Conservation Assessment for Northern Wild Comfrey (Cynoglossum virginianum var. boreale (Fern.) Cooperrider)

Photo: Ian Shackleford

USDA Forest Service, Eastern Region

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Hiawatha National Forest

This document is undergoing peer review, comments welcome

This conservation assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a conservation assessment 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 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

Cynoglossum virginianum var. *boreale* (Fern.) Cooperrider (northern wild comfrey) is designated as a regional forester sensitive species on the Chequamegon-Nicolet, Huron-Manistee, and Hiawatha National Forests in the Eastern Region of the U.S. Forest Service (USDA Forest Service 2003). This species is also listed as extirpated from the White Mountain National Forest in New Hampshire. *Cynoglossum virginianum* var. *boreale* is documented, but not listed on the Chippewa, Green Mountain, Superior, and Ottawa National Forests (USDA Forest Service 2003). The purpose of this document is to provide background information necessary to create a management plan, known as a "conservation strategy," which will be designed specifically to conserve this species.

Cynoglossum virginianum var. *boreale* is a taprooted perennial with pubescent leaves concentrated near the base of the plant (Gleason & Cronquist 1991). Basal leaves have long petioles, while upper cauline leaves tend to be sessile or clasping. Leaves are simple, entire, alternate, and decrease in size going up the stem. One to four raceme-like stalks branch from the terminal and bractless peduncle. The small light-blue flowers are five-merous with funnelform- to salverform-shaped corollas. Each flower produces one ovary with four deep lobes and can produce up to four single-seeded nutlets with barbed prickles (Gleason & Cronquist 1991).

Cynoglossum virginianum var. *boreale* occurs in North America from Maine and Nova Scotia in the east reaching as far south as New Jersey. The species is scattered westward to eastern Wyoming in the United States and across Canada to British Columbia and the Yukon Territory (NatureServe Explorer 2003). Over eighty occurrences of *C. virginianum* var. *boreale* have become extirpated in the southeastern part of its range. Of the sixteen states within the historic range of *C. virginianum* var. *boreale*, six have no extant occurrences (CT, IN, MA, NJ, OH, and PA). Four other states (ME, NH, NY, and VT) have less than ten known extant occurrences, with more historic than extant occurrences. The species has not been documented as declining in the other six states within its range (MI, MN, ND, SD, WI, and WY). In Canada the species is most plentiful in Ontario, Quebec, and British Columbia.

Cynoglossum virginianum var. *boreale* tends to occur in dry to mesic forests and openings of forests. Soils are described as rich, rocky, sandy, calcareous, or clay. Documented occurrences in the eastern United States are found in coniferous forests (with a combination of balsam fir, jack pine, red pine, white cedar, white spruce, red cedar, and eastern hemlock), mixed forests, and deciduous forests (predominantly quaking aspen, white birch, oak species, sugar maple, and red maple). The disappearance of many populations in the eastern U.S. is perplexing given that the habitat of the species does not seem to be uncommon. Explanations for the decline of populations that are suggested in this document include herbivory by white-tailed deer, fire suppression, forest maturation, logging, and climate change. Until research examines the life history and population dynamics of this species, the cause for the species' decline in the eastern U.S. will not be known. Likewise, the viability of populations in other areas of the species' range will remain uncertain.

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NOMENCLATURE AND TAXONOMY

Table 1. Current taxonomic placement and nomenclature of *Cynoglossum virginianum* var. *boreale* (PLANTS Database 2003).

Order:	Lamiales
Family:	Boraginaceae
Genus:	*Cynoglossum*
Scientific name:	*Cynoglossum virginianum* L. var. *boreale* (Fern.) Cooperrider
Common name:	Northern wild comfrey, northern hound's tongue
USDA Symbol:	CYVIB
Synonyms:	*Cynoglossum boreale* Fern.

Cynoglossum virginianum L. is a species within the Boraginaceae (borage family) (Table 1). Like other families of the Order Lamiales (including Lamiaceae and Verbenaceae), the Boraginaceae tend to have one superior ovary per flower that has four distinct lobes united by a gynobasic style (Cronquist 1988). The Boraginaceae, however, mostly have alternate entire leaves, round stems, and regular-shaped flowers, while the Lamiaceae and the Verbenaceae primarily have square stems, irregular-shaped flowers, and opposite leaves that are often toothed or cleft (Cronquist 1988). The Borginaceae are also distinguished by containing alkannin and pyrrolizidine alkaloids (Cronquist 1988).

Genus *Cynoglossum* is distinguished from other genera of Borginaceae in eastern North America by having ovaries with four deep lobes, salverform- to funnelform-shaped corollas with a well developed tube, barbed prickles on the nutlets, bractless flowers, and the gynobase attaching to the upper third of the nutlet (Gleason & Cronquist 1991). This document follows the nomenclature of PLANTS Database (2003) which recognizes two varieties of *C. virginianum*, variety *virginianum* L. and variety *boreale* (Fern.) Cooperrider. This may not be the finalized identity of these varieties as some recent reputable sources distinguish these varieties as distinct species including Flora of the Great Plains (Kaul 1986), Michigan Flora Volume III (Voss 1996), Illustrated Flora of British Columbia (Pojar 1998), and Wisconsin State Herbarium (2003). Besides the two varieties of *C. virginianum*, the only other species of *Cynoglossum* found in eastern North America are exotic weedy species, most commonly *C. officinale* (Gleason & Cronquist 1991).

DESCRIPTION OF SPECIES

Cynoglossum virginianum var. *boreale* is a taprooted perennial with rough pubescence on leaves and stems (Gleason & Cronquist 1991, Voss 1996, Pojar 1998, and Magee & Ahles 1999). Plants have elliptic to oblong basal leaves with long petioles. Cauline leaves are simple, entire, and alternate. Uppermost cauline leaves tend to be sessile and may clasp the stem, while lower cauline leaves tend to be petiolate (Figure 1). Leaves are concentrated on the lower half of the stem and decrease in size going up the stem (Gleason & Cronquist 1991, Voss 1996). Variety *boreale* has one to four raceme-like flowering stalks branching from the terminal bractless peduncle. Each flower has a single superior ovary that has four deep lobes, and the style connects at the base of the

ovary. Flowers are five-merous with funnelform- to salverform-shaped corollas that are light blue, oblong, and do not overlap (Gleason & Cronquist 1991, Voss 1996). Calyxes have hairy appendages (fornices) that grow opposite the lobes of the corolla nearly closing the short tube (Gleason & Cronquist 1991). The five stamens are inserted within the tube, alternating with the corolla lobes, and have very short anthers. Each of the four lobes of the ovary may develop into a single-seeded nutlet with barbed prickles (Gleason & Cronquist 1991, Voss 1996, Pojar 1998, and Magee & Ahles 1999). Refer to Table 2 for more details on the technical characteristics of *C. virginianum* var. *boreale*.

Unlike variety *boreale*, variety *virginianum* does not have petioles on any of its cauline leaves and its corolla lobes overlap and are broadly rounded (Gleason & Cronquist 1991, Table 3). Variety *virginianum* is in general larger than variety *boreale*. In particular, the calyx, corolla, and nutlets of variety *virginianum* are wider than those of variety *virginianum* (Gleason & Cronquist 1991, Magee & Ahles 1999, Table 3). In addition, variety *boreale* is distributed north of variety *virginianum* (Gleason & Cronquist 1991)

Figure 1. *Cynoglossum virginianum* var. *boreale*. Drawing by R. Shackleford.

Cynoglossum virginianum var. *boreale* can be easily distinguished from *C. officinale* by examining a few basic characteristics. *Cynoglossum virginianum* var. *boreale* has a blue corolla, while *C. officinale* has a red or maroon colored corolla (Gleason & Cronquist 1991). Variety *boreale* has leaves growing only on the lower portion of the stem, while *C. officinale* is leafy along the entire stem. The inflorescence of *C. virginianum* is terminal having few racemose branches at the end of the peduncle, while that of *C. officinale* is axillary with many false racemes in the upper axils of leaves (Gleason and Cronquist 1991). When in fruit, the style of variety *boreale* is short and inconspicuous,

while relatively longer and more conspicuous on *C. officiale* (Voss 1996). *Cynoglossum virginianum* var. *boreale* has nutlets that are flat on top with no raised rim, while *C. officinale* has nutlets with a convex top and a raised rim (Voss 1996). *Cynoglossum amabile* is a less common exotic species that is similar to *C. officinale* except it has bright blue or white flowers (Gleason & Cronquist 1991).

Table 2. Technical characteristics of *Cynogolossum virginianum* var. *boreale*. References for descriptions include: Gleason & Cronquist 1991, Voss 1996, Pojar 1998, and Magee & Ahles 1999.

General:	Single unbranched stem, perennial, tap-rooted, rough-pubescent stem and leaves, to 8 dm tall.
Leaves:	**Basal:** long, decurrent petiole; elliptic to oblong, 10-20 cm long, 2.5-7 cm wide. **Cauline:** Alternate, simple, entire, lack stipules, larger and closer together near base, reduced going upward, lower leaves may be petiolate, upper leaves may be sessile or clasping.
Inflorescence:	Cymose, appears raceme-like, naked (no leaves or bracts), terminal, peduncle with 1-4 racemose branches.
Flowers:	Perfect, five-merous, symmetrical. **Pistil:** superior ovary, deeply lobed into four parts; style forms from between lobes and is inconspicuous; stigma is not lobed. **Stamen:** inserted, alternate to lobes. **Corolla:** 5-8 mm wide, light blue, sympetalous, funnelform to salverform, short tube, lobes oblong and not-overlapping, fornices (five hairy appendages opposite each lobe) close the tube. **Calyx:** 1-3 mm at anthesis, inconspicuous when in fruit. **Fruit:** 1-4 nutlets per flower, 3.5-5 mm, each with one seed, prickly, convex surface, protruding horizontally (attached near summit of style), no margin. **Bracts:** none.

Table 3. Distinguishing characteristics between *Cynoglossum virginianum* var. *boreale* and variety *virginianum* (Gleason and Cronquist 1991).

	Var. boreale	Var. virginianum
Size	Generally smaller	Generally larger
Petioles on cauline leaves	On some lower leaves	Absent
Calyx at anthesis	1-2.5 mm	3-4 mm
Corolla lobes	Not-overlapping, oblong	Overlapping, broadly rounded
Corolla width	5-8 mm	8-12(16) mm
Nutlet width	3.5-5 mm	6-8 mm

LIFE HISTORY

Reproduction

Cynoglossum virginianum var. *boreale* is a non-clonal perennial that re-sprouts from a taproot each spring (Gleason & Cronquist 1991, Whigham *et al*. 1993). Immature and

non-flowering plants grow one to six (sometimes more) basal leaves in a rosette, while reproductive plants grow a stem with cauline leaves from the center of the rosette (Whigham *et al.* 1993, Abrams & Brumback 2001). Variety *boreale* is moneocious and flowers from May to June and fruits ripen from July through August (Gleason & Cronquist 1991, Magee & Ahles 1999, Abrams & Brumback 2001). Variety *boreale* is probably self-compatible given that the closely related variety *virginianum* is self-compatible (Whigham *et al.* 1993). *Cynoglossum virginianum* var. *boreale* flowered two years after germinating when grown for a year in a nursery and transplanted to a garden (Brumback pers. comm. 2004).

Ecology

The ecology of *C. virginianum var. boreale* has not been studied specifically; however, the ecology of this species may be similar to other species that grow in similar habitat. *Cynoglossum virginianum* var. *boreale* is found in forest gaps, openings, edges, as well as under full-canopy forest (Appendixes A & B). Its association with forests suggests that some part of the life cycle of *C. virginianum* var. *boreale* may be dependent on certain conditions within forests such as greater humidity, lower temperatures, or less competition. Like many understory herbs, it may also depend on forest openings for flowering and seedling establishment due to associated conditions such as increased light levels and soil disturbance (Hughes *et al*. 1988, Collins & Pickett 1988, Reader & Bricker 1992, Whigham *et al*. 1993). On the other hand, if forest openings are too large, woody species that tend to shade forest herbs may establish and prevent the long-term persistence of many forest herbs (Reader & Bricker 1992).

Many native plants of forest ecosystems are adapted to occasional fires. Fires improve conditions for some species by decreasing plant competition, changing soil conditions, and increasing light availability (Barbour *et al.*1987). Fires may also induce fire-adapted plants to flower, disperse, and/or germinate (Barbour *et al.*1987). The general habitat of *C. virginianum* var. *boreale* suggests that this species may be adapted to conditions created by occasional fire. This species often occurs in pine forests (jack, white, and red pine) in the Upper Midwest (see "Habitat" section) which historically had frequent fires (Curtis 1987, Spies & Turner 1999). The species is also associated with disturbed areas of forests suggesting that fire may improve conditions for this species.

Whigham *et al.* (1993) tracked individual plants of variety *virginianum* in three subpopulations for fifteen years. Two subpopulations occurred in mature forest and one occurred in a forest gap. Plants that occurred in the forest gap flowered annually for three or four years, however, the gap was shaded by shrubs within six years and flowering nearly stopped. A high proportion of plants in closed-canopy subpopulations flowered only once or twice in fifteen years. Seedlings in all three subpopulations had high mortality rates, with no seedlings reaching maturity during the fifteen year study (Whigham *et al*. 1993). This study suggests that, like variety *virginianum*, variety *boreale* may be long-lived, reproduce infrequently, and take years to reach maturity (Whigham *et al*. 1993).

Cynoglossum virginianum var. *boreale* may have a similar life history as variety *virginianum* given that they are closely related and occur in similar habitats. The subpopulation of variety *virginianum* that grew in a forest gap had more flowers per plant, a greater flowering frequency, as well as more seeds that germinated than subpopulations in the closed-canopy forest (Whigham *et al.* 1993). On the other hand, many of the seedlings in the gap died, suggesting that seedlings survivorship is lower in gaps than in the closed-canopy forest (Whigham *et al.* 1993). Cipollini *et al.* (1993), in a theoretical analysis of the study by Whigham *et al.* (1993), suggest that seed dormancy or dispersal of seeds from gaps into mature forest may be important for *C. virginianum* to establish seedlings. The research of Whigham *et al.* (1993) and Cipollini *et al.* (1993) suggests that *C. virginianum* may need a combination of forest gaps and mature forest to maintain populations.

