Currently, Appalachian Jacob's ladder is state listed as T in Vermont; the rationale for maintenance of existing populations is to prevent a change in state listing to E.

The second objective is to protect all but one of the New England sites that are not currently protected (the one omission is on land owned by someone who does not allow access to the property). This will involve determining ownership of one Maine population and one Vermont population, seeking cooperation from these landowners and the landowners of two Vermont populations that are entirely on private land, and one of the two that are partially on private land. The rationale behind this objective is to prevent accidental loss of populations due to landowners' lack of awareness of the species' presence and vulnerability. Note, however, that if in meeting the second objective, it is determined that the Maine population is introduced, protection of that site may not be as important as protection elsewhere.

The third objective is to attempt to determine the origin of the one small population in Maine, which is a few hundred kilometers east of all other known New England occurrences. Because this population is such an outlier with respect to the other populations, and also because the European *P. caeruleum* occasionally escapes from cultivation in this country, and can be easily confused with the wild species in the field (as happened in the early 1900's in Maine), the question of whether or not this one extant population is truly Appalachian Jacob's ladder is inevitable. However, Johnson and Murray, who first documented this population, were aware of the potential for misidentification, citing it in their report (1988). Thus, it is unlikely that this population is also a misidentification. Another question that warrants investigation is whether or not this disjunct population was introduced. Given that seeds from Appalachian Jacob's ladder are easily cultivated, it is possible that this population is not natural. Thus, the rationale behind this objective is that, if it is determined that this is not a naturally occurring population of Appalachian Jacob's ladder, it may not be worth spending scarce conservation dollars to protect or augment that population, or to look for new populations nearby. On the other hand, if it is a natural population, genetic studies of this and other populations would enable development of a hypothesis regarding its origin, which, in turn, might suggest the best geographic locations for future searches for new populations. Investigating the origin of this population is one step toward updating information regarding the species' distribution and status, which, in turn, is an important piece of an overall conservation plan.

The fourth objective is to confirm or update the current understanding of the species' distribution in New England by: 1) developing a monitoring protocol that is consistent within and across site; 2) monitoring known populations; 3) revisiting historic sites in Vermont; and 4) searching for new populations in suitable habitats. This will include searching for new populations in the remaining New England states (New Hampshire, Connecticut, Massachusetts, and Rhode Island, if preliminary investigation suggests that suitable habitat may be present), and possibly in Maine, if it is determined that the one known population there is a natural population. The rationale behind searching in other New England states is that, since there are populations in New York, Pennsylvania, Maryland, and West Virginia, it seems plausible that there might be undocumented occurrences elsewhere. The rationale behind searching for new populations in Maine (if the one extant population is determined to be a natural population) is that there is only one extant population, yet suitable habitat is apparently not scarce. Although a search of New England records completed more than two decades ago showed no populations outside of Vermont (Jenkins 1982), five of the seven extant natural populations in Vermont and the one population in Maine have been discovered since then. This suggests that, while the species was not well-known historically in New England, there may still be populations out there that are undocumented. Note, however, that three of the "newly discovered" Vermont populations may, in fact, be rediscoveries of historic populations (see the section on distribution and status. If no new populations are found, the searches would not necessarily be wasted time; instead, these searches might either increase our understanding of the differences between sites where Appalachian Jacob's ladder does and does not occur, or might result in suitable habitats for introducing new populations, thereby expanding the species' distribution in New England. In addition, searches in circumneutral, wet sites might yield discoveries of new populations of other rare plant species associated with this habitat type (E. Farnsworth, New England Wildflower Society, personal communication).

The fifth objective is to develop management plans for the five Vermont populations that are entirely on public land, and two that are partially on public land. If possible, management plans should also be developed in cooperation with owners for the two out of three populations on private land (in both Maine and Vermont) where access has been allowed. Likewise, if new populations are found, management plans should be developed for those as well. The rationale behind this objective is to prevent extant populations from being destroyed by such human activities as roadside maintenance and timber harvest, and from other natural events such as canopy closure. In addition, experimenting with different management techniques would give us information about the response of the species to environmental variables, including disturbance. Inherent in this objective is to better understand Appalachian Jacob's ladder's habitat preferences. For example, a current problem that needs to be addressed is that two large Vermont populations, each of which consists of a number of subpopulations, grow in roadside ditches, which are difficult to protect. Understanding Appalachian Jacob's ladder habitat preferences might help us to develop a plan to protect those and other vulnerable sites in the future.

