

New England Plant Conservation Program

Hydrastis canadensis L.
Goldenseal

Conservation and Research Plan
for New England

Prepared by:
Penelope C. Sharp
Environmental Consultant
Northford, Connecticut

For:

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

Approved, Regional Advisory Council, May 2003

SUMMARY

Goldenseal, *Hydrastis canadensis* L. (Ranunculaceae), is an herbaceous species of deciduous forests that is endemic to North America. *Hydrastis canadensis* is found throughout most of eastern North America, and ranges from Alabama and Georgia in the south northward to Vermont into Ontario and westward to Minnesota. Its western limits include Kansas and Oklahoma. The New England Plant Conservation Program (NEPCoP) lists *H. canadensis* as a Division 2 (regionally rare) plant species. In New England, there are eight extant populations: three in Vermont, two in Massachusetts, and three in Connecticut. There are also eight historic occurrences divided amongst the three states. Population sizes at extant locations are estimated to range from fourteen stems to greater than several hundred. The state rankings for the species in Vermont, Massachusetts, and Connecticut are S1, and it is listed in these states as Endangered. It is ranked N4 at the federal level and is considered to be apparently secure. Potential threats to *H. canadensis* include collecting for medicinal purposes, habitat loss, competition from aggressive species, herbivory, and canopy closure.

Hydrastis canadensis is in wide use today as a medicinal plant and is reported to be among the top selling medicinal herbs in the United States. It is valued for its bright yellow rhizomes, which are nearly always collected from the wild. Because of concern for its potential increased scarcity, *H. canadensis* has recently been listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) and this has led to the recognition of the need for cultivated supplies. *Hydrastis canadensis* is a species of nutrient-rich, mesic, deciduous woodlands. It will grow in slightly acidic to basic soils and appears to prefer a soil with a pH between 5.5 and 6.5. In New England, all of the extant populations are found in rich woods, frequently in low areas adjacent to streams. Although *H. canadensis* is an obligate forest species, it may respond positively to openings in the canopy. Under cultivated and natural conditions, optimal plant growth has occurred under 63 to 80 percent shade.

The primary conservation objectives in New England for *Hydrastis canadensis* are to restore vigor to existing populations and to maintain a minimum of ten occurrences, each with no less than 100 ramets. This latter objective would approach the historic levels of *H. canadensis* in New England. Site-specific management plans aimed at reinvigorating and maintaining the existing populations should be developed and implemented for each of the New England extant populations. *De novo* searches should be conducted in areas where suitable habitat exists, beginning at locations near extant or historic populations. Finally, additional collections for the seed bank are recommended for establishment of new populations, reestablishment of an historic population, and as insurance against an unforeseen catastrophic loss of any of the remaining wild populations.

PREFACE

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

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

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

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

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

This document should be cited as follows:

Sharp, P. C. 2003. *Hydrastis canadensis* L. (Goldenseal) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

© 2003 New England Wild Flower Society

I. BACKGROUND

INTRODUCTION

Goldenseal (*Hydrastis canadensis* L.) is a member of the buttercup or crowfoot family (Ranunculaceae) and is endemic to temperate North America. Although goldenseal is the best known common name for this plant, it has many other monikers including orangeroot, yellow puccoon, eyebalm, eyeroot, Indian paint, wild turmeric, jaundiceroot, and ground raspberry. Many of the common names relate directly to the varied medicinal uses of the plant. *Hydrastis canadensis* was used both as a dye and for medicinal purposes by the Cherokee Indians who purportedly introduced it to early colonists. Medicinally, it is an herbal remedy for a variety of disorders including digestive ailments, bronchial infections, pneumonia, whooping cough, diarrhea, and as a booster to the immune system (Sinclair and Catling 2000a). The first record of its medicinal uses by American settlers dates to 1798 (Lloyd undated). Its popularity as an herbal remedy continues today; during the 1990s, the demand for goldenseal increased dramatically. It has been estimated that upwards of 250,000 pounds of goldenseal root are marketed each year (Foster 2000).

Globally and nationally, *Hydrastis canadensis* is ranked G4 and N4 respectively, meaning that it is considered to be “apparently secure.” *Hydrastis canadensis* has recently been listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora (UNEP-WCMC 2003). This listing decision was reached at the Tenth Conference of the CITES Parties (COP10) which was held in June of 1997. The listing became effective September 18, 1997 and covers live plants as well as whole and sliced roots and parts of roots, excluding manufactured parts or derivatives such as powders, pills, extracts, tonics, teas, and confectionary. By the listing of *H. canadensis* in CITES, the live plants and roots are now covered by the U.S. Fish and Wildlife Service's regulations regarding import or export of wildlife.