Many forest herbs have seeds that are dormant immediately upon ripening or become dormant under certain conditions (Granström 1982, Leckie *et al.* 2000). Dormant seeds may become part of a seed bank that persists in the soil for years. Requirements to break seed dormancy are often associated with the creation of an opening in the forest such as light, abrasion of the seed coat, or heat from fire (Granström 1982, Leckie *et al.* 2000). Seed banks, therefore, are one manner that forest species can quickly establish in unpredictable openings. Brumback (pers. comm. 2004) of the New England Wild Flower Society indicates that three of ten *Cynoglossum virginianum* var. *boreale* seeds germinated after 90 days of refrigeration, while six other seeds germinated two years after being collected when in an outside nursery. This information suggests that seeds can germinate after a period of cold storage and may become dormant for at least a few years. Moisture, light, and temperature changes may be possible triggers breaking dormancy. More research is needed to determine if *Cynoglossum virginianum* var. *boreale* can have viable seed banks.

In spruce-fir forest in the Upper Peninsula of Michigan (Maycock 1961) and northern parts of Wisconsin, Minnesota, and Michigan (Maycock & Curtis 1960), *C. virginianum* var. *boreale* was found in forests that had components of both deciduous and boreal forests. In both studies *C. virginianum* var. *boreale* had a low percent presence and low average frequency in plots. The species apparently does not naturally produce large populations or occur as a dominant species in the plant community (see "Population Biology and Viability").

Dispersal/Migration

Mammals may occasionally disperse seeds due to the adherence of the barbed fruit to their fur (Whigham *et al.* 1993, Voss 1996). However, a fifteen year study of a population of *C. virginianum* var. *virginianum* in Maryland suggests that dispersal by mammals may be rare (Whigham *et al.* 1993). During their study, most seeds fell near the parental plant. The frequency of seed dispersal by mammals may differ in other forests depending on the species of mammals present and their densities. In the Black Hills National Forest some occurrences of *C. virginianum* var. *boreale* are found along animal trails suggesting that seeds were transported by animals (K. Zacharkevics pers.

comm. 2003). Occasional transport of seeds by animals may be important for establishing new populations.

Pollen dispersal may be an important mode by which genes are dispersed within and between populations (see "Population Biology and Viability" section). Pollen is probably dispersed by insects given the attractive blue flowers of *C. virginianum* var. *boreale*. Other species of *Cynoglossum* have been observed to be visited by bumble bees (De Jong & Klinkhamer 1991).

Defense mechanisms

Pyrrolizidine alkaloids occur in species of the Borginaceae family (Cronquist 1988). These chemicals are believed to protect plants to some degree from generalist herbivores (Van Dam *et al.* 1995). The toxicity of pyrrolizidine alkaloids may differ in different species (Pedersen 1975) and have not been examined in *C. virginianum* var. *boreale*. Some evidence suggests that deer may regularly browse upon *C. virginianum* var. *boreale*, suggesting that pyrrolizidine alkaloids are not a strong defense mechanism for this species (see "Potential Threats" section).

HABITAT

Range-wide

Throughout its range, *Cynoglossum virginianum* var. *boreale* occurs in forests and forest openings (Fernald 1905, Gleason & Cronquist 1991, Magee & Ahles 1999, Appendix A). Soil moisture descriptions vary from dry to mesic; soil nutrient levels tend to be rich; soil texture has been described as rocky, sandy, gravely, and occasionally clay (Appendixes A & B). In the eastern United States, the species occurs in a combination of coniferous, mixed, and deciduous forests (Voss 1996, Abrams & Brumback 2001, Appendixes A & B). Descriptions in Door County, Wisconsin (Wisconsin State Herbarium 2003, Appendix B) and Vermont (Steckler *et al.* unpublished) indicate that it can also occur on limestone cliffs and ledges. In the eastern United States, *C. virginianum* var. *boreale* occurs in coniferous forests that may be dominated by *Abies balsamea* (balsam fir), *Pinus banksiana* (jack pine), *Pinus resinosa* (red pine), *Thuja occidentalis* (northern white cedar), *Picea glauca* (white spruce), *Juniperus virginiana* (red cedar), and *Tsuga canadensis* (eastern hemlock) (Appendix B). Deciduous forests that it occurs in are dominated by a combination of *Populus tremuloides* (quaking aspen), *Betula papyrifera* (paper birch), *Quercus* species (oaks), *Acer saccharum* (sugar maple), *Acer rubrum* (red maple), *Populus balsamifera* (balsam poplar), and *P. grandidentata* (big-toothed aspen) (Appendix B).

Northern Great Lakes Region

Michigan, Minnesota, and Wisconsin each have numerous documented occurrences of *C. virginianum* var. *boreale*. Habitat descriptions from over 30 documented populations from each of these three states were obtained from herbaria (University of Michigan in Ann Arbor, University of Minnesota Herbarium in St. Paul, and Wisconsin State Herbarium at the University of Wisconsin-Madison) and national forests within these states (Chippewa, Superior, Chequamegon-Nicolet, Ottawa, Hiawatha, and Huron-Manistee National Forests). These habitat descriptions are listed in Appendix B and are summarized in the following paragraphs. Habitat descriptions were available for only a portion of known populations and most descriptions have few details, therefore the following habitat descriptions are tentative.

Table 4. Number of and fraction of populations of *C. virginianum* var. *boreale* with habitat descriptions available (Appendix B) that are associated with the given tree species in Michigan (MI [N=33]), Minnesota (MN [N=52]), and Wisconsin (WI [N=31]).

	Number of populations				**Fraction of populations**			
	MI	**MN**	**WI**	**Total**	**MI**	**MN**	**WI**	**Total**
Abies balsamea	14	4	7	25	0.42	0.08	0.23	0.22
Acer rubrum	3	4	1	8	0.09	0.08	0.03	0.07
Acer saccharum	5	2	3	10	0.15	0.04	0.1	0.09
Betula spp.	5	19	9	33	0.15	0.37	0.29	0.28
Fagus grandifolia	1	0	0	1	0.03	0	0	0.01
Fraxinus nigra	1	0	0	1	0.03	0	0	0.01
Pinus spp. (total)	10	30	10	50	0.30	0.58	0.32	0.43
P. banksiana	5	14	3	22				
P. resinosa	6	8	1	15				
P. strobus	3	0	2	5				
Picea glauca	5	2	6	13	0.15	0.04	0.19	0.11
Picea mariana	1	0	1	2	0.03	0	0.03	0.02
Populus spp.	18	15	11	44	0.55	0.29	0.35	0.38
Quercus spp.	6	0	4	10	0.18	0	0.13	0.09
Thuja occidentalis	6	0	2	8	0.18	0	0.06	0.07
Tilia americana	1	0	0	1	0.03	0	0	0.01
Tsuga canadensis	1	0	2	3	0.03	0	0.06	0.03
Ulmus Americana	1	0	0	1	0.03	0	0	0.01

Most herbarium labels with habitat descriptions mention that the species was found in deciduous, mixed, or coniferous forests, forest edges, or forest openings, although some occurrences are within full shade. In Minnesota, the species has been documented most often in coniferous forests (57%), and least often in mixed forests (<25%) (Appendix B). In Wisconsin the species is documented most often in mixed forest (45%), and least often in coniferous forests (Appendix B). In Michigan the species occurs nearly equally within

the three general forest types (Appendix B). In all three states nearly a third of the populations have been found in deciduous forests (Appendix B).

Table 4 was created using habitat descriptions from Appendix B. This table indicates the associated tree species for *C. virginianum* var. *boreale* in Michigan, Minnesota, and Wisconsin. Pine species (primarily *Pinus banksiana* and *P. resinosa* [jack and red] with few *P. strobus* [white pine]) are associated with over half of the populations with descriptions in Minnesota, while only around a third of populations in Michigan and Wisconsin (Table 4). A combination of *Betula* species (primarily *Betula papyrifera*) and *Populus* species (*P. tremuloides* and *P. grandidentata*) are dominant in over a third of populations in the three states. In Michigan, *Populus* species are listed as occurring in over half of populations. *Abies balsamea* (balsam-fir) is listed in over 20% of populations of Wisconsin and Michigan, while it is listed in less than 10% of populations in Minnesota (Table 4). *Thuja occidentalis* (northern white cedar) is associated with 18% of Michigan populations, while associated with few Wisconsin populations and no Minnesota populations. *Acer saccharum* (sugar maple) is associated with less than a fifth of populations in the three states. *Quercus* species (oak) are associated with populations in Wisconsin and Michigan, but not with populations in Minnesota. *Fagus grandifolia* (beech), *Fraxinus nigra* (black ash), *Ulmus americana* (American elm), *Tilia americana* (basswood), and *Tsuga canadensis* (hemlock) are each associated with single populations in Michigan. *Tsuga canadensis* (hemlock) was also associated with two populations in Wisconsin.

New England

Vermont, New Hampshire, and Maine are the only New England states with extant populations of *C. virginianum* var. *boreale*. In these states the species "tend[s] to grow in shallow calcareous soils, in cedar/hemlock/hardwood forests. Plants are often found in very rocky soil or on steep slopes and tend to grow in tree-fall gaps, recently burnt areas, along road or trail edges, or in other such canopy disturbances" (Abrams & Brumback 2001). *Cynoglossum virginianum* var. *boreale* may also occur in northern hardwood or oak/pine northern hardwood forests (SVE panel 2002, cited in Steckler *et al.* unpublished). Four of the eight extant populations occur in mixed forests with combinations of *Thuja occidentalis* (northern white cedar), *Juniperus virginiana* (red cedar), *Tsuga canadensis* (eastern hemlock), *Ostrya virginiana* (ironwood), *Picea glauca* (white spruce) *Quercus rubrum* (red oak), *Acer rubrum* (red maple), and *Acer saccharum* (sugar maple) (Appendix B). One occurrence is in a *Thuja occidentalis* (white cedar) forest, and one occurrence is in an aspen forest with *Populus tremuloides* (quaking aspen), *P. grandidentata* (big-toothed aspen), and *P. balsamifera* (balsam poplar) (Appendix B). Two of the populations in Maine were discovered in "young" forests due to a fire or clear-cut in the last ten to twenty years. Two other populations in Maine were discovered in mature forests that were later logged (Appendix B). The populations may have been extirpated prior to logging as neither of these populations was re-located even in searches prior to logging.

New York

Cynoglossum virginianum var. *boreale* occurs in "rocky maple-birch forest… northern successional hardwoods and mixed ash-maple rocky woods; in openings on thin, dry, probably calcareous soil…dry woods; along path in woods; wet woods; hills; thickets; in or near forest openings, especially on limestone" (New York Natural Heritage Program [NYNHP] unpublished).

Associated trees include: *Acer saccharum* (sugar maple) and *Betula papyrifera* (paper birch). Associated herbs include: *Actaea pachypoda* (baneberry), *Aralia nudicalis* (sarsaparilla), *Aster macrophyllus* (large-leaved aster), *Botrychium dissectum* (dissected grapefern), *Brachyletrum erectum* (a grass), *Carex* species (sedges), *Oryzopsis asperifolia* (rice grass), *Poa saltuensis* (a grass), *Prenanthes altissima* (rattlesnake root), and *Solidago caesia* (goldenrod) (NYNHP unpublished).

North Dakota

Cynoglossum virginianum var. *boreale* is documented in aspen forests of the Turtle Mountains in northern North Dakota (Bottineau and Rolette Counties) and in aspen and bur oak-aspen forests of the Killdeer Mountains in west-central North Dakota (Dunn County) (Northern Prairie Science Center 1996, G. K. Clambey pers. comm. 2003, J. La Duke pers. comm. 2003). In both areas occurrences are described as occasional or uncommon.

South Dakota/Wyoming

Cynoglossum virginianum var. *boreale* is only known on the Black Hills National Forest in these states. Refer to the habitat description for this national forest (see following section).

National Forests

Cynoglossum virginianum var. *boreale* is documented as occurring on the White Mountain National Forest in New Hampshire and Green Mountain National Forest in Vermont based exclusively on historical occurrences (USDA Forest Service 2003). Historical occurrences are also documented within the proclamation boundaries of the Finger Lakes National Forest in New York, however, these occurrences are not on Forest Service land (Finger Lakes National Forest 2000). Habitat descriptions for occurrences on these three national forests are old, vague, and may not be relevant (Appendix B). Habitat descriptions of the numerous extant occurrences on national forests in Michigan, Minnesota, South Dakota, and Wisconsin are summarized below.

Michigan

Hiawatha National Forest

Only three occurrences on the Hiawatha National Forest have habitat descriptions available (Appendix B). One population occurs in a *Betula papyrifera* and *Populus tremuloides* forest (with *Acer saccharum*, *Abies balsamea*, and *Pinus banksiana*), one occurs in *Acer saccharum* forest, and one occurs in northern mesic forest with some *Thuja occidentalis* (Appendix B).

Huron-Manistee National Forest
Most occurrences on the Huron-Manistee National Forest occur in sandy soil, often in mixed forest with a combination of *Populus tremuloides*, *Quercus* spp., *Pinus resinosa*, and *P. banksiana* (Appendix B). A few populations are in *Thuja occidentalis* forests.

Ottawa National Forest
Most occurrences on the Ottawa National Forest are in openings or along edges of forests that are dominated by *Populus tremuloides* and *Abies balsamea* (Appendix B). Other dominant trees in associated forests include *Acer saccharum, Picea glauca, Tsuga canadensis, Acer rubrum, Tila americana, Fraxinus nigra, Betula papyrifera,* and *Ulmus americana*. Most known sites occur on clay soil (Appendix B).

Herbs associated with at least two occurrences include: *Aster macrophyllus* (large-leaved aster), *Pteridium aquilinium* (bracken fern), *Waldsteinia fragarioides* (barren-strawberry), *Rubus pubescens* (dwarf raspberry), *Aralia nudicaulis* (wild sarsaparilla), *Hepatica americana* (round-leafed hepatica), *Actaea* spp. (baneberry), *Brachyelytrum erectum* (a grass), *Sanicula marilandica* (black snakeroot), *Maianthemum canadense* (Canada mayflower), *Oryzopsis asperifolia* (rice grass), and *Fragaria virginiana* (wild strawberry).

