New England Plant Conservation Program

Polemonium van-bruntiae Britton
Appalachian Jacob's Ladder

Conservation and Research Plan
for U. S. Forest Service Region 9

Prepared by:
MaryBeth Deller
Botanist
Green Mountain and Finger Lakes National Forest

For:

New England Wild Flower Society
180 Hemenway Road
Framingham, MA 01701
508/877-7630
e-mail: conserve@newfs.org • website: www.newfs.org

Approved, Regional Advisory Council, 2002

SUMMARY

Appalachian Jacob's ladder (*Polemonium van-bruntiae* 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 2002).

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Because they contain sensitive information, full plans are made available to conservation organizations, government agencies and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

NEPCoP 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. If you require additional information on the distribution of this rare plant species in your town, please contact your state's Natural Heritage Program.to their land for plant monitoring and data collection.

This document should be cited as follows:

Deller, MaryBeth. 2002. *Polemonium van-bruntiae* Britton (Appalachian Jacob's ladder) New England Plant Conservation Program Conservation and Research Plan for U. S. Forest Service Region 9. New England Wild Flower Society, Framingham, Massachusetts, USA.

I. BACKGROUND

INTRODUCTION

Polemonium van-bruntiae 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 USDA 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 van-bruntiae* 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. van-bruntiae* 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 van-bruntiae* 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. van-bruntiae* or *P. caeruleum*.

Common names for *Polemonium van-bruntiae* 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 and Thompson 2002), 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 van-bruntiae* 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		