GENERAL CONSERVATION ACTIONS FOR THE TAXON

Generally speaking, there are eight actions included in the successful conservation of a taxon. Specific to Appalachian Jacob's ladder, they are listed below, in the order of their priority:

Land Acquisition or Protection of Occurrences

The first step in protection of occurrences may simply be education of landowners, as described in the next section. Land acquisition may not be necessary if existing landowners are interested in protecting Appalachian Jacob's ladder plants. If new populations are located, protection of these occurrences would be a subsequent conservation action. If any populations are on private land, and the landowner is not interested in plant protection but is willing to sell the land, land acquisition may be an appropriate conservation action. However, prior to purchasing land, an evaluation of the quality and vulnerability of the site is necessary; given that conservation resources are often limited, land acquisition may not always be the best option. In Vermont, VT.002 (Cornwall), VT.003 (Leicester), and VT.007 (Lincoln) are on private land, and so should be the focus of this conservation action.

Concurrent with protection of the Maine site, however, the origin of this population should be investigated, as stated in the third conservation objective. If it is determined to be a natural population, protection of the site would then be a top priority in Maine. Protection should be undertaken to prevent irreversible declines in the species status in New England. This action is a also a necessary first step in Vermont, where there are nine populations, some of which are large; it should be taken to prevent or reverse significant declines in the species' status in New England.

Land acquisition or protection of occurrences, in conjunction with education of landowners, the public, etc., in the next section are Priority 1: they are actions that should be taken to prevent irreversible declines in the species' status in New England. They are also necessary actions for meeting the first and second conservation objectives (maintenance of existing populations and numbers of individuals, and protection of sites not currently protected, respectively).

Education of Landowners, Public, etc.

The second conservation objective is to protect all but one of the sites with extant occurrences of Appalachian Jacob's ladder (the one omission is due to a landowner's refusal to allow access to one site in Vermont.) An essential conservation action needed in order to meet this objective is to determine ownership where not known, and confirm or update all other ownership information. The next step is to meet with landowners, ensure that they are aware of Appalachian Jacob's ladder plants on their land, discuss with them the kinds of actions that might harm or help these plants, and ask their cooperation in protecting them. In some cases, landowners may be well-acquainted with

these populations, and may be able to pass along interesting and useful information about changes in size of the population or habitat over time. This exchange of information would help with the fourth conservation objective: development of management plans and understanding habitat preferences.

These actions, which should occur in conjunction with land acquisition and protection of occurrences as described above, are especially important for the sole Maine population, and also for sites in Vermont for which ownership is unknown and/or site protection has not been secured. Since determining the origin of the sole Maine population may take time, it is recommended that at least preliminary actions to protect the site — e.g., to determine ownership — begin in the meantime.)

Regular Surveys

Regular population monitoring (surveys) and standardization of monitoring methods are needed for Appalachian Jacob's ladder. Although they will not directly *prevent* loss of populations, they are necessary in order to *detect* downhill trends, which are the first indication that a change in management strategy is needed; thus, they are still considered Priority 1 — actions that should be taken to prevent irreversible declines in the species' status in New England. In order to measure whether or not the first conservation objective — maintenance of at least the current number of populations and individuals per population — is being met, regular monitoring is necessary.

In New England, nine out of ten occurrences have not had formal monitoring in at least five years (although three have had less formal visits), and most have not been visited for at least nine years. Since the majority of the populations are threatened by at least one environmental factor, as described previously, it is possible that some have diminished over the past several years. Likewise, the nature or intensity of threats to individual populations may have changed, and should be documented simultaneously. The combination of threats to populations and lack of recent monitoring indicates that the current condition of most Appalachian Jacob's ladder populations is not known. In addition, the three historic sites should be revisited, if they can be found, to determine whether or not they still exist.

Compounding the problem is that the populations are difficult to monitor. It is difficult to discern ramets from genets, and there is no consistency between population measurement units. Terms recorded in EORs include stems, individuals, plants, clumps, ramets, and genets, all of which are not comparable. Development and implementation of a standardized monitoring protocol are needed to meet the fourth conservation objective, which is to confirm or update the current understanding of the species' distribution in New England. They are also needed to meet the first objective, which is to maintain the number of populations in New England, and number of individuals per population, at or above the level documented in this report. Botanists must develop a monitoring protocol that is, at the very least, consistent within each site, with the ultimate

goal of having that protocol be consist among sites and accepted range-wide. Without this consistency, data from year to year and site to site are not comparable.