Minnesota
Chippewa National Forest
Many of the occurrences on the Chippewa National Forest are in *Pinus banksiana* and *P. resinosa* forests (Appendix B). A few occur in deciduous forests. Other tree species associated with the species include *Picea glauca* and *Acer rubrum*.

Superior National Forest
Most occurrences are near or in forests dominated by *Populus tremuloides* and/or *Betula papyrifera*; a portion of associated forests also have *Abies balsamea* or *Acer rubrum*. A few occurrences are in *Pinus banksiana* and/or *P. resinosa* forests (Appendix B). Shrubs listed in habitat descriptions include *Corylus cornuta* (beaked hazelnut), *Diervilla lonicera* (bush honeysuckle), *Rubus strigosus* (red raspberry), and *Cornus rugosa* (round-leaved dogwood). Herbs listed in habitat descriptions include *Aster macrophyllus* (large-leaved aster), *Fragaria virginiana* (wild strawberry), and *Rubus pubescens* (dwarf raspberry) (Appendix B).

South Dakota/Wyoming

Black Hills National Forest

Cynoglossum virginianum var. *boreale* occurs primarily on mesic soils with a hardwood component on the Black Hills National Forest (K. Zacharkevics pers. comm. 2003). Such areas are relatively uncommon on that national forest. The species tends to occur in partially to mostly shady habitat that is undisturbed or mildly disturbed (such as deer or rabbit trails) (K. Zacharkevics pers. comm. 2003). Occurrences have primarily been found in *Betula papyrifera* forest with *Corylus* species (hazelnut) understory (K. Zacharkevics pers. comm. 2003). Other dominant tree species include *Populus tremuloides*, *Picea glauca*, *Ostrya virginiana*, and *Pinus ponderosa*.

Wisconsin

Chequamegon-Nicolet National Forest

Many occurrences are in mixed forests with a combination of *Populus tremuloides*, *Betula papyrifera*, *Pinus strobus*, *Tsuga canadensis*, *Pinus banksiana*, *Quercus* species and *Ostrya virginiana* (Appendix B). Soils are described as sandy, gravelly, or sandy-loam.

DISTRIBUTION AND ABUNDANCE

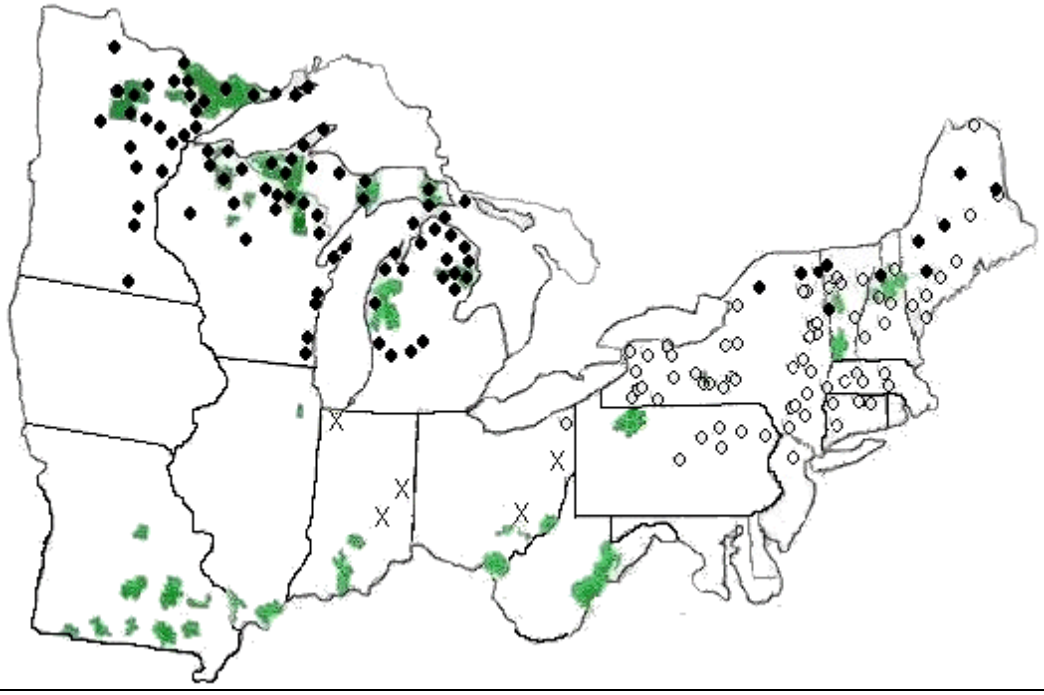


Figure 2. Documented occurrences of *C. vigininanum* var. *boreale* in the Eastern Region of the U.S. Forest Service. Green areas (grey if not in color) indicate Forest Service land. Open circles indicate extirpated occurrences, while filled circles indicate extant occurrences. An "X" indicates extirpated occurrences that may be variety *virginianum*. Each circle may represent more than once occurrence. Sources are indicated in Table 5. Appendix B lists dates and descriptions of occurrences.

Table 5. Numbers of historical (assumed extirpated) and extant populations of *C. virginianum* var. *boreale* in the U.S. A question mark (?) after extant populations in Michigan, Minnesota, North Dakota, and Wisconsin indicates the number of populations that were documented over 40 years ago. These populations are assumed to be extant since population decline has not been documented in that region. Appendix B lists dates and descriptions of occurrences.

State	Historic	Extant	Total	Sources and comments
Connecticut	4	0	4	Abrams & Brumback unpublished.
Indiana	3	0	3	Deam 1940, Swink & Wilhelm 1994.*
Iowa**	0	0	0	M. Leoschke, pers. comm. 2003.; D.Q. Lewis, pers. comm. 2005.
Maine	6	5	11	Maine Department of Conservation 1999.
Massachusetts	6	0	6	Abrams & Brumback unpublished.
Michigan		76 +11?	87+	Voss 1996; herbaria (MICH, MCT) (codes in Appendix B); Huron-Manistee, Hiawatha, and Ottawa National Forests.
Minnesota		34 + 31?	65+	University of Minnesota Herbarium 2003, Element occurrences from Superior and Chippewa National Forests; "Uncommon species of upland forests" on the Superior National Forest (J. Greenlee, pers. comm. 2003).
New Hampshire	5	1	6	New Hampshire Natural Heritage Inventory 2003.
New Jersey	1	0	1	NatureServe Explorer 2003.
New York	45	3	48	NYNHP unpublished.
North Dakota		8 + 5?	13+	G. K. Clambey, pers. comm. 2003 (North Dakota State Herbarium), J. La Duke pers. comm. 2003 (University of North Dakota Herbarium), Northern Prairie Science Center 1996.
Ohio	1	0	1	Ohio Division of Natural Areas and Preserves 2000.
Pennsylvania	11	0	11	S. Grund, pers. comm. 2001, T. Block, pers. comm. 2003.
South Dakota	?	90	90	K. Zacharkevics, pers. comm. 2003.
Vermont	8	3	11	Abrams & Brumback unpublished.
Wisconsin		37 + 33?	72+	Wisconsin State Herbarium 2003, Chequamegon-Nicolet National Forest element occurrences; "Uncommon to rare in Wisconsin" (Chequamegon-Nicolet National Forest 2002).

*The specimens need to be re-examined to verify that they are variety *boreale* and not *virginianum* (M. Homoya pers. comm. 2003).

***Cynoglossum virginianum* var. *boreale* does not occur in Iowa according to Mark Leoschke of the Iowa Natural Features Inventory and Debra Lewis of the Ada Hayden Herbarium at Iowa State University. It is, however, listed as being reported by NatureServe Explorer 2003.

Range-wide Distribution

Cynoglossum virginianum var. *boreale* occurs in North America from Maine and Nova Scotia in the east reaching as far south as New Jersey (NatureServe Explorer 2003). The species is scattered westward to eastern Wyoming in the United States and across Canada to British Columbia and the Yukon Territory. The range of the species apparently is in decline in the eastern United States as 87 historical occurrences have not been relocated, with 45 of these from New York State (Table 5, Figure 2). Occurrences are most plentiful in Michigan, Minnesota, Wisconsin, and western South Dakota in the United States (Table 5). Sources from each of these states suggest that the species is relatively uncommon as populations are small and infrequent (J. Greenlee pers. comm. 2003, Chequamegon-Nicolet National Forest 2002, K. Zacharkevics pers. comm. 2003). In Canada the species is most plentiful in Ontario, Quebec, and British Columbia (Table 6). Given the number of known occurrences of variety *boreale* and regional assessments of the species (Table 5 & 6), this species is not apparently abundant and common in any area of its range.

Table 6. Abundance information regarding *C. virginianum* var. *boreale* in provinces of Canada.

Province	Abundance information
Alberta	Two known occurrences (J. Rintoul, pers. comm. 2001). "Possibly introduced in our area" (Moss 1983).
British Columbia	"Infrequent in [central] and [nothern] BC" (Pojar 1998).
Manitoba	Tracked by province, however, no records are in the database (N. Firlotte, pers. comm. 2003). The natural heritage rank (S3?) suggests that the species is relatively rare in Manitoba (see "Range Wide Status" section).
New Brunswick	Uncommon, rare, or very rare (Hinds 1986).
Newfoundland Island	No known occurrences (S. Blaney, pers. comm. 2001).
Nova Scotia	Known from one county (Roland and Smith 1969, as cited in Maher *et. al.* 1978).
Ontario	Not tracked (Ontario Natural Heritage Information Centre 2003).
Quebec	Over 15 occurrences (J. Labrecque, pers. comm. 2001).
Saskatchewan	Two occurrences (S. Lamont pers. comm. 2001)
Yukon Territory	One known occurrence that is based on a herbarium specimen (B. Bennett, pers. comm. 2001).

State and National Forest Distribution

Of the 16 states within the historic range of *C. virginianum* var. *boreale*, six have no known extant populations (Connecticut, Massachusetts, New Jersey, Pennsylvania, Indiana, and Ohio; Table 5). Four other states have less than ten known extant populations (Maine, New Hampshire, New York, and Vermont; Table 5). Herbaria in North Dakota document 13 occurrences in that state (Table 5). In South Dakota the species is restricted to the western part of the state in the vicinity of the Black Hills National Forest (South Dakota Natural Heritage Database 2003). Michigan, Minnesota,

and Wisconsin each have more than 30 occurrences that have been documented since 1960 (Table 5, Appendix B). The species primarily occurs in northern parts of these three states (Figure 2). These three states most likely have more documented sites than what are known as the species is not listed as rare by these states. Without state listing, occurrences may be less often sampled and recorded in local herbaria.

Cynoglossum virginianum var. *boreale* is known from only historical occurrences within the proclamation boundary of three national forests including the Green Mountain, White Mountain, and Finger Lakes National Forests (Finger Lakes National Forest 2000, Green Mountain National Forest 2000, White Mountain National Forest 1999; Figure 2). Historical occurrences have not been re-located in these national forests in over 40 years and new occurrences have not been discovered. Six national forests in the Eastern Region of the U.S. Forest Service have extant populations including the Chippewa, Superior, Chequamegon-Nicolet, Ottawa, Hiawatha, and Huron-Manistee National Forests (Table 7). Each of these national forests has numerous occurrences (Table 7). The occurrences known in South Dakota are located on the Black Hills National Forest which is in the Rocky Mountain Region of the U.S. Forest Service (South Dakota Natural Heritage Database 2003).

Table 7. Number of occurrences of *C. virginianum* var. *boreale* on national forests. All national forests with occurrences are in the Eastern Region (R9), except for the Black Hills National Forest which is in the Rocky Mountain Region (R2) (Appendix B).

National Forest	State	Number of occurrences
Black Hills	South Dakota	90
Chequamegon-Nicolet	Wisconsin	20
Chippewa	Minnesota	18
Hiawatha	Michigan	32
Huron-Manistee	Michigan	14
Ottawa	Michigan	18
Superior	Minnesota	32

RANGE WIDE STATUS

The Nature Conservancy's Ranking

Range wide status can be assessed by a ranking system developed by The Nature Conservancy, NatureServe, and the Natural Heritage Network (NatureServe Explorer 2003). This ranking system uses information on species that are tracked by The Nature Conservancy and natural heritage programs throughout the world. The ranking that a species receives indicates the species' vulnerability to extirpation and is based on many factors such as the number of occurrences, the quality of the occurrences, and their rate of decline. The global ranking (G-rank) gives the status of a species throughout its range. Each country where the species occurs has a national ranking (N-rank) that indicates the species vulnerability within that country. If the species occurs within the boundaries of provinces, states, or other divisions within a country, the species is given a subnational ranking (S-rank) for that area (NatureServe Explorer 2003).

The number or letter following G, N, or S is the ranking of current vulnerability of the species within the given geographical boundary (NatureServe Explorer 2003). Numeral ratings range from 1 to 5. The more vulnerable a species is to extirpation within the given geographical boundary, the lower the numeral rating. If a letter or punctuation follows the G, N, or S, the symbol indicates what is known about the species' distribution (see Table 8 for details, NatureServe Explorer 2003).

Cynoglossum virginianum has a global rank of "G5" (26 Aug 2002) indicating that the species (including the two varieties) is secure (NatureServe Explorer 2003). Variety *virginianum* has a rank of "N4N5" in the United States (26 Aug 2002) indicating that it is ranked between apparently secure and secure (NatureServe Explorer 2003). Variety *boreale* is ranked as "N3N4" (22 May 2000) in the United States, indicating that it is between apparently secure and vulnerable in this country (NatureServe Explorer 2003). Historical occurrences of *C. virginianum* var. *boreale* are the only known occurrences in six of the sixteen states with documented occurrences (Table 8). NatureServe Explorer (2003) ranks the species as "SH" (possibly extirpated) or "SX" (presumed extirpated) in four of these states (Massachusetts, New Jersey, Ohio, and Pennsylvania; Table 8). Although NatureServe Explorer (2003) ranks the species as "S?" (unranked) in Connecticut, the Connecticut Department of Environmental Protection (2003) lists the species as a special concern that is presumed to be extirpated from the state. NatureServe Explorer (2003) ranks the species as "SR" (reported) in Indiana. However, only historical herbarium specimens cited by Deam (1940) and Swink and Wilhelm (1994) are known from the state (M. Homoya pers. comm. 2003).