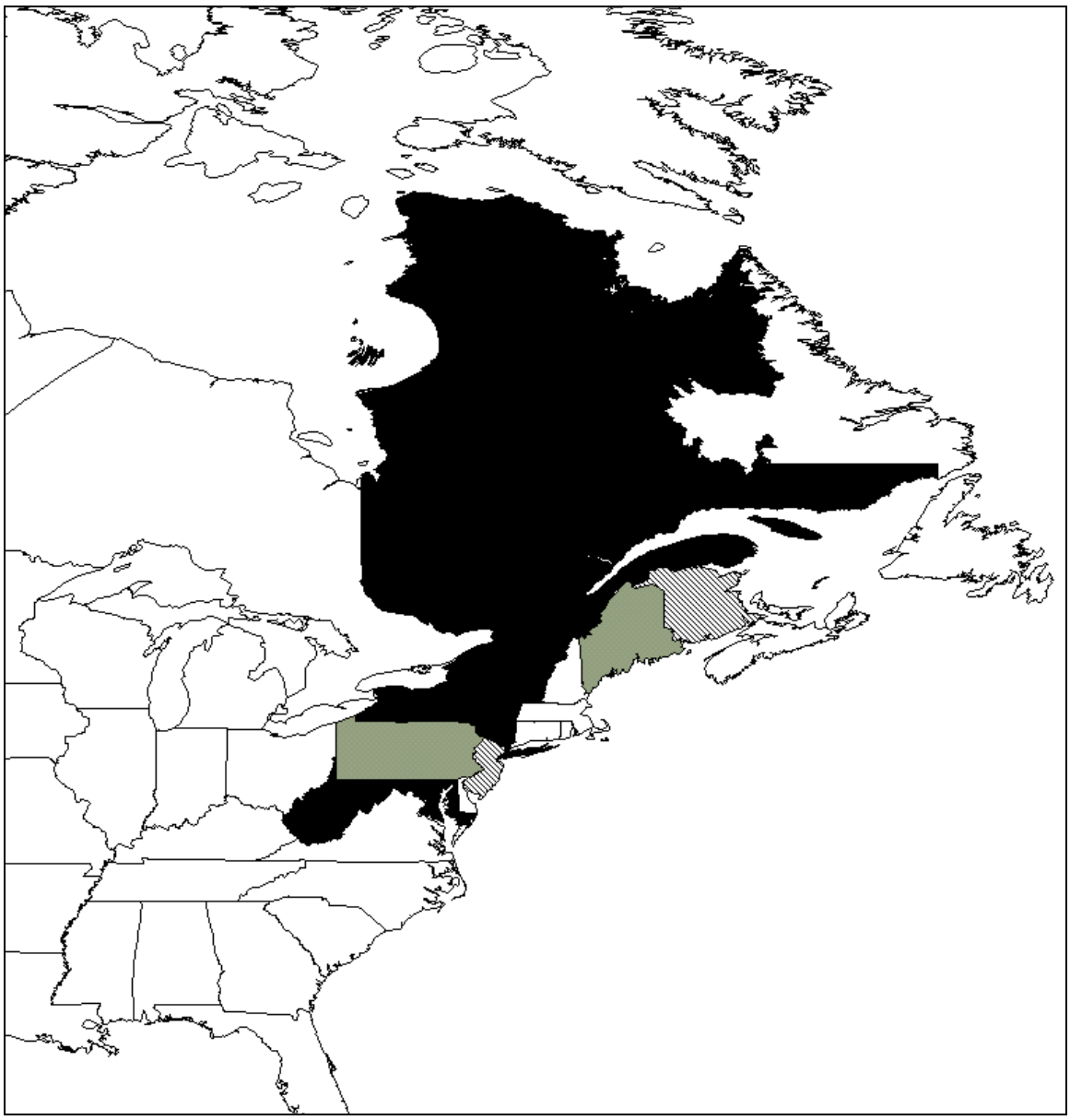

Figure 1. Occurrences of *Polemonium van-bruntiae* in North America. States and provinces shaded in gray have one to five current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated,"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

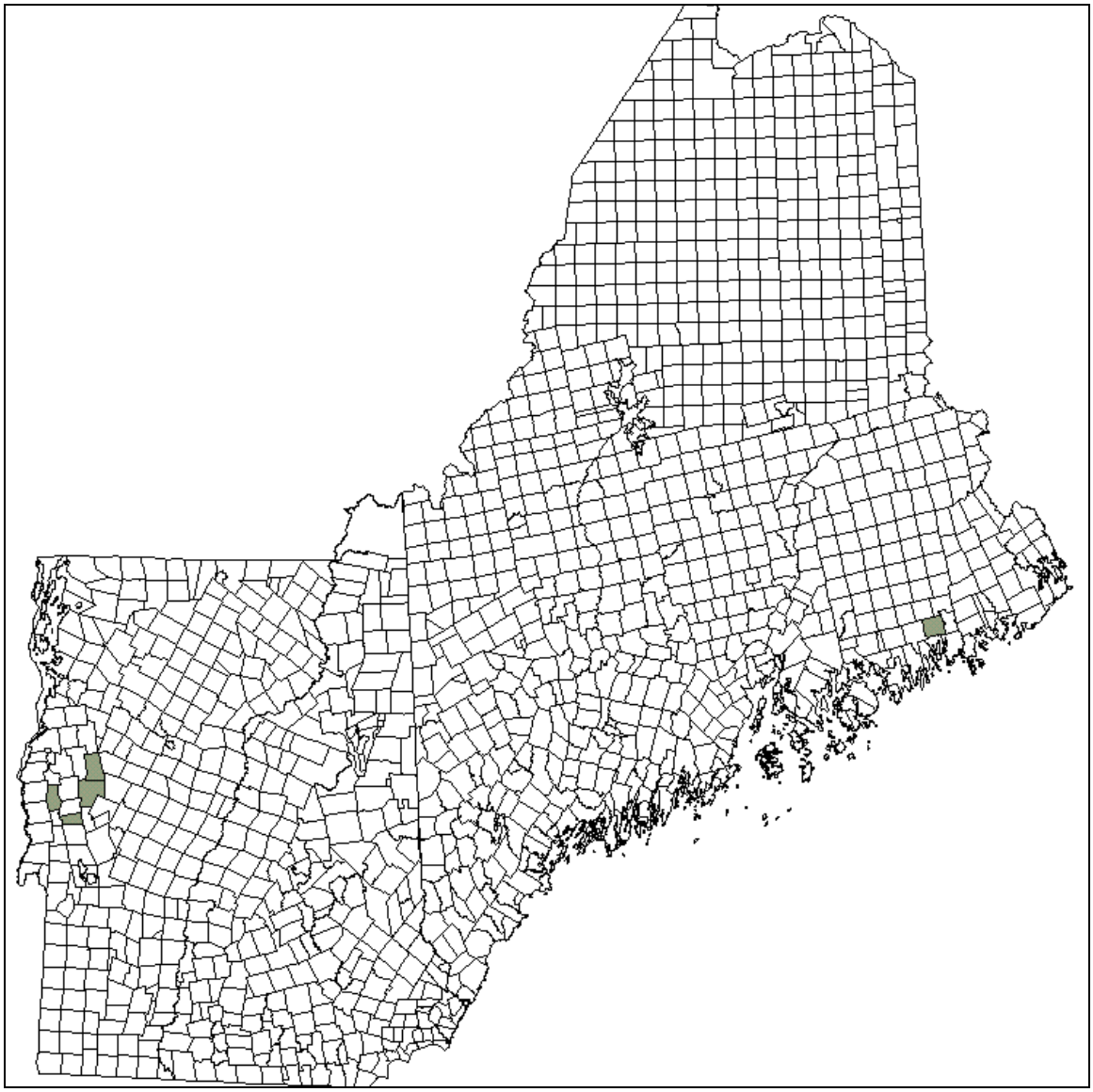

Figure 2. Extant occurrences of *Polemonium van-bruntiae* in New England. Town boundaries for Maine, New Hampshire, and Vermont are shown. Towns shaded in gray have one to five extant occurrences of the taxon. All occurrences in New England are considered extant, so a map of historic records is not shown.