The author proposes the following population measuring protocol as a starting point, based on discussions with Farnsworth (personal communication) and a limited field trial:

1) within a population, subjectively choose five representative sampling plots, 0.5 m by 0.5 m
2) in each plot, record the number of flowering stems, plus the total number of stems
3) use these data to calculate the average numbers of flowering stems and total stems per 0.25 square meter
4) multiply this by 4 to obtain the average numbers per sq m
5) estimate the average length and width of the entire population by measuring your stride and then walking the boundaries of the population and calculating the size of the population per square meter
5) multiply this estimated population area times the average number of flowering stems to calculate the estimated numbers of flowering stems for the entire population, and do the same for total stems.

For very small populations, it may be possible to count flowering total stems and total stems. The method described is suggested only as a starting point, and should be refined after experimentation. Ultimately, and perhaps as a result of more extensive research on the biology of Appalachian Jacob's ladder, methods should be developed that meet widely accepted sampling and management objectives, including acceptable levels of ability to detect change in populations. Toward this goal, the author recommends "*Measuring and Monitoring Plant Populations*" (Elzinga et al. 1998).

De novo *Searches for New Populations*

New searches are important actions in the conservation of any species for which not all suitable habitat has been searched; an up-to-date picture of a species' distribution in a given region is the foundation for developing a strategy for conservation. In Vermont, a number of suitable habitats (natural communities adjacent to and appearing similar to those already occupied) have been searched; it is not known whether there are others that still need to be searched. In Maine, where there is only one documented population but apparently no lack of suitable habitat, searches will help to clarify the extent of the species' status in that state, which is one aspect of its vulnerability to extirpation (however, it may be prudent to undertake searches in Maine only if the existing Maine population is determined to be natural). In other New England states, where there are no documented extant or historic occurrences, searches are necessary to confirm or update assumptions about Appalachian Jacob's ladder's distribution. While these actions will not directly prevent declines in the species' status, they are necessary to meet conservation objective number four — to determine the extent of the species distribution in New England — and will also help to meet all of the other conservation objectives. Maintaining existing numbers of a species is easier if there are more populations than originally thought, and these new populations can only be protected and managed when

their existence is documented. Likewise, understanding habitat preferences and, if necessary, choosing new sites for introduction of plants are both enhanced by searching what appears to be suitable habitat, regardless of whether Appalachian Jacob's ladder plants are found at those places, and the results of these searches may help us understand the biogeography of this species. For all of these reasons, they should be considered Priority 2 — actions that should be taken to prevent or reverse significant declines in the species' status in New England

Species Biology Research

Development of management plans (the fifth conservation objective) depends upon an understanding of species biology. Presently, we do not know why Appalachian Jacob's ladder is rare. The majority of populations apparently flower and set fruit regularly, and suitable habitat is apparently not lacking. This suggests that there is much about this species that is not yet known: 1) suitable habitat may be more narrowly defined than we realize; 2) some stages of reproduction may not be very successful; 3) there are factors affecting the species' success that we have not yet ascertained. Conservation actions needed to support the fifth objective include the following investigations of species biology:

- **Germination rate and seedling survival rate** (some data already exist from a previous introduction of plants into a new site in Vermont)

- **Population demographics** (e.g., percent of new stems in a population per year, average age of individual plants and age structure of population, average age and range of ages at reproductive maturity, average and range of number of seeds set, and average lifespan), the size of clones and the genetic structure of populations (e.g., average number of ramets per genet and genets per population); following marked individuals would be helpful, and data obtained might allow researchers to model population viability (A. Dibble, University of Maine, personal communication)

- **Pollinator/pollination success** (while bees have been observed visiting some flowers, very little is documented about Appalachian Jacob's ladder pollination); percent seed set, and mechanisms of dispersal; understanding these may be especially important for managing small populations, like the one in Maine

- **Habitat requirements** (e.g., why is it rare, if it grows well in roadside ditches?), especially light, tolerance for flooding and drought, and soil pH and nutrient profile

- **Effects of disease and herbivory**

These actions are not easily assigned a priority ranking. At sites where canopy closure may threaten the population, development of a management plan depends upon understanding the habitat requirements of the plants. Understanding the habitat

requirements can lead to sound management, which in turn can prevent or reverse significant declines in the species' status in New England. All management plans at all sites depend on an understanding of habitat requirements. Thus species biology research should be Priority 2 — an action that should be taken to prevent or reverse significant declines in the species' status in New England.