Five of the ten states with extant populations track *C. virginianum* var. *boreale* due to its rarity. NatureServe Explorer (2003) ranks this species as either as S1 (critically imperiled) or S1S2 (between critically imperiled and imperiled) in four of these states (Maine, New Hampshire, New York, and Vermont) (NatureServe Explorer 2003). As one might expect given these S-rankings, the natural heritage programs of these states rank the species as "endangered" or "threatened" and track known occurrences (Maine Department of Conservation 1999, New Hampshire Natural Heritage Inventory 2003, Young & Weldy 2003, Vermont Nongame and Natural Heritage Program 2003). NatureServe Explorer (2003) ranks the species as "SU" (unrankable) in South Dakota, nevertheless, this state tracks the species and includes it in a list of rare species (South Dakota Natural Heritage Program 2002).

Five states (Michigan, Minnesota, North Dakota, Wisconsin, and Wyoming) do not track *C. virginianum* var. *boreale*. NatureServe Explorer (2003) ranks the species as "S3" (vulnerable) in Michigan, while it ranks it as "SR" (reported) in Minnesota, North Dakota, and Wisconsin. Since occurrences of *C. virginianum* var. *boreale* were discovered in Wyoming recently (K. Zacharkevics pers. comm. 2003), the status of this species in that state has not yet been evaluated.

Table 8. Subnational rank (S) of *C. virginianum* var. *boreale* by U.S. states and Canadian provinces in which it occurs as listed by NatureServe Explorer (2003). (S1=critically imperiled, S2=imperiled, S3= vulnerable, S4=apparently secure, SX= presumed extirpated, SH= possibly extirpated [SH.1= one documented historical occurrence], SR=reported, SU=unrankable, S?=unranked). State status is the rarity ranking that states recognize on their state species lists. "Endangered" are the most vulnerable or rare species, "threatened" are less vulnerable or rare, and "special concern" species are usually tracked but not as much of a concern.

U.S. State	S-Rank	State Status	Canadian Province	S-Rank
Connecticut	S?	special concern*****	Alberta	S1
Indiana	SR	not listed[†]	British Columbia	S3S4
Iowa	~~SR~~[‡]	never present	Manitoba	S3?
Maine	S1	endangered	New Brunswick	S2
Massachusetts	SX	extirpated	Newfoundland Island	SR
Michigan	S3	not listed	Nova Scotia	S1
Minnesota	SR	not listed	Ontario	S4
New Hampshire	S1	threatened	Quebec	SR
New Jersey	SH.1	endangered	Saskatchewan	S1
New York	S1S2	endangered	Yukon Territory	SR
North Dakota	SR	not listed		
Ohio	SH	possibly extirpated		
Pennsylvania	SH	extirpated		
South Dakota	S?	tracked[§]		
Vermont	S1	threatened		
Wisconsin	SR	not listed		
Wyoming[**]		not listed		

*****Believed extirpated (Connecticut Department of Environmental Protection 2003)

[†]Based on specimen in herbaria that are cited as being *C. virginianum* var. *boreale*. Variety *virginianum* is known in southern Indiana. The identity of the specimen needs to be verified (M. Homoya pers. comm. 2003).

[‡]M. Leoschke (pers. comm. 2003) of the Iowa Natural Areas Inventory indicates that NatureServe Explorer (2003) erroneously reported the species in Iowa as the species is not known to occur in the state.

[§]No plants are state listed in South Dakota (South Dakota Natural Heritage Program 2002).

[**] First recorded occurrences were found in 2002 (K. Zacharkevics pers. comm. 2003).

Variety *boreale* is ranked as "N4" (17 Nov 1996) in Canada, indicating that it is "apparently secure" in that country (NatureServe Explorer 2003). Ten provinces in Canada have documented occurrences of *C. virginianum* var. *boreale* as listed by NatureServe Explorer (2003; Table 8). Occurrences in Newfoundland Island, however, are not known by the natural heritage program of that province (S. Blaney, pers. comm. 2001). The species is "reported" (SR) in the Yukon Territory based on a single herbarium specimen (B. Bennett, pers. comm. 2001). *Cynoglossum virginianum* var. *boreale* is ranked as "critically imperiled" (S1) in three provinces (Alberta, Nova Scotia, and Saskatchewan) and "imperiled" (S2) by one province (New Brunswick) (NatureServe Explorer 2003). The species is ranked as vulnerable (S3?) in Manitoba (NatureServe Explorer 2003), and it is tracked by Manitoba Conservation (N. Firlotte pers. comm. 2003). British Columbia ranks the species between "vulnerable" and

"apparently secure" (S3S4), while Ontario ranks the species as "apparently secure" (S4) (NatureServe Explorer 2003). NatureServe Explorer (2003) ranks the species as "reported" (SR) in Quebec.

National Forest Status

Cynoglossum virginianum var. *boreale* is listed as extirpated from the White Mountain National Forest as only historical records are known from that forest and extant occurrences are not likely to occur (White Mountain National Forest 1999). Nevertheless, since extant occurrences are known in the vicinity of this forest, the species is included on a watch list (White Mountain National Forest 1999). Despite having only historical occurrences, the species is not listed as extirpated from the Green Mountain National Forest (Green Mountain National Forest 2000): An expert panel concluded that it was more likely to occur on this national forest than to not occur (D. Burbank pers. comm. 2003). Risk evaluations indicate that the species is within the proclamation boundaries of the Finger Lakes National Forest, but not on Forest Service land. The species is believed to be extirpated from the vicinity of the Fingers Lakes National Forest, and it is not expected to be found on that forest (Finger Lakes National Forest 2000).

Due to the low N-rank given to this subspecies in 2000, *C. virginianum* var. *boreale* was added to the regional forester sensitive species list on any national forests with occurrences. The Hiawatha, Huron-Manistee, and Chequamegon-Nicolet continue to list the species as a regional forester sensitive species (USDA Forest Service 2003, Hiawatha National Forest 1999). The risk evaluation from the Chequamegon-Nicolet National Forest indicates that this species is listed because "repeated active survey for this species over the past decade has resulted in very few new sites. Across its range, it appears to be of increasing conservation concern and Wisconsin might represent a refugia for its continued existence" (Chequamegon-Nicolet National Forest 2002). The Superior and Ottawa National Forests have de-listed the species due to the plentiful habitat on the forests, the lack of state or local concern for the species, and the expectation that more undocumented occurrences exist on these forests (Superior National Forest 2002, Ottawa National Forest 2002). No risk evaluations were available for the Chippewa or Huron-Manistee National Forests regarding this species. The Black Hills National Forest, which is within the Rocky Mountain Region of the U.S. Forest Service, does not rank this species as sensitive although it has been tracked in recent years (K. Zacharkevics pers. comm. 2003).

POPULATION BIOLOGY AND VIABILITY

Whigham *et al*. (1993) studied the population structure of *C. virginianum* var. *virginianum* over a period of fifteen years. The population dynamics of *C. virginianum* var. *virginianum* is probably similar to variety *boreale* given that it grows in similar a habitat, has a very similar morphology, and is distributed just south of variety *boreale*. The study by Whigham *et al*. (1993) suggests that *C. virginianum* is long-lived and reproduces infrequently (see "Life History" section). The study also suggests that *C. virginianum* may be able to persist under full-canopy for many years. Whigham *et al.*

(1993) determined that subpopulations of variety *virginianum* under full tree-canopy of the 125 year old forest were larger than the subpopulation in a forest-gap. The shaded subpopulations did not have significantly different sizes after fifteen years of monitoring, although they were actually increasing in size during the years prior to the conclusion of the study. The subpopulation that occurred in a tree-fall gap had greater flowering and seedling establishment during the first six years after the gap was created. However, all of the young seedlings died prior to maturity due to competition within the gap. This subpopulation's size at the conclusion of the study was not significantly different than its size at the beginning of the study (Whigham *et al.* 1993).

The study by Whigham *et al*. (1993) demonstrates that conditions within forest gaps may promote flowering, seed production, and seed germination; however, such conditions may not necessarily result in the establishment of mature plants. In addition, the study demonstrates that population dynamics are complex and difficult to understand without long-term research. More in-depth studies need to be preformed before the population dynamics of this species are completely understood.

As noted in the "Ecology" section, populations of *C. virginianum* var. *boreale* may be naturally small. Community ecology studies in the northern Great Lakes region have indicated that it occurs at a low frequency and with low cover (Maycock & Curtis 1960, Maycock 1961). Ninety-one percent of populations with information on population size had less than 100 plants (N=55) (Table 9). In Michigan, Minnesota, and Wisconsin about 60% of populations with population size descriptions had less than ten plants per population (Table 9). Even though approximately 90 sites have been located during the last few years on the Black Hills National Forest, Katherine Zacharkevics (pers. comm. 2003) indicates that the species is not common and population sizes are small.

Table 9. Size of *C. virginianum* var. *boreale* populations in the U.S. (Appendix B).

	Population size (number of populations with the given population size)						
State	Not found during last search	Un-known	<10	10-50	50-100	>100	Descriptions of population size
Maine	2			1		2	
Michigan		72	17	7	2	1	locally frequent (1), plentiful (1), local (1), scarce (1), occasional (1)
Minnesota		57	12	5		1	
New Hampshire					1		
New York				2		1	
Vermont				1	1		
Wisconsin		68	2	2	1		

Generally, large populations of any species tend to be more viable than small populations due to lower chances of inbreeding depression, less loss of genetic variability due to

genetic drift, and less chance that a catastrophic event would destroy the entire population (Primack 1993). However, species vary in their population structure and may naturally consist of small populations (Primack 1993). Populations of *C. virginianum* var. *boreale* apparently consist of small patches that are scattered over a large area. Populations on the Ottawa National Forest, for example, consist of from one to 34 plants (Ottawa National Forest unpublished). Nineteen of 25 populations in the vicinity of or on the Ottawa National Forest are located within 77 square miles; and ten of these are within 15 square miles. One might expect the gene flow among these small populations may decrease the negative effects of their small population sizes. If populations naturally are rather small, the importance of population size is difficult to assess. A more important judge of population viability may be the long-term persistence of multiple patches scattered over a large area.

If dispersal of seeds by animals is rare as Whigham *et al.* (1993) suggest, gene flow among the scattered patches of *C. virginianum* var. *boreale* may be more dependent on pollen dispersal by bees and other insects. Insects tend to visit flowers depending on the flower density, patch size, insect preferences for certain species, and other factors (Briggs & Walters 1997). One might expect, therefore, that small patches of *C. virginianum* var. *boreale* may be visited by pollinators less often than larger patches where more flowers tend to bloom together. Although insects tend to pollinate neighboring plants, occasional long-distance dispersal occurs as insects may fly from one patch of flowering plants to another (Ellstrand and Marshall 1985). Molecular tracking of pollen suggests that pollen flow can connect nearby populations (Briggs & Walters 1997). For example, Ellstrand and Marshall (1985) determined that 8 to 18% of seeds in *Raphanus sativus* (wild radish) populations were pollinated by plants over a kilometer away. Although pollen dispersal may not establish new subpopulations or populations, it can maintain the gene flow among the scattered patches in an area and, subsequently, maintain the genetic similarities of subpopulations and nearby populations.

If populations of *C. virginianum* var. *boreale* are connected to nearby populations by occasional gene flow, populations may have less inbreeding and less negative impacts by inbreeding depression than if they are isolated. In addition, interconnected populations may maintain higher genetic diversity than isolated populations by having fewer impacts from genetic drift. Thus, population viability may depend in part on the size of nearby populations, the distance between populations, and the frequency of pollen or seed movement between populations. Habitat fragmentation or other environmental conditions that may decrease gene flow among populations could decrease the viability of the populations.

Cynoglossum virginianum var. *boreale* populations have been suggested as being structured into "metapopulations" (Abrams & Brumback 2001). Metapopulations have large core populations that are stable with outlying temporary populations (Primack 1993). On the other hand, *C. virginianum* var. *boreale* seems to consist of small populations, with few populations that would probably be described as "core" populations (Table 9). As forests mature, some patches of populations may decline and become extinct; on the other hand, this has not been clearly demonstrated. The study by

Whigham *et al.* (1993, described previously), in fact, suggests that the closely related variety *virginianum* maintains subpopulations under closed-canopy at least as well as subpopulations within forest gaps. Moreover, *C. virginianum* var. *boreale* has been suggested as having temporary populations in part due to the inability to relocate historic occurrences in the eastern U.S (Abrams & Brumback 2001). Since few new populations have been located and the species has disappeared throughout a large portion of its eastern range, the extinction of historic populations may not be part of the natural population biology of the species. Given the limited information on the extirpated populations, they could have persisted for hundreds of years prior to their disappearance. Many plant species are distributed in a patchy manner especially within forest communities (Hughes *et al.* 1988, Whigham *et al.* 1993). Many different life-history strategies may maintain populations with patchy population structures such as seed banks, long-life spans, adaptations to certain disturbances such as fire, clonal growth, and seed and pollen dispersal mechanisms. Although *C. virginianum* var. *boreale* may have a metapopulation structure, not enough information is available to indicate that the species primarily persists by this population structure.

The population viability of *C. virginianum* var. *boreale* is uncertain especially in New England and northern New York. Over 80 populations south of extant populations in that region have become extirpated in the last 100 to 150 years due to unknown causes (see "Potential Threats"). The loss of so many populations at the southeastern border of the species' range suggests that the range of the species is contracting to the north. Without knowing the cause of population loss or a timetable that populations became extinct, one cannot predict if the range of the species is still in the process of decline. Of the eleven extant occurrences in New England and New York, six occurrences have less than 100 plants, three have over 100 plants, and two occurrences have not been relocated when searched for in the 1990s (Table 9). The size of one Vermont population had decreased from over 650 plants to about 70 plants in thirteen years (Abrams & Brumback 2001). The decrease in population size of the Vermont population and the recent difficulties relocating two populations in Maine suggests that population viability in New England and New York may still be low. Factors that influenced over 80 populations in the eastern U.S. to become extirpated may be influencing the viability of these populations.