In New England, *Hydrastis canadensis* is ranked by NEPCoP as a Division 2 or regionally rare species “with fewer than 20 occurrences seen since 1970” (Brumback and Mehrhoff et al. 1996). In the northeast, *H. canadensis* is an uncommon species of deciduous forests that is at the northern periphery of its range, one of several factors that accounts for its rarity in the region. The plant has been extensively collected from the wild due to its popularity as a medicinal plant; however, the extent to which it has been collected from New England populations is not known. Bissell (1899) states that *H. canadensis* has probably never been abundant in New England, although he presents no data to support this conclusion. At present, there are eight extant occurrences in the region: three in Vermont, two in Massachusetts, and three in Connecticut. Within the three states, there are eight historic occurrences and none in the other New England states. Because of its rarity, *H. canadensis* is state-ranked S1 (Endangered) in Vermont, Massachusetts, and Connecticut.

This plan summarizes the available information on *Hydrastis canadensis* and identifies potential threats to its continued survival in New England. Additionally, the plan proposes specific measures to be taken toward the achievement of recovery objectives and the continued presence of *H. canadensis* as a component of the New England flora.

DESCRIPTION

The following description of *Hydrastis canadensis* is based upon a compilation of morphological characteristics taken from the following references: Fernald (1950), Mitchell and Dean (1982), Foster (1991), Gleason and Cronquist (1991), and Sinclair and Catling (2000a).

Hydrastis canadensis is a perennial woodland herb of North America. The shoot develops from an underground yellow rootstock that consists of an irregularly knotted, thick rhizome. The rhizome bears small cuplike scars made by the previous year's peduncle and has numerous fibrous rootlets. The scars are thought to resemble the wax seals once used to seal envelopes, thus the derivation of the plant's common name. A single leaf emerges from the rhizome in early spring, simultaneously with a simple, fluted, hairy stem that may reach a height of 36 cm above the ground. The stem is downwardly pilose when young; however, it becomes glabrous at maturity. The stem has small clasping scales at the point where it joins the rhizome.

When mature, *Hydrastis canadensis* typically has three leaves per stem, two cauline and one basal, which are similar in morphology. They are doubly serrate, heavily veined and palmately lobed, usually having three to five and occasionally seven lobes. Leaves are densely hairy when young and commonly remain so at maturity. One of the cauline leaves is sessile and subtends the peduncle, which is an extension of the stem. The leaf, 2 to 7 cm at anthesis, grows to approximately 15 cm at maturity. The other cauline leaf is petioled and larger, becoming 12 to 20 cm wide at maturity. Its pubescent petiole is 0.5 to 9.5 cm in length. The basal leaf is the largest of the three and may grow to a diameter of 26 cm. A single bisexual flower, with three small, greenish-white sepals appears in early spring. The sepals drop as soon as the flower opens. The flower has no petals, but has numerous, prominent stamens that are 4 to 8 cm long. The cream-colored filaments distinguish the flower and give it color. Each flower contains 5 to 12 (up to 15) one styled ovaries. The style is flat and two-sided. The ovaries ripen into red berries tipped with the persistent styles that are borne in a fused head. This fruit has the superficial appearance of a raspberry and ripens in mid summer. The fruit has given rise to two of the plants common names, Indian raspberry and ground raspberry. Each small, fleshy, red berry contains 1 or 2 black, shiny seeds.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Hydrastis is a monotypic genus occurring only in the temperate regions of North America. There is only one other closely related species to *Hydrastis canadensis*, namely *Glaucidium palmatum*, which is found in Japan (Foster 1991). In the first edition of *Species Plantarum*, Linnaeus named goldenseal *Hydrophyllum verum canadense* based upon a leaf specimen that resembled *Hydrophyllum* (Foster 1991). Linnaeus was later provided with a flowering specimen, which he named *Hydrastis* in the *Systema Naturae*, Tenth Edition in 1759. *Hydrastis canadensis* was regarded as a member of the buttercup or crowfoot family, Ranunculaceae, from 1789 until the end of the 19th century (Tobe and Keating 1985). At the end of the 19th and beginning of the 20th centuries, it was transferred into the Berberidaceae due to its similarities to *Podophyllum* and *Diphylleia* (Tobe and Keating 1985). It was later returned to the Ranunculaceae due to its strong resemblance to *Glaucidium*, a closely related species. Based upon a number of unique characters, it was placed in a separate family, Hydrastidaceae by Lemesle in 1948 (Tobe and Keating 1985). Takhtajan (1969) lists ten families in the order Ranunculales, Hydrastidaceae being one of them.