Habitat or Site Management

Empirical evidence at some sites suggests that canopy closure/succession of open habitat to forest may be a threat to Appalachian Jacob's ladder; however, there are no known studies that document this possibility. Thus, two conservation actions are needed at this time. The first is to conduct a study on the relationship between canopy closure and the health of impacted Appalachian Jacob's ladder populations, and the second is to manage sites using guidelines that arise from the study.

Additional conservation actions are needed for those populations that grow in roadside ditches. For those on public land that have been previously flagged and staked (VT.004 [Lincoln] and VT.006 [Lincoln]), maintenance of site markers and monitoring of their effectiveness are crucial. For the one (VT.005 [Ripton]) on a mix of public and private land, an informal survey by the author at the end of summer 2001 revealed that roadside mowing had recently occurred, suggesting that either a management plan is not in place, or is not being implemented. The action needed is to determine whether a plan is in place, and if not, to develop one in cooperation with the various landowners, and then to monitor its implementation and effectiveness.

A final action needed is to work with all other willing landowners to develop site management plans. The development of management plans (the fifth conservation objective) is a higher priority at sites where there is an imminent threat (e.g., along roadsides). It is a somewhat lower priority elsewhere. However, habitat or site management activities should collectively be Priority 2 — actions that should be taken to prevent or reverse significant declines in the species' status in New England.

Ex-situ *Activities Including Seed Banking, Germination Research and Propagation*

Although introduction of new populations, reintroduction, and augmentation are not listed as conservation objectives at this time, if current populations decline despite all the above-recommended conservation actions, the objectives or recommended actions might change. At that time, these options might seem more worthwhile, and their success would require a good seed source. Thus, these actions should be Priority 3 and 4 — all other actions necessary to meet the conservation objectives — since they might ultimately help to maintain populations at current levels. Some germination research and propagation has already occurred (Brumback 1989), and further activities of this sort should commence only after a careful review of the work previously undertaken. At this time, no particular sites have been chosen from which to collect seeds.

Augmentation, Introduction, and Reintroduction

Given the apparent success of one of the two introduced populations of Appalachian Jacob's ladder in Vermont, it is tempting to recommend more introductions, reintroduction, or augmentation to improve the status of the species throughout New England. However, NEPCoP does not measure conservation success by an improved species status, and these actions are recommended only if other actions fail, in an attempt to meet the first conservation objective (maintenance of at least current numbers of populations and individuals). In addition, these actions present an additional set of problems, including obtaining resources, choosing an appropriate site and an appropriate seed source, and understanding the effects of potential outcrossing between natural and introduced populations (Dibble, personal communication).

If augmentation, introduction, and reintroduction are undertaken, the following steps would be necessary conservation actions:

1) search for appropriate sites with suitable habitat in protected locations
2) determine the best seed source, and collect and germinate seeds
3) develop site management and population monitoring plans for those sites
4) specific to augmentation, determine, through species biology and habitat research, the most likely reason why a population has remained small over the years, prior to simply bringing in more plants
5) introduce plants.

Given that there are three historic sites known for this species in Vermont, and some sub-populations have been lost in Vermont, as well, reintroduction at those sites might be a worthy first attempt. Before doing so, however, investigation of the reasons for loss and likelihood of success of reintroductions into those sites should be evaluated.

As with *ex-situ* activities described in the previous section, augmentation, introduction, and reintroduction are not top priority actions at this time. However, if current populations decline despite all the above-recommended first and second priority conservation actions, the objectives or recommended actions might change. At that time, these options might seem more worthwhile; for now, they are not given any particular priority rating.

RECOMMENDED CONSERVATION ACTIONS FOR EACH OCCURRENCE

ME .001 (Columbia) — Determine ownership, and if the landowner is willing, ask for cooperation in the protection of this site. Revisit site to monitor population size and health (last visit was in 1993). Attempt to discern the origin of this population, including, but not limited to, whether or not it might be an introduced population. If it is reasonably certain that it is a natural population, search geographically close, suitable habitat for new plants.