The viability of *C. virginianum* var. *boreale* populations in Wisconsin, Minnesota, and Michigan is difficult to assess as little information is available regarding population sizes and changes in population structure. Currently populations apparently occur throughout the historic range in these three states. Although a high proportion of populations were documented over 40 years ago (prior to 1961), most counties with historic records also have a more recent record. However, occurrences in nine counties of Wisconsin, primarily at the southern border of the species' range, were last documented before 1961 (Wisconsin State Herbarium 2003, Appendix B). Given that the species is not tracked in these three states and that limited effort has been made to re-locate documented occurrences, historic records could indicate extant occurrences. Viability may also be difficult to assess given that *Cynoglossum virginianum* var. *boreale* was probably historically uncommon. From surveys of forests in northern Wisconsin in 1950, for example, it had a relative frequency of 0.07% (4 out of 1240 quadrats: Rooney *et al.*

2004). However, a decline could be occurring given that when these same 62 sites were resurveyed in 2000 its relative frequency was 0.00% (1 out of 7440 quadrats: Rooney *et al.* 2004).

If similar factors that caused occurrences to disappear in the eastern U.S. will affect or are affecting occurrences in Minnesota, Michigan, and Wisconsin, the viability of populations in these states may be in danger. If, however, the habitat in these three states is generally more suitable than that of states to the east, occurrences may have good population viability. In addition, the factors that influenced the extirpation of eastern occurrences may not be present in these three states. Nevertheless, without more scientific evidence on the life history and ecology of the species, one cannot predict the probability that populations in the northern Great Lakes region will decline.

POTENTIAL THREATS

Superficially *C. virginianum* var. *boreale* may not seem to be immediately threatened as the variety is globally ranked between "secure" and "apparently secure" and its range spans across North America (NatureServe Explorer 2003). On the other hand, the southeastern portion of the species' range has noticeably shrunk in the last hundred years with more than 80 populations that have not been re-located despite searches. Populations have primarily been extirpated from the southern-most 150 miles of its historic range in the eastern U.S. (New Jersey, Pennsylvania, southern and central New York, Massachusetts, and Connecticut). Populations are also scarce in the New England states of Maine, New Hampshire, and Vermont. Possibly existing populations are stable and the current range of the species will persist. Alternatively, populations at the southern edge of the range may be in danger of extirpation and the range of the species will continue to contract. Although *C. virginianum* var. *boreale* still has numerous populations in Michigan, Minnesota, South Dakota, Wisconsin and parts of Canada, the viability of these populations is unknown. The documentation of multiple populations does not indicate these populations are stable will persist. If southern populations are currently in the process of decline the species may be more threatened than the current ranking suggests.

Present or Threatened Risks to Habitat

The disappearance of many populations of *C. virginianum* var. *boreale* with no known cause suggests that habitat requirements of this species are not understood. Often species decline due to the loss of habitat and fragmentation of habitat (Primack 1993). However, *C. virginianum* var. *boreale* has become extirpated from areas in New York and New England where suitable habitat, or what is believed to be suitable habitat, is available (Edinger *et al.* 2002, NYNHP unpublished, Steckler *et al*. unpublished). In addition, the species is relatively uncommon in Michigan, Wisconsin, and Minnesota despite the fact that suitable habitat seems to be quite prevalent. Possibly habitat requirements for *C. virginianum* var. *boreale* are more specific than what habitat descriptions suggest. Certain factors that may not be obvious may affect the viability of populations. For example, high herbivory pressure by white-tailed deer, fire suppression, forest

maturation, logging, climate change, or even pollinator loss may affect the persistence of the species.

Herbivory

Herbivory may potentially be the most important threat to the viability of *C. virginianum* var. *boreale*. In the Eastern U.S. white-tailed deer densities commonly are greater than 10 per square km (Diefenbach *et al.* 1997 [cited in Rooney 2001], Russell *et al.* 2001 [cited in Rooney 2001]) which is about 2 to 5 times greater than presettlement times. (Estimates of presettlement densities in Eastern North America range from 2 to 4 deer per square km [Alverson *et al*. 1988, McCabe & McCabe 1997 {cited in Rooney 2001}]). Browsing by white-tailed deer (*Odocoileus virginianus*) has been shown to negatively impact the establishment of tree species such as *Thuja occidentalis* and *Tsuga canadensis* and is believed to impact the composition of herbaceous plants (Alverson *et al*. 1988, Miller & Bratton 1992, Rooney *et al*. 2004).

Rooney *et al*. (2004) compared the herbaceous species at 62 sites in Wisconsin documented in 1950 with the species composition 2000. Their study indicates that the decline of certain herbaceous species in northern Wisconsin forests cannot be explained by habitat changes, succession, or invasion by exotic species. At sites without deer hunting, there was a greater loss in the number of native species since 1950 compared to sites with deer hunting. This suggests that the overabundance of deer may be an important threat to many herbaceous species in forests of Wisconsin. Plant species that are animal-pollinated or animal-dispersed (as is *C. virginianum* var. *boreale*) were less frequent in 2000 compared to 1950 plots than species that are not animal-pollinated or animal-dispersed. Rooney *et al*. (2004) suggest that animal-pollinated and -dispersed plants are more easily seen by deer and browsed upon.

Some evidence suggests that *C. virginianum* var. *boreale* may be declining in areas due to deer herbivory. In the study by Rooney *et al.* (2004), *C. virginianum* var. *boreale* was present in three of the 62 sites sampled in 1950. The species occurred in four quadrats out of 1240 quadrats sampled in these 62 sites (D. Waller, pers. comm. 2005). Despite sampling six times more quadrats (7440) in 2000, only one quadrat contained *C. virginianum* var. *boreale* (D. Waller, pers. comm. 2005).

A population of *Cynoglossum virginianum* var. *boreale* in Vermont that had not flowered in over ten years did not begin flowering after a few trees had been cut to improve light penetration. However, the population did have four of the 36 plants flower in 2003, the year after a deer exclosure was constructed around the population (B. Popp pers. comm. 2004). No plants were found outside the exclosure (B. Popp pers. comm. 2004).

Six of the 18 populations on the Ottawa National Forest contained plants that had been browsed upon when they were first described (Ottawa National Forest, unpublished). The top portion of plants which has the flowers and/or fruit is described as being chewed off (Ottawa National Forest, unpublished). Given the small size of populations, herbivory of the reproductive parts of plants could significantly impact population

viability. If white-tailed deer prefer to browse on *C. virginianum* var. *boreale* plants when it is available, herbivory could be a significant threat to the species.

Forest Maturation

Maturing forests may threaten populations of *C. virginianum* var. *boreale* (Abrams & Brumback 2001). Many eastern forests were cut between 100 and 150 years ago when many of the historic occurrences of *C. virginianum* var. *boreale* were documented in eastern states. These forests have generally been maturing since that time. Logging may give at least short-term benefits for the species by allowing more light to reach it and increase the amount of flowering and fruiting (Whigham *et al*. 1993). Possibly it can subsequently establish new plants from resulting seeds at a faster rate than in mature forest. Also, a large percent of occurrences in the Midwest are associated with trees of early successional forests such as *Populus* and *Betula* species (Table 4).

On the other hand, the extirpation of 45 occurrences in New York State over the last century is hard to link to forest maturation when successional forest types are common. The New York Natural Heritage Program (NYNHP) defines successional forests as "forests that develop onsites that have been cleared (for farming, logging, etc.) or otherwise disturbed (by fire, ice scour, wind throw, flooding, etc.)" (Edinger *et al.* 2002). Successional northern hardwood forests are one of the community types that the NYNHP lists in the habitat description for *Cynoglossum virginianum* var. *boreale*. These forests are ranked as "secure" (S5) in New York and are distributed "throughout upstate New York north of the Coastal Lowlands ecozone" (Edinger *et al.* 2002).

Most likely this species occurred throughout its historic range prior to logging when forests were generally more mature and less fragmented. Moreover, other forest species that have an association with forest-gaps have not been documented as declining with forest maturation. Such forest herbs are adapted to occasional forest disturbances such as fire, tree tips, and blow-downs, in addition to natural forest openings such as river ways and forest edges (Collins & Pickett 1988, Hughes *et al.* 1988, Reader & Bricker 1992, Whigham *et al*. 1993). Such species are adapted to forest gaps gradually closing and unpredictable patches opening (Hughes *et al.* 1988). *Cynoglossum virginianum* var. *boreale* may also persist for numerous years under full canopy like variety *virginianum* (Whigham *et al*. 1993). Research is needed to determine if forest maturation is a threat to *C. virginianum* var. *boreale*.

Logging

Although *C. virginianum* var. *boreale* can occur in disturbed areas of forests, it also is almost always in or at the edge of a forest (Appendix B). Certain aspects of the life history of the species may, therefore, depend on conditions of the closed-canopy forest. Extirpated populations could have been negatively impacted by changes in the composition of tree, shrub, or understory species after logging, by changes in the microclimate, or by soil compaction due to logging. In addition, exotic species and other competitive species within larger openings may out-compete and displace *C. virginianum*

var. *boreale*. Logging, development, and other human impacts could also interfere with gene dispersal via seeds or pollen within and among populations (Primack 1993). This species may be very sensitive to such disturbances in gene flow due to the small sizes of populations.

Fire suppression

During the last hundred years, fires have been suppressed and are less frequent than historically across much of the United States. Over a third of *C. virginianum* var. *boreale* populations in the upper Midwest are in pine forests which historically had fires at 10 to 100 year intervals (Curtis 1987). If *C. virginianum* var. *boreale* is dependent on specific conditions provided by fire in establishing new populations or maintaining current populations, fire suppression could be a significant factor in the decline of the species.

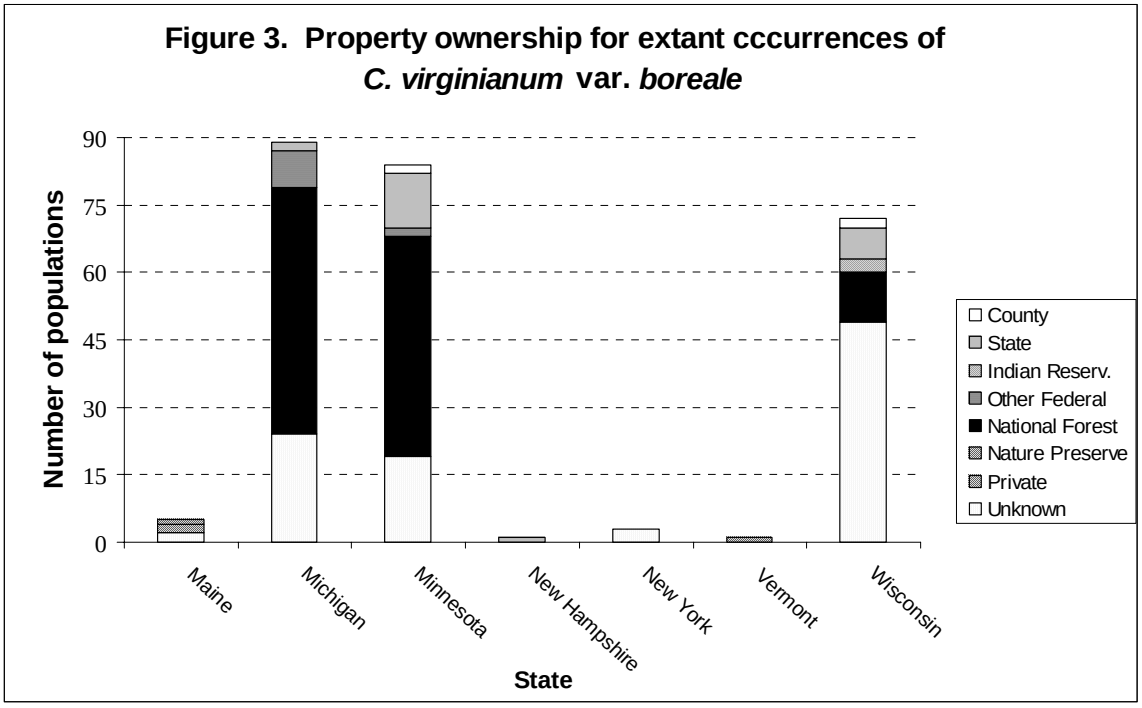
Climate change

Climate change may threaten populations of *C. virginianum* var. *boreale*. The fact that the southern-most populations have become extirpated suggests that populations in warmer temperatures may be most susceptible to extirpation. Scientists throughout the world have predicted that a worldwide warming trend (Global Warming) is beginning to occur and will continue to increase during the coming century (Primack 1993, Levitus *et al.* 2001). Global Warming is an expected effect of the increase in carbon dioxide and other "greenhouse gases" in the atmosphere from human activities (Primack 1993, Levitus *et al.* 2001). Climate change could potentially explain the extirpation of so many populations in the southeastern portion of the species' range. If the loss of populations of *C. virginianum* var. *boreale* is related to changes in the climate, this species is very sensitive to the climate and would be important to monitor.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Of the eight extant populations of *C. virginianum* var. *boreale* in New England, four are on private land, and landownership is not known for two occurrences (Abrams & Brumback unpublished, Appendix B). The population in New Hampshire occurs on state land and one population in Maine is in a nature preserve. Although some private landowners have interest in preserving populations (such as one of the populations in Vermont), the protection of these populations is not secure given that ownership as well as priorities for owners can change. Given that *C. virginianum* var. *boreale* is listed as threatened in New Hampshire and endangered in Maine, populations on state land and in a nature preserve will probably receive the most habitat protection.

National forests are important in the management of this species especially in Michigan and Minnesota where over 40% of known populations are on Forest Service land. Over two-thirds of populations in these two states are on public land. Land ownership for a large portion of Wisconsin populations is unknown; however, a portion of these populations are probably on public land as many are in the vicinity of state or national forest land.



SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

The New England Plant Conservation Program prepared a "conservation and research plan" for *C. virginianum* var. *boreale* in New England (Abrams & Brumback 2001). The plan encourages groups interested in this species to work cooperatively with private landowners. The plan also suggests partial canopy removal to maintain populations that occur in mature forest. In addition, the plan suggests establishing populations at historic locations with suitable habitat and removing exotic honeysuckle shrubs from the vicinity of one population. A deer exclosure was built around a population of *C. virginianum* var. *boreale* in Vermont to protect it from deer browsing (Bob Popp, pers. comm. 2004).