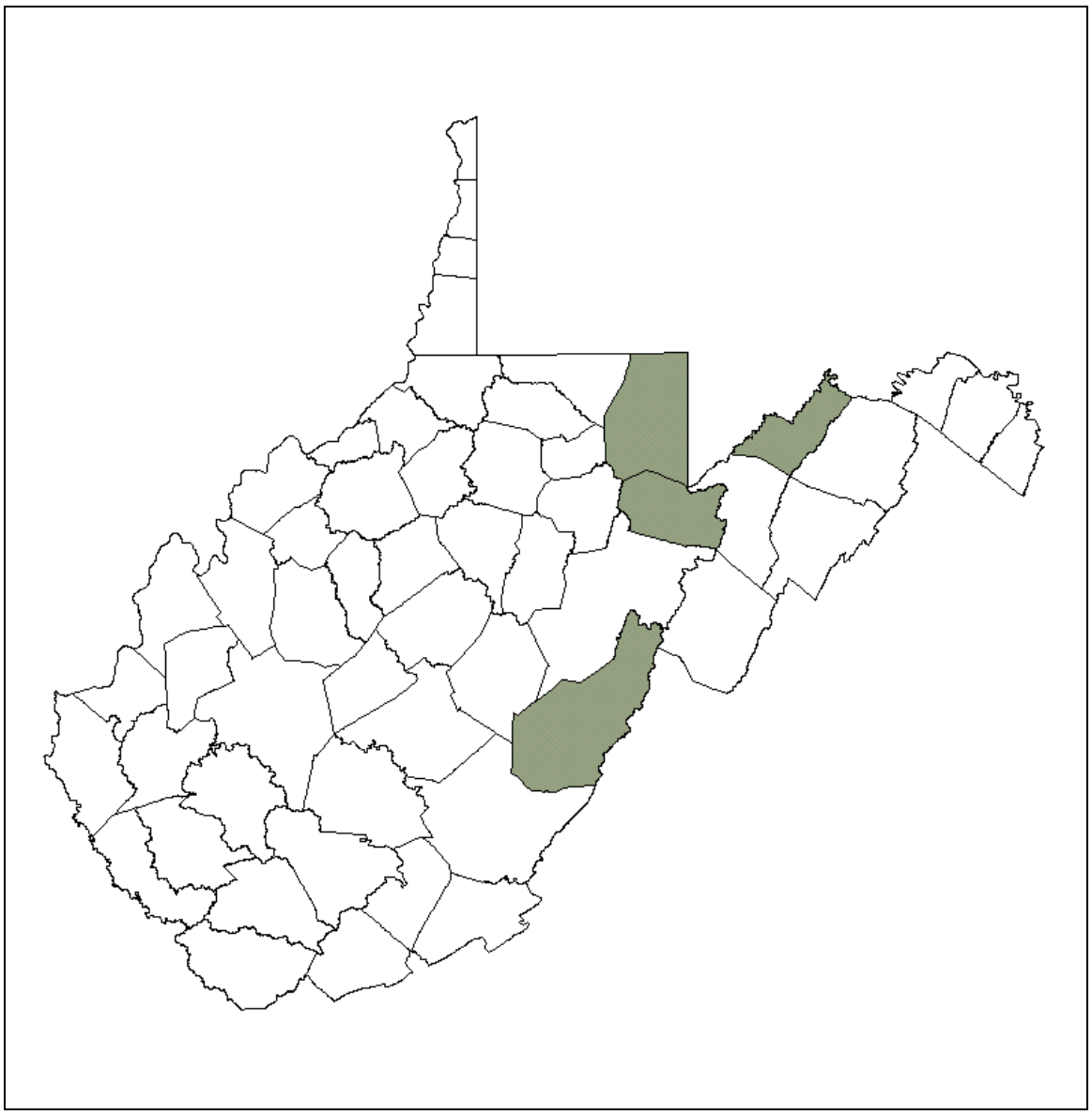

Figure 3. Occurrences of *Polemonium van-bruntiae* in West Virginia. County boundaries are shown. Preston, Tucker, Mineral, and Pocahantas Counties are shaded to indicate presence of the taxon.