VT.001 (Ripton) — Monitor site for damage caused by beaver-induced flooding. This could be done either every five years or when there is a major change in water level. Measure population size to determine if the population trend is still upward at this site. Given that this site is within a Research Natural Area owned and managed by the Green Mountain National Forest, this may be an appropriate site for studying population demographics, reproductive characteristics of the species, and habitat details. Likewise, it would be a good place to develop a management plan. Permission would need to be obtained prior to beginning any study, and Forest personnel should be involved in the development of the management plan.

VT.002 (Cornwall) — This population occurs on land that belongs to several different people and organizations. Consult with the Vermont chapter of the Nature Conservancy and/or the Vermont Nongame and Natural Heritage Program to determine what progress has been made in obtaining permission from one reluctant landowner to access the site. If these agencies approve, try to obtain permission to visit the site from the one landowner who has previously denied access. Visit the portion of the site where access is allowed, and measure population size to determine if a downward trend is still occurring. Since the EOR indicated that cutting of timber was a potential threat to this site, the status of that threat should also be investigated. The exact nature of the threat should also be documented; since canopy closure is listed as problematic at some sites, timber harvest may only be a threat if it occurs during the growing season and results in trampling of the plants, or substantial changes in hydrology. Meeting with the various landowners and educating them about the presence and status of the plants would help determine the degree of protection afforded to this population, and would be a first step toward developing a management plan that would garner the cooperation of the various landowners.

VT.003 (Leicester) — Determine the ownership of this site. Visit the site to monitor population size and health, and to assess any current threats (evidence of past logging was listed as a red flag for a potential future threat to this population). If the landowners are willing, develop a plan for protection and management of the site.

VT .004 (Lincoln) — This population originally consisted of several subpopulations, in wet roadside ditches, semi-open swales, and a densely forested ravine, all on land owned by the Green Mountain National Forest. The first action needed is to visit the roadside ditch subpopulations, try one more time to relocate subpopulations not found in 2001, and relocate stakes and flagging, replacing them as necessary. The second is to measure the population size and determine the overall health of the population, including all subpopulations. The third is to develop a management plan that incorporates information gathered during monitoring. For example, is staking and flagging the roadside ditch populations working? Is attempting to prevent mowing the best management technique, or would it be wise to allow mowing late in the season, after seeds have set, so that competing vegetation does not take over the site? Educating the mowing contractor might also be necessary. Finally, reintroduction of the one lost subpopulation might eventually be considered, but only after reviewing the possible reason for its demise. For example, if the sub-site is in a ditch that has washed out and is likely to do so again,

perhaps it would be best not to reintroduce plants to that specific location. These roadside subpopulations would also be good sites for measuring environmental variables to compare to other sites, since we do not understand why these plants are apparently thriving in a roadside ditch, but are globally rare. (It is possible that these ditches are simply all that remains of what was once a more extensive site.) Likewise, studying the genetic structure of the subpopulations would help to determine the degree to which "clumps" of plants are clones versus unique individuals, and might elucidate seed dispersal patterns.

VT.005 (Ripton) — This population consists of a number of subpopulations in forest seeps, springs, riverside seeps, and seepy roadside ditches, and is on a combination of private and Green Mountain National Forest land. Actions needed for the roadside subpopulations are the same as those described for VT.004 above, but may involve consultation and cooperation with more than one landowner. The rest of the subpopulations also need monitoring, both to assess the status of the purported threats (deer browsing, periodic flooding of the adjacent river and canopy closure), and to determine the population trends. If these threats still exist (and they most likely do), the next action needed is the development of a management plan, which will need to be specific to the subpopulations. In the process, it should be determined whether the landowners of the portions of private land are aware of the Appalachian Jacob's ladder population and are willing to protect the plants. If canopy closure is occurring, and the affected subpopulation is declining, this might be a good site (if owners approve) to experiment with some careful removal of canopy (with logging to occur during winter months only), to see if this has a positive effect on the Appalachian Jacob's ladder plants. These subpopulations may also be a good site for studying the genetic structure of a population, as described for VT.004, above.

VT.006 (Lincoln) — Monitor population size and health. Survey adjacent potential habitat for additional plants. Determine whether roadwork and timber harvest are still potential threats. Timber harvest could be especially damaging if it occurs during the growing season. Develop a management plan, and if logging is to occur, specify winter logging only.

VT.007 (Lincoln) — Monitor population size and health. Determine whether canopy closure and cattle grazing are still threats. Since this site is privately owned, determine whether the landowner is aware of the Appalachian Jacob's ladder plants and is interested in protecting the site. If so, work with the landowner to develop a management plan for this site.