If browsing by white-tailed deer is a major threat to population viability, controlling deer populations may be an important factor in managing populations. In the study by Rooney *et al.* (2004), land in northern Wisconsin that did not have deer hunting (state parks and preserves) lost on average over 60% of the native species that were present in plots in 1950, while plots located on properties with deer hunting lost on average16%.

PAST AND CURRENT CONSERVATION ACTIVITIES

In New England conservation has been primarily directed towards protecting known populations by making landowners aware of the rare species on their land. Unlike many rare species, the general habitat of *C. virginianum* var. *boreale* is not rare in itself. Until specific habitat requirements are understood, habitat protection may not be effective given that populations have become extirpated in areas that seem to have suitable habitat.

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

Little research has been carried out on *C. virginianum* var. *boreale* specifically. Whigham *et al.* (1993) investigated the population structure of variety *virginianum* over a 15 year period. Their study indicated that the subpopulation in a tree-fall gap had a short-term increase in seedling establishment compared to subpopulations in closed-canopy forest. Overall all subpopulations in full canopy forest and within a forest gap maintained the same population size.

Abrams and Brumback (unpublished) found that *C. virginianum* var. *boreale* plants had increased growth when neighboring plants were trimmed. In addition, they found that plants in small subpopulations had fewer flowers per plant, fewer seeds per plant, and fewer seeds per flower than larger subpopulations.

Pyrrolizidine alkaloids have been studied in *C. officinale* due to the occurrence of this weedy exotic species in fields and its toxicity to cattle and horses (Knight *et al*. 1984). While alive, *C. officinale* has an odor which discourages animals from eating it. However, when dried, animals do not notice the odor and may eat the plants (Knight *et al*. 1984). Horses, in fact, have been documented as dying after being fed hay mixed with *C. officinale* (Knight *et al*. 1984). Pyrrolizidine alkaloids within different species of Boraginaceae vary in their toxicity and are not necessarily poisonous (Pedersen 1975). Some of these chemicals have been considered for cancer treatment (Pedersen 1975). Studies have also been done on the reproductive biology of *C. officinale* (De Jong & Klinkhamer 1991). Given that the species is a biennial and weedy in the U.S., the biology of that plant is difficult to compare with *C. virginianum* var. *boreale*.

Populations of *C. virginianum* var. *boreale* have been monitored regularly in New York and New England due to the species' rarity (Abrams & Brumback 2001).

Survey Protocol

1. New England and New York

Since no extant populations are in the vicinity of the Finger Lakes National Forest, extant occurrences are not likely to occur on that national forest and surveying for the species is not necessary. Despite the fact that only historic occurrences are known on the White Mountain and Green Mountain National Forests, extant occurrences are known within the vicinity of these national forests (within 20 miles) and other occurrences that have not been located could persist on these forests (SVE Panel 2002, cited in Steckler *et al.* unpublished). Although these forests are currently at the edge of the species' range, historical records in Massachusetts, Connecticut, New York, and Pennsylvania indicate that the species' range was well distributed over 150 miles to the south and west (Figure 2). Given the historical and current range of the species, *C. virginianum* var. *boreale* should be continued to be surveyed for on the Green Mountain and White Mountain National Forests. Surveys should be carried out by botanists that are acutely aware of the vegetative and immature characteristics of *C. virginianum* var. *boreale*.

Possibly populations have not been re-located, in part, because fewer individuals are flowering compared to the early 1900s when the forests had been recently cut.

Additional surveys with the goal of finding *C. virginianum* var. *boreale* on the Green Mountain and the White Mountain National Forests would be the most aggressive manner to determine if the species does still occur on one or both of these forests. Due to the inconspicuous nature of non-flowering plants, *Cynoglossum virginianum* var. *boreale* may be overlooked even during regular surveys unless it is targeted specifically. Such surveys could be carried out in the prime habitat of the species and the vicinity of historical occurrences.

2. Northern Great Lakes region.
Given the inexplicable contraction of the range of *C. virginianum* var. *boreale* in the eastern U.S., tracking the species in the northern Great Lakes region is a way to detect future population declines. If the species' range is in the process of decline, populations in Michigan, Minnesota and Wisconsin could be affected in the near future as these states contain part of the southern border of the species' range. If the existence of populations is not regularly noted by surveyors, population decline may not be noticed until many populations are lost. Although this species is not extremely rare in Minnesota, Michigan and Wisconsin, the species is uncommon and populations tend to be small (Table 9). The disappearance of populations could go unnoticed for many years if tracking is not done. Tracking the species may also suggest threats that may have caused the species' decline in the eastern U.S. If the range of the species does not continue to contract in the east after a certain amount of time or the cause of population loss is determined to not be a factor in these states, tracking the species could be discontinued.

Research Priorities

Given that little research has been carried out specifically on *C. virginianum* var. *boreale*, any research focusing on the species would improve our understanding of it. Research that may suggest causes for the disappearance of populations in the eastern U.S. would be the most beneficial for managing extant populations. The following studies are suggestions on how one might research the basic life-history, population ecology, or population genetics of this species.

1. Study of the population dynamics. Monitoring multiple natural populations could indicate the changes of populations over time and suggest factors that affect population viability. Such a study would have to be carried out over a long period of time to have interpretable data. Optimally, populations in young or recently logged forests could be compared to populations in mature forests. The vicinity surrounding each population should be thoroughly searched to find any scattered subpopulations so that the structure of the entire population is described and monitored. If individual plants were to be tracked as was done by Whigham *et al.* (1993), one could determine the fecundity of plants growing in different conditions and suggest the optimal conditions for seedling establishment.

2. Population viability in and out of deer exclosures
In conjunction with the first study, one could enclose portions of populations in deer exclosures to prevent deer browsing. Plant viability in and out of the exclosures could be monitored for a number of years. Such a study might more clearly indicate if deer are affecting population viability.

3. Study of population dynamics following fire
A study of the effects of fire on populations of *C. virginianum* var. *boreale* may be difficult to plan given that the species tends to have small and uncommon populations. In addition prescribed burns need much preparation and manpower to carry out. A simple study might be done by monitoring known populations located in areas proposed to be burned for forest management reasons. Population structure before and after the fire might indicate if the fire is beneficial. Populations should be monitored over many years after the fire to determine the long term effects of fire.

4. Study of pollination biology. The seed production from open-pollinated flowers compared to flowers that are covered and hand-crossed with other plants may indicate if there is a shortage of pollinators. Flowers that are covered and self-pollinated could indicate if flowers are self-compatible.

5. Determine the optimal conditions for plant development. Greenhouse studies could determine conditions needed for seed germination and development from seedlings to reproductive adults. Seed germination requirements may also suggest if the species may produce a seed bank. Factors such as humidity, shading, temperatures, competition, and soil types could be varied among the experimental groups to determine the optimal conditions for each life stage.

6. Study of allozyme diversity among populations. A study of the allozyme diversity of *C. virginianum* var. *boreale* might indicate any genetic differences among the populations scattered across North America. Populations in British Columbia and South Dakota, for example, may have genetic distinctions compared to populations in Minnesota, Wisconsin and Ontario given that few populations are known in the area between these regions. Populations in New England may also have genetic distinctions compared to those in the northern Great Lakes region. The level of genetic differentiation among populations may indicate the degree of gene flow throughout the species' range. If the species has low allozyme diversity, this may indicate that genetic factors may limit the species' ability to adapt to changing conditions.

7. Systematics study. A systematics study using molecular techniques could determine the genetic uniqueness of variety *boreale* and variety *virginianum,* as well as the genetic similarities of other species of *Cynoglossum.* Such a study might indicate if these varieties are distinct enough to be recognized as separate species. One could, in addition, grow the two varieties and cross-breed them to determine if they hybridize and the degree of fecundity of hybrids.

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APPENDIX A: Published Habitat Descriptions

Habitat descriptions from technical field guides and other regional sources in the U.S. and Canada.

State/Province	Habitat descriptions
United States	"Usually occurs in coniferous woods" Fernald 1905.
	Eastern: "Upland woods" (Gleason & Cronquist 1991, p 425). "Rich woods and thickets" (Fernald 1950, p. 1203).
	New England: "Open woods" Magee & Ahles 1999.
	"Tends to grow in shallow calcareous soils, in cedar/hemlock/hardwood forests. Plants are often found in very rocky soil or on steep slopes and tend to grow in tree-fall gaps, recently burnt areas, along road or trail edges, or in other such canopy disturbances" (Abrams & Brumback 2001).
Maine	"Rich upland woods. [forested wetland; Hardwood to mixed forest (forest, upland)]" (Maine Department of Conservation 1999).
Michigan	"Borders, openings, and clearings or under dense shade in coniferous or mixed woods (fir, cedar, spruce, pine, birch, aspen, occasionally beech and maple), especially in sandy or rocky soil" (Voss 1996).
North Dakota	"Dry woods & thickets" (Kaul 1986).
Pennsylvania	"Open woods and roadsides" (Rhoads & Block 2000, p. 265).
Wisconsin	Northern upland forest and boreal forest (Wisconsin State Herbarium 2003).
Canada	
Alberta	"Dry woods" Moss 1983.
British Columbia	"Mixed forest openings in the lower montane zone" Pojar 1998.
Nova Scotia	"Woods and thickets" Roland & Smith 1969, cited in Maher *et al.* 1978.

APPENDIX B: Element Occurrences.

Documented element occurrences of *Cynoglossum virginianum* v. *boreale* in U.S. states. Occurrences are listed alphabetically by location (state, county, and then nearest town). "Date" is the last date the occurrence was observed. "Status" is either "E" meaning extant or "H" meaning historical, extirpated, or not found during a search. "Source" of the information includes cited scientific papers, herbaria (as indicated by the herbarium code) or element occurrences as listed by National Forests.

Abbreviations for National Forests: **CNF** (Chippewa NF), **CNNF** (Chequamegon-Nicolet NF), **HNF** (Hiawatha National Forest), **HMNF** (Huron-Manistee National Forest), and **SNF** (Superior National Forest).

Codes for herbaria: **CONN** (Torrey Herbarium, University of Connecticut, CT), **CUW** (Clark University; Worcester, MA), **GH** (Gray Herbarium, Harvard, MA), **MAINE** (University of Maine; Orono, ME), **MICH** (University of Michigan Herbarium; Ann Arbor, MI), **MCT** (Michigan Technological University Herbarium, Houghton, MI), **MTU** (Michigan Technological University; Houghton, MI), **NEBC** (Harvard University Herbaria; Cambridge, MA), **NHA** (University of New Hampshire; Durham, NH).

CONNECTICUT (Source: As cited by Abrams & Brumback , [unpublished])

Status	Date	County	Town	Source	Population description
H	1907	Litchfield	New Milford	CONN	
H	1916	Litchfield	Salisbury	CONN	
H	Unknown		Union	Seymour 1982	
H	1930		Woodstock	GH	"In dry woods"

MAINE (Source: As cited by Abrams & Brumback [unpublished], except Oxford County occurrence.)

Status	Date	County	Source	Population description
H	1915	Andros-coggin	NEBE/GH	"Roadside woods"
H	1904	Aroostook	NEBC/GH	
H	1899	Aroostook	NEBC/GH	
E?	1988	Aroostook	Abrams & Brumback , unpublished	**Habitat:** Cedar and hardwoods; Cut in 1998, not found during search in the 1990's.
H	1902	Franklin	NEBC/GH	**Habitat:** Open woods; dry sandy soil; on an esker.
E	**1999**	Franklin	Abrams & Brumback , unpublished	**Habitat:** Young hardwood-spruce-fir stand; along old skid road. **Population size:** 150 plants (120 flowering).

MAINE (Source: As cited by Abrams & Brumback [unpublished], except Oxford County occurrence.)

Status	Date	County	Source	Population description
				Ownership: Non-profit land conservation group
E?	**1987**	Oxford	E. Pinkham pers. comm. 2001	Rich hardwood forest being logged (searched in 1998, not found).
H	1898	Penobscot	NEBC/GH	"Open woods" (MAINE)
E	**1996**	Piscata-quis	Abrams & Brumback unpublished, MAINE	**Habitat**: In open, young softwood stand. **Ownership**: Private. **Population size**: 18 flowering plants in two areas.
E	**1999**	Somerset	Abrams & Brumback , unpublished	**Habitat:** *Popululus tremuloides* (quaking aspen), *P. grandidentata* (big-toothed aspen), *P. balsamifera* (balsam poplar). Within an area that had a stand replacement fire in 1978. **Population size**: >2000 plants, five subpopulations. **Associate species**: *Anaphaois margaritacea*, *Aralia nudicaulis*, *Cornus canadensis*, *Hieracium vulgatum*, *Solidago* spp., and *Lycopodium* spp. **Ownership**: Private
H	1931	York	NEBC/GH	low thickets

MASSACHUSETTS (Source: as cited by Abrams & Brumback [unpublished])

Status	Date	County	Town	Source
H	1897	Berkshire	Tyringham	NYBC
H	1904	Berkshire	Stockbridge	NEBC
H	1906	Franklin	Sunderland	GH
H	1876	Hampshire	Amherst	NEBC
H	1879	Worcester	Millbury	CUW
H	prior to 1894	Worcester	Princeton	Jackson (1894)

MICHIGAN

Date	County	Owner	Source	Habitat
	Alcona	HMNF	HMNF	5 individuals, "moist sand soil, slope [along] stream, filtered canopy of aspen, red maple, red oak and balsam fir."
	Alcona	HMNF	HMNF	4 populations, 4-150 plants each, "low-lying, sandy soil, moderately dry, with moderate to heavy canopy cover of aspen/oak.