Table 2. New England Occurrence Records for *Polemonium van-bruntiae.* Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
ME	**.001**	**Washington**	**Columbia**
VT	**.001**	**Addison**	**Ripton**
VT	**.002**	**Addison**	**Cornwall**
VT	**.003**	**Addison**	**Leicester**
VT	**.004**	**Addison**	**Lincoln**
VT	**.005**	**Addison**	**Ripton**
VT	**.006**	**Addison**	**Lincoln**
VT	**.007**	**Addison**	**Lincoln**
VT	**.012**	**Addison**	**Ripton**
VT	**.013**	**Addison**	**Ripton**

Table 3: Occurrence Records Elsewhere in Region 9, in which *Polemonium van-bruntiae* is known from National Forest lands. Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
WV	**.001**	**Tucker**	**Davis**
WV	**.002**	**Pocahontas**	**Osceola**
WV	**.003**	**Tucker**	**Davis**
WV	**.004**	**Tucker**	**Gladwin**
WV	**.005**	**Tucker**	**Davis**
WV	**.006**	**Randolph**	**Wildell**
WV	.007	Mineral	Hartmansville
WV	**.010**	**Tucker**	**Davis**
WV	**.011**	**Preston**	**Cranesville**
WV	**.012**	**Pocahontas**	**Richwood**
WV	**.013**	**Preston**	**Cranesville**
WV	**.014**	**Tucker**	**Davis**
WV	.015	Tucker	Davis
WV	**.016**	**Tucker**	**Davis**
WV	**.017**	**Tucker**	**Davis**
WV	**.018**	**Tucker**	**Davis**
WV	**.019**	**Tucker**	**Davis**
WV	**.020**	**Tucker**	**Davis**
WV	**.021**	**Tucker**	**Davis**
WV	**.022**	**Tucker**	**Davis**

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 2001a). 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.

II. CONSERVATION

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.

III. LITERATURE CITED

Anonymous. 2002. *Cranberry Glades and Vicinity*. Available at http://www.spies.com/`gus/forests/cranberry.htm.

Beattie, A. J. and D. C. Culver. 1981. The guild of myrmecochores in the herbaceous flora of West Virginia forests. *Ecology* 62: 107-115.

Bouchard, A., D. Barabe, M. Dumais, and S. Hay. 1983. *The Rare Vascular Plants of Quebec*. National Museums Canada, Syllogeus 48. Ottawa, Ontario, Canada.

Britton, N. L. 1892. Untitled. *Bulletin of the Torrey Botanical Club* 19: 224-225.

Brumback, W. E. 1989. Notes on propagation of rare New England species. *Rhodora* 91: 154-162.

Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.

Crow, G. E. and C. B. Helquist. 2000. *Aquatic and Wetland Plants of Northeastern North America*. Volume 1. The University of Wisconsin Press, Madison, Wisconsin, USA.

Darlington, H. C. 1943. Vegetation and substrate of Cranberry Glades, West Virginia. *Botanical Gazette* 104: 371-393.

Davidson, J. F. 1947. A revision of the genus *Polemonium*. Ph. D. Dissertation, University of California, Berkeley, California, USA.

Davidson, J. F. 1950. The genus *Polemonium* (Tournefort) L. *University of California Publications in Botany*. Volume 23: 209-282.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. Available from: Bureau of land Management, National Business Center, BC-650B, P. O. Box 25047, Denver, Colorado, USA.

Farnsworth, E. In press. *Polemonium vanbruntiae* Britton (Polemoniaceae) or van Brunt's Jacob's Ladder. Unpublished Web Information Sheet for Center for Plant Conservation, Missouri Botanical Garden, St. Louis, Missouri, USA.

Fernald, M. L. 1950. *Gray's Manual of Botany*. Eighth Edition. American Book Company, New York, New York, USA.

Galen, C. 1999. Flowers and enemies: predation by nectar-thieving ants in relation to variation in floral form of an alpine wildflower, *Polemonium viscosum*. *Oikos* 85: 426-434.

Galen, C. and M. E. A. Newport. 1988. Pollination quality, seed set, and flower traits in *Polemonium viscosum*: complementary effects of variation in flower scent and size. *American Journal of Botany* 75: 900-905.

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Second Edition. The New York Botanical Garden, Bronx, New York, USA.

Harborne, J. B., and D. M. Smith. 1978. Correlations between anthocyanin chemistry and pollination ecology in the Polemoniaceae. *Biochemical Systematics and Ecology* 6: 127-130.

Hinds, H. R. 1983. *The Rare Vascular Plants of New Brunswick*. Connell Memorial Herbarium, Fredericton, New Brunswick, Canada.