VT.012 (Ripton) — This is an introduced population that has done very well. Continue to monitor population size, reproduction, and health, especially after rain heavy enough to cause flooding. Develop a management plan for this site, which is owned by the Green Mountain National Forest. Compare the habitat parameters, especially light and seasonal flooding, of this site with that of the other introduced site, to gain a better understanding of the differences between sites where Appalachian Jacob's ladder does and does not do well.

VT.013 (Ripton) — This is an introduced population that has not done very well. Monitor population size and health. Compare the habitat parameters, especially light and seasonal flooding, of this site with that of the other introduced site, to gain a better understanding of the differences between sites where Appalachian Jacob's ladder does and does not do well. Develop a management plan for this site, which is owned by the Green Mountain National Forest.

Note that a standardized monitoring protocol should be developed prior to monitoring any of these sites, and that development of management plans would be most efficiently accomplished *after* studies of habitat preferences.

Prioritized Implementation Table

The Prioritized Implementation Table that follows (Table 4) lists and ranks actions that should be undertaken in order to implement the conservation plan for *Polemonium vanbruntiae*. This schedule is subject to revision based on annual review of conservation objectives. Conservation actions are arranged in priority order based on the following definitions:

> **Priority 1** — An action that should be taken to prevent irreversible declines in the species' status in New England.
>
> **Priority 2** — An action that should be taken to prevent or reverse significant declines in the species' status in New England.
>
> **Priority 3 and 4** — All other actions necessary to meet the conservation objectives.

As landowner contact is required for each site to gain site access and permission to perform other research activities, it is considered a priority action and will not be listed separately for each occurrence unless special circumstances exist. Conservation activities to follow assume landowner permission has been acquired. Conservation actions for West Virginia populations are not discussed here. For those populations occurring on the Monongahela National Forest, conservation strategies will be developed during Forest Plan revision.

Table 3: Prioritized Implementation Table for Taxon. Landowner permission is prerequisite to these actions.
No action should be undertaken without the review of conservation professionals and the prior consultation and consent of state Natural Heritage Programs.

State	EO #	Town	First Priority	Second Priority	Third Priority	Fourth Priority
ME	.001	Columbia		Determine ownership and protect site. Determine if this population is natural or introduced, and if it is really as disjunct and isolated as it seems. Monitor population size and health. Develop management plan.		(Possible future action: investigate the potential for augmentation at this site.)
VT	.001	Ripton	Site is protected. Monitor site for damage caused by beaver-induced flooding. Monitor population size and health.	Study population demographics, reproductive characteristics, and habitat parameters. Develop management plan.		
VT	.002	Cornwall	Obtain permission to access site; investigate nature and status of threats; protect site. Monitor population size and health.	Develop a management plan.		
VT	.003	Leicester	Determine ownership. Assess current threats. Protect site. Monitor population size and health.	Develop a management plan.		(Possible future action: investigate the potential for augmentation at this site.)

Table 3: Prioritized Implementation Table for Taxon. Landowner permission is prerequisite to these actions.
No action should be undertaken without the review of conservation professionals and the prior consultation and consent of state Natural Heritage Programs.

State	EO #	Town	First Priority	Second Priority	Third Priority	Fourth Priority
VT	.004	Lincoln	Monitor population size and health. Relocate stakes and flagging, replacing as needed, and assess effectiveness of current management plan.	Study genetic structure of subpopulations. Revise management plan.		(Possible future action: investigate the potential for reintroduction of a subpopulation at this site.)
VT	.005	Ripton	Monitor population size and health.	Develop management plan that addresses vulnerability of roadside ditch populations. Assess status of threats, and consider the possibility of experimentation with canopy reduction over one subpopulation. Study genetic structure of subpopulations		.
VT	.006	Lincoln	Site is secure. Monitor population size and health.	Assess status of threats, and develop management plan.		(Possible future action: investigate the potential for augmentation at this site.)
VT	.007	Lincoln	Determine ownership and protect site. Assess status of threats. Monitor population size and health.	Develop management plan.		

Table 3: Prioritized Implementation Table for Taxon. Landowner permission is prerequisite to these actions.
No action should be undertaken without the review of conservation professionals and the prior consultation and consent of state Natural Heritage Programs.