MICHIGAN

Date	County	Owner	Source	Habitat
	Alcona	HMNF	HMNF	68 plants, "dry sand soil, low-lying, cold air drainage under filtered canopy of red pine, jack pine and aspen."
1973	Alger	Federal	MICH	Jack Pine grove back side of dune
	Alger	HNF	HNF	
1912	Alpena		MICH	Plentiful.
1986	Alpena		MICH	Old cedar, balsam.
1990	Alpena		MICH	Cedar, spruce, balsam fir.
1962	Baraga	MTU	MCT	White pine – black spruce bottom along creek.
1984	Benzie	Federal	MICH	Moist woods south of lake.
1957	Charlevoix		MICH	locally frequent mixed woods.
1966	Charlevoix		MICH	Island
1971	Charlevoix		MICH	Scarce in birch-fir woods.
1973	Charlevoix		MICH	In dense needle litter.
1926	Cheboygan		MICH	
1998	Cheboygan		MICH	Open birch-maple woodland.
1979	Chippewa		MICH	Local in dry deciduous woods; Island.
1980	Chippewa		MICH	Occasional in damp woods; Island.
1948	Chippewa		MICH	Cut-over coniferous woods; Island.
1935	Chippewa		MICH	Island.
	Chippewa	HNF	HNF	3 populations.
	Crawford	HMNF	HMNF	low woods, aspen, edge of cedars, streamside.
	Delta	HNF	HNF	4 populations.
1948	Emmet		MICH	rocky calcareous soil in beech-maple forest.
1953	Emmet		MICH	mixed woods.
2003	Gogebic	ONF	ONF (#299)	"2 plants, overgrown old road in hemlock-hardwoods."
2004	Gogebic	ONF	ONF	"One plant, apparently browsed. Open forested area with scattered trees (balsam fir, red maple, white birch, aspen). Ground cover thick with bracken fern and *Aster macrophyllus*. Area opened up through logging."
1954	Grand Traverse		MICH	Moist aspen woods.
1931	Iosco		MICH	Low woods.
	Iosco	HMNF	HMNF	"Low woods."
1905	Iron	Camp 6	MICH	
1996	Keweenaw	Isle Royale N.P.	MCT	Five populations (4 located in 1960s, 1 in 1996): slope of hill, open dry area; on mountain; along trail going along a ridge; woods edge.
1961	Keweenaw		Maycock 1961	75-85 yr old trees, burn marks on bark suggesting previous fire, wet-mesic, *Picea*

MICHIGAN

Date	County	Owner	Source	Habitat
				glauca, Abies balsamea dominant with *Populus tremuloides, Thuja occidentalis, Pinus strobus. Herbs: Aster macrophyllus, Mitella nuda, Carex pedunculata, Cornus canadensis, Viola spp, Mertensia paniculata, Rubus pubescense*
1986	Leelanau	Federal	MICH	Near cedar swamp.
1998	Mackinac	HNF	HNF	In cracks of limestone pavement in an area of northern mesic forest with scattered white cedar, 80% canopy.
	Mackinac	HNF	HNF	21 other populations found in surveys. (Pontchartrain shores, Ozark, Kenneth, Allenville, Simmons)
1990	Mackinac	HNF	HNF	Mostly paper birch and quaking aspen 2nd growth with red maple, sugar maple, balsam fir and a few jack pine.
1992	Mackinac	HNF	HNF	Occasional in mature sugar maple woods with *Aralia nudicaulis.*
	Marquette		MICH	Red pine association, sandy soil
1985	Mason	HMNF	Hazlett 1986	"Occasional in mixed deciduous woods near open dunes."
1986	Menominee		MICH	Growing with *Iris lacustris* in rocky woods
	Ogemaw	State		moist woodlands
	Ogemaw	HMNF	MICH	cedar woods.
1923	Ontonagon	State	MICH	
1994	Ontonagon	ONF	ONF (#170)	Apen/fir forest
2001	Ontonagon		ONF (#243)	2 plants
2002	Ontonagon	ONF	ONF (#270-273)	7 plants scattered in four populations; Three areas clear-cut and disturbed; one area with quaking aspen and fir. One population browsed. *Alnus rugosa, Pteridium aquilinum, Fragaria virginiana*
2003	Ontonagon	ONF	ONF (#293)	Scattered subpopulations (20 plants total) along sugar maple/ basswood/ fir forest edge bordering a wetland. Browsed; moist soil. *Aster macrophyllus* dominant herb.
2003	Ontonagon	ONF	ONF (#294)	1 plant; low competition; silty-clay/moist soil; Quaking aspen, fir, sugar maple, white spruce, black ash. Dominant herbs: *Aster macrophyllus, Pteridium aquilium.*
2003	Ontonagon	ONF	ONF (#171)	One plant located in small pocket of well shaded white spruce & fir surrounded by young quaking aspen.
2003	Ontonagon	ONF	ONF (#296)	11 scattered plants; some browsed; clay soil;

MICHIGAN

Date	County	Owner	Source	Habitat
				Opening and along road within forest of aspen, sugar maple, red maple, fir, white birch.
2003	Ontonagon	ONF	ONF (#295)	12 scattered plants; some browsed; quaking aspen, fir, white spruce, elm, red maple. *Aster macrophyllus* dominant herb. Silty clay, moist soil.
2004	Ontonagon	private	ONF	On narrow ridgetop with *Aster macrophyllus*, bracken fern, *Clinopodium borealis*, *Bromus ciliatus*, and thimbleberry. Canopy is aspen, spruce, and fir, with a sugar maple subcanopy. 19 stems with fruit. One plant browsed.
2004	Ontonagon	ONF	ONF	One plant, in fir thicket on east side of a snowmobile trail.
2004	Ontonagon	ONF	ONF	Under quaking aspen and sugar maple on a steep south-facing slope. *With Pteridium*, *Trillium*, *Oryzopsis*, *Thalictrum dioicum*, and *Uvularia grandiflora*. Clay loam soil. Two plants in bud.
2004	Ontonagon	private	ONF	Four populations (six plants total) on buff on north side of river in clay soil.
2004	Ontonagon	ONF	ONF	One plant along a deer trail, near a steep hillside over the south side of river. Soil is calcareous clay, with little duff. Northern white cedar, small maple & balsam fir create filtered shade.
2004	Ontonagon		ONF	Three scattered individuals along shoulder of grassy, wet logging road. With sugar maple, hemlock, cedar, red maple.
2004	Ontonagon		ONF	Fourteen scattered plants (one budding) in two patches in opening (partial light) of pristine forest with no evidence of logging; on gentle slope, dry-mesic soil; hiking trail nearby; Overstory: P*inus strobus, Abies balsamea, Acer rubrum, Betula papyrifera.*
2004	Ontonagon		ONF	Five plants, one budding; On dry south facing slope; High use due to hiking in area; *Pinus resinosa* and *Pinus strobus* overstory
2004	Ontonagon		ONF	Thirty-four plants (none budding) at base of gentle slop in gradient between upland mixed hardwoods and stream valley, partial light, Near a stream; moist soil; Overstory of *Picea glauca*and *Abies balsamea*.
	Oscoda	HMNF	HMNF	25 plants, “Slopes of cold air drainage,

MICHIGAN

Date	County	Owner	Source	Habitat
				moderately dry sand soil, filtered canopy cover of red pine, jack pine, and aspen."
	Oscoda	HMNF	HMNF	1 plant, Similar as above except filtered canopy of red pine.
	Oscoda	HMNF	HMNF	90 plants, relatively moist swale, sandy soil, heavy canopy cover of jack pine.
	Oscoda	HMNF	HMNF	1 plant, slope of dry kettle, sandy soil, filtered canopy of red pine and oak.
1984	Oscoda		MICH	Scarce in shady cedar woods
1989	Presque Isle		MICH	Cut-over red pine/aspen woods
1988	Presque Isle		MICH	Shade of white pine, paper birch, balsam fir, moosewood

MINNESOTA (Source: University of Minnesota Herbarium [2003] or owner noted by "*").

Date	County	Owner	Habitat
1995	Aitkin	State	Densely shaded hillside with mixed forest of spruce and maple; Assoc. with *Aralia nudicaulis*
	Beltrami	CNF*	Jack pine forest type
	Beltrami	CNF*	Northern hardwoods
	Beltrami	CNF*	Dry pine (red and jack)
1940	Carlton		Mixed forest
1948	Carlton	State	Mixed woods
1940	Carlton	State	Pine woods; sandy soil
1982	Carlton		Mesic woodland in shade.
1979	Carlton		Wet woods
1981	Cass	CNF	Mesic jack pine forest.
1992	Cass	CNF	Plants growing in a cutover area planted to *Picea glauca*. Assoc. with *Lathyrus venosus var.intonsus, Acer rubrum, Actaea rubra.*
1993	Cass	CNF	Old railroad grade near small lake
	Cass	CNF*	Extremely poor pine forest community type
	Cass	CNF*	Northern hardwoods
1925	Clearwater	State	Jackpine forest; dry gravelly soil.
1925	Clearwater	State	
1929	Clearwater	State	Norway pine; sand.
1935	Clearwater	State	
1967	Clearwater	State	Edge of coniferous woods
1936	Cook	SNF	Forest

MINNESOTA (Source: University of Minnesota Herbarium [2003] or owner noted by "*").

Date	County	Owner	Habitat
1936	Cook	SNF	Forest
1938	Cook	SNF	In a clearing
1945	Cook	SNF	Open woods of BWCA
1969	Crow Wing	Natural Area	Mixed hardwood forest
1982	Freeborn	Nature preserve	Edge of hardwood forest
?	Hennepin		Rich woods
1942	Isanti		
1946	Itasca	State	Norway pine stand
1951	Itasca	State	
1952	Itasca	State	Pine forest
1977	Itasca	State	Jack pine stand. In rather dry, sandy soil.
1977	Itasca		In a northern hardwoods stand dominated by Acer saccharum. In moist soil with full shade.
1977	Itasca		Jack pine stand. In dry, sandy soil.
1991	Itasca	CNF	In open mature red pine at edge of old jack pine plantation
1925	Itasca	CNF	
	Itasca	CNF*	Lowland hardwood community type
	Itasca	CNF*	Red pine
	Itasca	CNF*	Red pine
	Itasca	CNF*	Red pine
	Itasca	CNF*	Poor pine forest
	Itasca	CNF*	Poor pine forest
	Itasca	CNF*	Dry pine (red and jack)
	Itasca	CNF*	Poor pine forest
1991	Koochi-ching	State	Mature forest dominated by *Pinus banksiana*. Dry sandy soil. Associated with *Chimaphila umbellata, Epigaea repens, Convolvulus spithamaeus.*
1976	Lake		Mature birch stand
1977	Lake	SNF	Aspen woods
1949	Lake	SNF	In BWCA
1980	Lake	SNF	In woods dominated by *Pinus banksiana*. With *Carex houghtonii* and *Streptopus roseus*
1914	Lake	SNF	In BWCA
2000	Lake, Cook or St. Lois	SNF*	4 plants in opening in paper birch dominated stand, in partial sun.

MINNESOTA (Source: University of Minnesota Herbarium [2003] or owner noted by "*").

Date	County	Owner	Habitat
2000	Lake, Cook or St. Lois	SNF*	1 plant in small opening in paper birch stand with red maple, shrub layer open.
2000	Lake, Cook or St. Lois	SNF*	1 plant in stand dominated by paper birch, quaking aspen, and red maple.
2000	Lake, Cook or St. Lois	SNF*	4 plants in clearing at edge of beaver marsh, mature aspen stand, and recent clearcut aspen stand.
2000	Lake, Cook or St. Lois	SNF*	1 plant on top of steep ridge in heavy shade of mature balsam fir, paper birch, quaking aspen forest.
2000	Lake, Cook or St. Lois	SNF*	1 plant in mature jack pine forest with red maple and paper birch.
2000	Lake, Cook or St. Lois	SNF*	7 plants ...along trail in mixed pine and hardwood stand...
2001	Lake, Cook or St. Lois	SNF*	Approx. 200 plants in jack pine forest, with strawberry, vetch, sweet bedstraw.
2001	Lake, Cook or St. Lois	SNF*	10 plants in stand of mature red pine with jack pine and paper birch, beaked hazel.
2002	Lake, Cook or St. Lois	SNF*	1 individual found in 20 year old paper birch forest with heavy beaked hazel, bush honeysuckle shrub layer
2002	Lake, Cook or St. Lois	SNF*	5-10 plants growing on hiking trail with Fragaria sp, Rubus pubescens, pasture grasses in birch/aspen forest.
2002	Lake, Cook or St. Lois	SNF*	20+ plants growing scattered on two-track trail with exotic grasses and some native forbs in aspen birch forest.
2002	Lake, Cook or St. Lois	SNF*	10 scattered plants within a 5 ac area in various habitats: OG rp stand, open blowdown salvage unit, hiking trail.
2002	Lake, Cook or St. Lois	SNF*	1 individual found on game trail in OG rp stand with beaked hazel, round leaved dogwood, bush honeysuckle.
2003	Lake, Cook or St. Lois	SNF*	Found in jack pine stand.
2003	Lake, Cook or St. Lois	SNF*	Found in red pine plantation.
2003	Lake, Cook or St. Lois	SNF*	6 individuals in birch/aspen forest with abundant *Corylus cornuta* and *Rubus strigosus*.
2003	Lake, Cook or St. Lois	SNF*	3 individuals in canopy gap in paper birch-aspen forest with *Diervilla lonicera* and *Aster macrophyllus.*
2003	Lake, Cook or St. Lois	SNF*	Found in aspen/birch stand.
2003	Lake, Cook or St. Lois	SNF*	4 plants in open, recent clearcut with *Diervilla lonicera*, with one other plant nearby in uncut aspen/fir/birch stand.
2003	Lake, Cook	SNF*	21 plants in birch/aspen/fir forest with *Corylus cornuta*,

MINNESOTA (Source: University of Minnesota Herbarium [2003] or owner noted by "*").