Jenkins, J. 1982. *Potential Habitats for the Rare Plant Species of the Green Mountain National Forest*. Unpublished report. Available at: Rochester Ranger District, 99 Ranger Road, Rochester, Vermont, USA.

Johnson, D. M. and N. A. Murray. 1988. New England Note: *Polemonium vanbruntiae* (Polemoniaceae) in Maine. *Rhodora* 90: 453-454.

Kartesz, J.T., and C.A. Meacham. *Synthesis of the North American Flora*, Version 1.0. North Carolina Botanical Garden, Chapel Hill, North Carolina, USA.

Magee, D. W. and H. E. Ahles. 1999. *Flora of the Northeast: A Manual of the Vascular Flora of New England and Adjacent New York.* University of Massachusetts Press, Amherst, Massachusetts, USA.

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.5. Arlington, Virginia USA: Association for Biodiversity Information. Available: http://www.natureserve.org/ (Accessed: September 10, 2001).

Newcomb, L. 1977. *Newcomb's Wildflower Guide*. Little, Brown, and Company, Boston, Massachusetts, USA.

Popp, R. 1990. Reintroduction of Eastern Jacob's Ladder (*Polemonium vanbruntiae*). Available from the Vermont Nongame and Natural Heritage Program, Vermont Department of Fish and Wildlife, 103 S. Main St., Waterbury, Vermont, USA.

Sabourin, A. and D. Paquette. 1994. Status report on the van Brunt's Jacob's Ladder, *Polemonium van-bruntiae*, in Canada. COSEWIC. Ottawa, Ontario, Canada.

Thompson, E. 1991. Element Stewardship Abstract for *Polemonium vanbruntiae*. The Nature Conservancy, Montpelier, Vermont, USA.

Thompson, E. and E. Sorenson. 2000. *Wetland, Woodland, Wildland*. The Vermont Department of Fish and Wildlife and The Nature Conservancy. University Press of New England, Hanover, New Hampshire, USA.

Thompson, S. A. 2002. *Vascular Plants: Review of Status in Pennsylvania*. Report for the Vascular Plants Technical Committee, Department of Conservation and Natural Resources, Harrisburg, Pennsylvania, USA. Available at http://www.dcnr.state.pa.us/pabs/vascular _plants.htm.

USDA Forest Service. 1998. Field notes on *Polemonium van-bruntiae*. Unpublished. Available from MaryBeth Deller, Rochester Ranger District, 99 Ranger Road, Rochester, Vermont, USA.

USDA Forest Service. 2002. *Regional Forester Sensitive Species*. Available at http://www.fs.fed.us/r9/wildlife/tes/docs/plants.pdf.

USDA Forest Service. 2001a. *Environmental Assessment For the Proposed Amendment to the Green Mountain National Forest Land and Resource Management Plan for Threatened, Endangered, and Sensitive Species.* Available at Green Mountain National Forest Supervisor's Office, 231 North Main Street, Rutland, Vermont, USA.

USDA Forest Service. 2001b. Field notes on *Polemonium van-bruntiae*. Unpublished. Available from MaryBeth Deller, Rochester Ranger District, 99 Ranger Road, Rochester, VT USA.

United States Fish and Wildlife Service. 2001. *Significant Habitats and Habitat Complexes of the New York Bight Watershed, Catskill High Peaks, Complex # 34*. Available at http://training.fws.gov/library/pubs/web_link/text/chp_form.htm.

Vermont Nongame and Natural Heritage Program, Vermont Department of Fish and Wildlife. 2001. The Biological and Conservation Data System, Rare Species and Significant Natural Community Digital Data Set. Waterbury, Vermont, USA.

Zimmerman, M. 1979. *An analysis of the reproductive strategies of* Polemonium *in Colorado*. Ph.D. Dissertation, Washington University, St. Louis, Missouri, USA.

Zimmerman, M. 1980. Reproduction in *Polemonium*: Pre-dispersal seed predation. *Ecology* 61: 502-506.

Zimmerman, M. 1984. Reproduction in *Polemonium*: a five year study of seed production and implications for competition for pollinator service. *Oikos* 42: 225-228.

Zimmerman, M. and G. H. Pyke. 1988. Experimental manipulations of *Polemonium foliosissimum*: effects on subsequent nectar production, seed production and growth. *Journal of Ecology* 76: 777-789.

Zomlefer, W. B. 1994. *Flowering Plant Families*. The University of North Carolina Press, Chapel Hill, North Carolina, USA.

IV. APPENDICES

---

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

2. **An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. 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

2. 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.