State	EO #	Town	First Priority	Second Priority	Third Priority	Fourth Priority
VT	.012	Ripton	Site is secure. Monitor population size and health.	Compare habitat parameters, especially light and seasonal flooding, to those at VT.013. Develop management plan.		
VT	.013	Ripton	Site is secure. Monitor population size and health.	Compare habitat parameters, especially light and seasonal flooding, to those at VT.012. Develop management plan.		
ME	Future sites			Search for new populations in suitable habitat.		
NH, CT, MA, & RI	Future sites			Search for new populations in suitable habitat.		

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APPENDICES

1. Personal Communication References

2. Complete list of species associated with Appalachian Jacob's ladder, as noted in EORs

3. An Explanation of Conservation Ranks Used by The Nature Conservancy and Natureserve

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2. Complete list of species associated with Appalachian Jacob's ladder, as noted in EORs (all scientific and common names used come directly from EORs and may not be the most widely accepted names. When only a common or a scientific name was given, the corresponding common or scientific name is that used by Kartesz and Meacham 1999).

Scientific Name	**Common Name**
TREES	
Abies balsamifera	Balsam fir
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Betula alleghaniensis	Yellow birch
Betula papyrifera	Paper birch
Fraxinus nigra	Black ash
Picea rubens	Red spruce
Pinus strobus	White pine
Populus tremuloides	Trembling aspen
Quercus bicolor	Swamp white oak
Thuja occidentalis	Northern white cedar
Tsuga canadensis	Hemlock
Ulmus americana	American elm

SHRUBS

Alnus spp.	Alder
Alnus incana	Speckled alder
Alnus rugosa	Smooth alder
Amelanchier spp.	Shadbush
Crataegus spp.	Hawthorn
Ilex verticillata	Winterberry
Lonicera oblongifolia	Swamp fly-honeysuckle
Rhamnus alnifolia	Alder-leaved buckthorn
Rubus spp.	Blackberry, dewberry, raspberry
Salix spp.	Willow
Salix rigida	Missouri willow
Salix sericea	Silky willow
Spiraea spp.	Spirea
Toxicodendron vernix	Poison sumac
Viburnum dentatum	Southern arrow-wood

MOSSES

Polytrichum spp.
Sphagnum spp.

HERBACEOUS FLOWERING PLANTS

Aralia nudicaulis	Sarsaparilla
Calamagrostis canadensis	Bluejoint
Carex brunnescens	Brownish sedge
Carex crinita	Fringed sedge
Carex disperma	Soft-leaved sedge
Carex leptalaea	Bristly-stalk sedge
Carex pedunculata	Long-stalk sedge
Carex scabrata	Eastern rough sedge
Carex stricta	Tussock sedge
Carex trisperma	Three-seed sedge
Cinna spp.	Wood-reed
Cirsium muticum	Swamp Thistle
Coptis trifolia	Goldthread
Epilobium leptophyllum	Bog willowherb
Geum laciniatum	Rough avens
Geum rivale	Purple avens
Glyceria spp.	Manna grass
Glyceria canadensis	Rattlesnake manna grass

Glyceria grandis	American manna grass
Glyceria melicaria	Melic manna grass
Glyceria striata	Fowl manna grass
Habenaria clavellata	Green woodland orchid
Impatiens capensis	Spotted touch-me-knot
Laportea canadensis	Wood-nettle
Leersia oryzoides	Rice cut grass
Maianthemum canadense	Canada mayflower
Mitella nuda	Naked miterwort
Polygonum sagittatum	Arrow-leaf tearthumb
Platanthera lacera	Green fringed orchid
Pyrola secunda	One-sided wintergreen
Solidago spp.	Goldenrod
Thalictrum polygamum	Tall meadow rue
Tiarella cordifolia	Golden saxifrage
Trillium cernuum	Nodding trillium
Veratrum viride	American false hellebore
Viola spp.	Violet

FERNS & ALLIES

Dryopteris spinulosa	Spinulose woodfern
Equisetum sylvaticum	Woodland horsetail
Osmunda cinnamomea	Cinnamon fern
Osmunda regalis	Royal fern
Onoclea sensibilis	Sensitive fern
Thelypteris palustris	Marsh fern

3. An Explanation of Conservation Ranks Used by The Nature Conservancy and Natureserve

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis — that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction — i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct)

or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that known to be extirpated. Not all EO's have received such ranks in all states, and ranks are not necessarily consistent among states as yet.