Date	County	Owner	Habitat
	or St. Lois		*Abies balsamea* saplings, *Diervilla lonicera*, and *Aster macrophyllus.*
2003	Lake, Cook or St. Lois	SNF*	Found in aspen/birch/balsam fir stand.
1980	Lake Of The Woods	State	
1914	Morrison		Burnt-over pineland
1993	Pine	Federal	Plants growing along the NW-facing sandstone escarpment; Assoc. with *Carex bromoides, Equisetum fluviatile, Petasites frigidus var. palmatus, Carex rosea, Botrychium virginianum.*
1905	St Louis	State	Birch-poplar stand
1975	St Louis		On edge of clearing and woods (dominated by white birch and quaking aspen)
1939	St Louis		Among shrubs, jack pine forest
1943	St Louis		Mixed woods
1944	St Louis		Wooded lake terrace
1951	St Louis		Woods
1949	St Louis		Woods
1946	St Louis		River woods
1943	St Louis		Mixed forest bordering a swamp
1976	St Louis	SNF	Mature paper birch stand
1951	St Louis	Federal	Along trail, Creek, mixed forest
1940	St Louis		Woods along river
1956	St Louis	SNF	On trail in poplar forest
1943	St Louis		Pine forest, roadside

NEW HAMPSHIRE (Source: As cited by Abrams & Brumback [unpublished])

Status	Date	County	Ownership	Population Description (Source)
H	1931	Carroll	Private	In hardwoods. (NHA)
E	**1999**	**Coos**	State Park	**Habitat:** Forest of *Picea glauca* (white spruce), *Quercus rubra* (red oak), *Thuja occidentalis* (northern white cedar), *Acer rubrum* (red maple), *Acer saccharum* (sugar maple), and *Ostrya virginiana* (ironwood). 570 m elevation, west facing 30-35% slope. Soils calcareous, very shallow and very rocky. **Associated species:** *Aster macrophyllus* (large-leaved aster). **Population size:** 70 plant (8 flowering) 1999.
H	1912	Coos	Private	(GH)

H	1886	Grafton	U.S. Forest Service	"Dry woods" (NEBC)
H	1969	Grafton	Private	(Steele Herbarium)
H	1882	Grafton	Private	(NEBC)

NEW YORK (Source: NYNHP unpublished)

Status *	County	Town (Date)	Population size
H	Albany	Indian Ladder	
H	Cattaraugus	Allegany State Park (1926), Olean (1921), Salamanca (1930, unknown)	
E	Clinton	Location A (2001), Black Brook (1990)	Location A: 100s Black Brook: 40
H	Erie	Collins (1927)	
H	Essex	Elizabethtown (1935), Keene Center (1958)	
H	Genesee	Indian Falls (1922)	
H	Greene	Catskill (1918)	
H	Jefferson	Limerick (1949)	
E	Lewis	Fort Drum (1992)	10-15 plants
H	Livingston	Springwater (unknown)	
H	Monroe	Mendon (unknown)	
H	Monroe	Rochester (1881)	
H	Niagara	Niagara Falls (no date)	
H	Onondaga	Manlius (1907), Memphis (1928)	
H	Orange	Cahoonzie (1925)	
H	Saratoga	Wilton (1929)	
H	Schenectady	Pearson (unknown), Rotterdam (1949)	
H	Schoharie	Central Bridge (1931)	
H	Schuyler	Hector (1918), Watkins Glen (1881)	
H	Tioga	Spencer (1915)	
H	Tompkins	Dryden (1917, 1955)	
H	Ulster	Catskill Mountains (1955), Marlborough (1963), Vernooy Falls (1955)	
H	Warren	Glens Falls (1892), Hague (1926)	
H	Washington	Fort Ann (1904, 1918)	
H	Yates	Penn Yan (unknown)	

OHIO (Source: Ohio Division of Natural Areas and Preserves [2000])

Status	Date	County	Details
H	post 1960	Jefferson	possibly var. *virginianum*
H	post 1960	Perry	possibly var. *virginianum*
H	pre-1960	Ashtabula	

SOUTH DAKOTA (Source: South Dakota Natural Heritage Database 2003)

Date	County	Owner	Population description

SOUTH DAKOTA (Source: South Dakota Natural Heritage Database 2003)

Date	County	Owner	Population description
2001	Lawrence	USFS	**Assoc. spp.** *Amelanchier*, *Spiraea* spp., *Rosa* spp., *Chimaphila* spp., *Thalictrum* spp. **Population size:** 65 plants (18 fruiting)
2001	Lawrence	USFS	**Assoc. spp.:** *Aralia* spp., *Cynoglossum officinale*, *Dicentra trachycaulum*, *Thalictrum* spp. **Population size:** 3 plants, (1 fruiting).
2001	Lawrence	USFS	On 20-50% NE-facing slope; Some plants damaged by trampling. **Population size:** 42 plants (18 fruiting)
2001	Lawrence	USFS	**Population size:** 5 (fruiting).
2001	Lawrence	USFS	In zone between hardwood drainage and N-facing hardwood slope. **Population size:** 6 (fruiting).
1990	Meade	USFS	On lower n-facing slope along game trail in birch-hazelnut woodland. **Assoc. spp**: *Aralia, Lathyrus, Halenia,Osmorhiza, Pteridium***. Population size:** Localized colony (6 plants)
1993	Pennington	USFS	Shady woodland of birch, aspen, ponderosa pine and white spruce; near ephemeral creek. Common as scattered individuals
1993	Pennington	USFS	Mouth of wooded drainage

VERMONT (Source: Abrams & Brumback 2001)

Status	Date	County	Population Description
H	1892	Addison	
H	1898	Addison	Woods 600 feet altitude in Green Mountain National Forest (Steckler *et al.* unpublished).
H	1876	Addison	
H	1914	Addison	By trail at 2250 feet altitude in Green Mountain National Forest (Steckler *et al.* unpublished).
H	1886	Caledonia	
H	1903	Chittenden	
H	1877	Chittenden	
E	1998	Grand Isle	**Habitat:** Shaded, sparse vegetation, 140 ft elevation, 0-5% slope, calcareous, well drained, very rocky over limestone. *Thuja Occidentalis, Juniperus virginiana, Tsuga canadensis,* with a few *Ostrya virginiana*. **Population size**: 70 plants in 1998 (none flowering); 600+ plants in 1985. **Ownership:** Private.
H	1891	Orange	
E	1989	Orange	
E	1990	Rutland	**Habitat:** Calcareous, *Thuja occidentalis* (white cedar) forest.

			Population size: 1990: 15 plants (6 flowering). **Ownership:** Private

WISCONSIN (Source: Wisconsin State Herbarium [2003] or *owner is source)

Date	County	Owner	Habitat (as quoted by source)
1931	Ashland		Woods.
1993	Ashland	Indian Reservation	Semi-open aspen/fir forest on clay soil.
1996	Ashland	Indian Reservation	Steep moist red clay slopes on E side of river; uncommon.
1888	Barron		Copses
1943	Bayfield		Oak & jack pine forest, sandy soil
	Bayfield	CNNF*	Big tooth aspen stand, shrubby in spots, West facing slope sandy, gravelly soil semi-open forest; 7 plants.
2000	Bayfield	CNNF*	75+ indiv. *Pinus stobus*, *Quercus rubra*. Open to partial shade, level to slightly sloped (3%), north aspect, sandy loam soil, dry mesic to mesic. Bottom of ravine, frost pocket.
	Bayfield	CNNF*	Semi-open pine woods (*Pinus strobus*, *Betula papyrifera*, *Ostrya virginiana*. Little shrub layer and moderate to sparse herb layer, soil is sandy gravel, pine needle duff and deciduous, somewhat rich moist, level to north facing; 10 plants.
1928	Bayfield		dry woods
1952	Bayfield		*Betula papyrifera, Quercus rubra, Betula lutea*. Deer yard
1993	Bayfield		Boreal forest on steep, E-facing slope above river; *Populus tremuloides*, *Quercus macrocarpa*, *Picea glauca*, and *Abies balsamea* dominant
1996	Bayfield	CNNF.	Moist jack pine thicket, sandy soil.
2000	Bayfield	CNNF*	Sub-populations of 28 & 11 plants. Moist depression; Young jack pine and trembling aspen stand. Partial shade, <1% slope, Loamy sand to sandy soil.
1883	Door		
1883	Door		
1978	Door		
1977	Door	State Park	Scattered in young open forest of *Betula papyrifera*, *Acer saccharum* & *Abies balsamea*. Although the area is very flat, the soil is only 1dm or less of gravel and sand over dolomite.
1928	Door		

WISCONSIN (Source: Wisconsin State Herbarium [2003] or *owner is source)

Date	County	Owner	Habitat (as quoted by source)
1935	Door		Woods near Lake Michigan
1961	Door		sandy woods
1940	Door		West woods
1996	Door	State Park	Disturbed areas in white cedar, paper birch forest.
	Door		
1938	Door	County Park	Limestone cliffs
1924	Douglas		
1897	Douglas		Lake Superior region
1996	Douglas	State Forest	White pine, poplar, white spruce, balsam fir, paper birch forest.
1996	Douglas	State Forest	Eroded clay banks along river. Trees: Balsam fir and white spruce.
1996	Douglas		Jack pine barrens with bur & hills oak.
1996	Douglas		Jack pine, Hills oak, bur oak barrens.
1969	Douglas	State Park	sparse shade, woods
1979	Douglas	State	W side of bay, with *Aster macrophyllus*, under Pinus strobus
1964	Florence		2nd-growth dry upland Northern Hardwoods with *Acer saccharum, Betula papyrifera*, & *Populu*s.
1955	Florence		
1964	Florence		2nd growth northern hardwoods (Popple, birch, fir, spruce). Along lumber road.
1982	Florence	CNNF	Boggy meadow on S side of lake, slopes above bog
1982	Florence	CNNF	Base of drift hill in aspen, birch, red maple woods.
1982	Forest		Dry, *Cladonia*-clad slopes among *Abies* & *Picea glauca*.
1978	Forest		
1978	Forest		
1978	Forest		
1978	Forest		
1959	Forest		Maple-Basswood forest. Hillside
1940	Iron		damp ground
1951	Lincoln		pine woods
1950	Lincoln		open woods near river
1950	Lincoln		rich deciduous woods
1960	Manito-woc	State Park	Inside E edge of Cedar, Pine, Oak, Maple forest
1919	Marathon		

WISCONSIN (Source: Wisconsin State Herbarium [2003] or *owner is source)

Date	County	Owner	Habitat (as quoted by source)
1979	Marinette		
1969	Marinette	County	One plant seen in old second growth woods of *Populus grandidenta*
Pre-1940	Milwau-kee		
1982	Oconto	CNNF.	2nd growth *Tsuga*-northern hardwoods. Medeola present.
1983	Oconto	CNNF	Slope above woodland pond.
1982	Oconto	CNNF	2nd growth mixed woods.
1975	Oneida		Upland dry forest of *Pinus resinosa*; occasional.
1964	Oneida		Second growth (40yrs) *Picea mariana*, on a shallow half-bog or moss-mor soil; sporadic raw humus plants in denser parts of the stand.
1930	Price		Beside field.
1880	Racine		
1905	Sawyer		
1977	Sawyer		Open low upland near bog, with *Populus tremuloides, Picea glauca, Hieracium aurantiacum, Viburnum rafinesquianum* .
1914	Sheboy-gan		
1928	Vilas		Jack pine woods
1957	Vilas		Aspen-Birch stand, with sugar maple and red oak understory; Old pine land.
1956	Vilas		
1961	Vilas		Aspen woods; rare.
1965	Vilas		Hemlock-hardwood forest
1940	Vilas		Sandy ground, in open woodland.
1956	Vilas		Deer yard.
1993	Vilas	CNNF	Open woods, thinned birch stand.
1915	Vilas	Indian Reservation	
1893	Vilas		

LIST OF CONTACTS

Information Requests

Ramona Shackleford requested information from contacts in 2003 and 2005. Communications in 2000 or 2001 were carried out by Patty Beryer, Angie Lucus, Linda Swartz and Christine Hura.

UNITED STATES	
Connecticut:	2000: N. Murray
Indiana:	2003: Michael A. Homoya, Botanist/Ecologist; Division of Nature Preserves; Indiana Department of Natural Resources; Indianapolis, Indiana
Iowa:	2003: Mark Leoschke, Botanist; John Pearson, Plant Ecologist; Iowa Natural Areas Inventory; Department of Natural Resources; Des Moines, Iowa. 2005: Deborah Q. Lewis, Curator; Ada Hayden Herbarium; Department of EEOB; Iowa State University; Ames, IA
Maine:	2001: E. Pinkham
Michigan:	2004: Ian Shackleford, Botanist; Ottawa National Forest; Ironwood, MI. 2003: Trull, Susan, Botanist; Ottawa National Forest; Ironwood, MI. 2001: Alix Clevelend; Huron-Manistee National Forest.
Minnesota:	2001: D. Pomroy-Petry, Olga Lakela Herbarium, University of Minnesota, Duluth, Minnesota. Ed Lindquist. Superior National Forest, Duluth, Minnesota. 2003: Jack Greenlee, Botanist; Superior National Forest, Duluth, Minnesota.
New Hampshire:	2001: Cairns, S
North Dakota	2003: Gary K. Clambey, North Dakota State University; Fargo, N.D. John C. La Duke, Biology Department; University of North Dakota; Grand Forks, North Dakota Rachel Seifert-Spilde, Natural Resource Biologist North Dakota Parks and Recreation Department; Bismarck ND
Pennsylvania	2000: A. F. Rhoads, Pennsylvania Flora Project 2001: Steve Grund, Western Pennsylvania Conservancy. 2003: Dr. Timothy A. Block; Director of Botany; Morris Arboretum of the University of Pennsylvania; Philadelphia, PA.
South Dakota:	2001: David Ode. 2003: Katherine Zacharkevics, Botanist; Black Hills National Forest

	Doug Backlund; South Dakota Dept. of Game, Fish and Parks; Pierre, S.D. 57501
Vermont:	2003: Diane H. Burbank, Ecologist; Green Mountain and Finger Lakes National Forest. 2004: Bob Popp, Botanist/Inventory Coordinator, Vermont Nongame and Natural Heritage Program
Wisconsin:	2001: K.Westad. Wisconsin Natural Heritage Inventory; Madison, Wisconsin. 2005: Donald Waller, Professor of Botany; University of Wisconsin-Madison; Madison, Wisconsin.

CANADA	
Alberta:	2001: John Rintoul; Natural Heritage Information Systems Coordinator; Alberta Natural Heritage Information Centre; Edmonton, Alberta, Canada
Manitoba	2003: N. Firlotte
Newfoundland:	2001. Blaney, S. Atlantic Canada Conservation Data Centre.
Quebec:	2001: J. Labrecque. Quebec Ministry of the Environment. S. G. Hay; University of Montreal.
Saskatchewan	2001: S. Lamont; Saskatchewan
Yukon Territories	2001: B. Bennett; Yukon

Review Requests:

William E. Brumback; New England Wild Flower Society; Framingham, MA

Bob Wernerehl, PhD Candidate; University of Wisconsin-Madison Dept. of Botany

Sarah Wright, Graduate Student; University of Wisconsin-Madison Dept. of Botany