Cronquist (1981) recognizes a total of eight families in the Ranunculales and includes *H. canadensis* in the Ranunculaceae family. He notes that the small, closely related genera of the family (*Hydrastis* and *Glaucidium*) are more or less transitional between Ranunculaceae and Berberidaceae. The two genera differ morphologically from both families, lacking the V-shaped vascular bundles of the Ranunculaceae and the specialized anthers of the Berberidaceae. Cronquist recognizes that both genera have been placed in monotypic families, Glaucidaceae and Hydrastidaceae respectively; however, he considers it preferable to place *Hydrastis* and *Glaucidium* within the variable family Ranunculaceae.

Hydrastis is perhaps the most controversial of the genera within the family Ranunculaceae. Final determination regarding the placement of this genus will likely require molecular studies of Berberidaceae, Ranunculaceae, and related families; however, Flora of North America places *H. canadensis* in the Ranunculaceae (Flora of North America 2002). Some recent analyses of its leaf anatomy, chromosome number, embryology, and the morphology of its fruits, flowers, and xylem have caused several researchers to support the reestablishment of the monotypic family, Hydrastidaceae (Tobe and Keating 1985, Hoot 1991).

SPECIES BIOLOGY

Hydrastis canadensis is a woodland herbaceous perennial herb which, in New England, flowers in late April and early May and fruits from late June into late August (Magee and Ahles 1999, Sharp personal observation). The flower lacks petals and its sepals drop as the bud opens, leaving a cluster of elongated stamens. The leaves become fully expanded by June prior to the development and ripening of the fruit (Sinclair and Catling 2000a). There is little root growth during the period of rapid above-ground growth; however, once the fruit

matures, root growth is more pronounced (Eichenberger and Parker 1976). Above ground biomass peaks around mid July and declines with plant senescence until the first killing frost (Eichenberger and Parker 1976).

Bowers (1891) observed that the ripe seeds of mid to late summer germinated in the last week of the following April into a “plantlet” (sic) or seedling consisting of a pair of cotyledons on long petioles joined to a slender radicle and that there was no further growth that year. During the second year, the young plant sends up a single leaf, a stage that may persist through the third year. The plant matures in the third or fourth year, by which time the stem reaches a height of 15 to 30 cm and has two alternate leaves, the lower one larger and petiolate, the upper one sessile at the junction of the flower peduncle and the stem of the plant (Bowers 1891). Flowers and fruit are produced in the third or fourth year. Bowers (1891) noted that germination of naturally sown seeds was slow. Davis and McCoy (2000) state that it takes five to seven years to grow harvestable roots from seed. They also observed the propagation of *Hydrastis canadensis* from seed to be difficult with unpredictable results. Studies of seed germination have been ongoing at Mountain Horticultural Crops Research Station in North Carolina for several years. In one study, Davis and McCoy (2000) found that the best germination rates the first spring after seed harvest were obtained when seeds were quickly extracted from the fruit using a sieve method. The seeds were kept in moist sand at 21° C until sowing in late fall. This treatment resulted in an average germination rate of 37 percent. For many of the treatments, they found that seed did not germinate until the second season after seed harvest. The highest germination rates in the second season were from seeds that were extracted from the fruit by the sieve method, held at 21° C for 30 days followed by 4° C until planting or held at 4° C. In each case, the seeds were planted the spring following seed harvest and germinated two seasons later. Average germination rate with this method was 45 percent (Davis and McCoy 2000). Baskin and Baskin (2001) observed that seeds of *H. canadensis* matured in mid- to late July, but that there was little embryonic growth in seeds kept under natural temperatures. Embryonic growth occurred in the autumn and in late fall; the seed coats began to split allowing the embryo to extend slightly beyond the end of the seed. The embryo remained covered by the endosperm until March when first the radicle and then the cotyledons emerged.

Hydrastis canadensis also propagates vegetatively and this is its primary method of reproduction (Sanders and McGraw 2002). It is a clonal species and aerial stems develop from the knotty, underground rhizome. Toward the end of the growing season, a “bud” may be produced on the rhizome and this bud grows into a stem in the following year (Sinclair and Catling 2000a). This method of propagation promotes the formation of large patches of genetically similar plants. Patches of up to 100 stems in a single square meter have been documented (Gagnon 1999). It is not known whether large patches represent a single genotype or whether multiple genotypes occur within a patch (Sanders and McGraw 2002).

There is scant information in the literature regarding the pollination and dispersal of *Hydrastis canadensis*; however, a recent study conducted in the Lake Erie Lowland Ecoregion

in Ontario documented that small bees (genera *Dialictus* and *Evyllaenus*) are the primary pollinators (Sinclair et al. 2000). Syrphid flies and some larger bees were also observed visiting *H. canadensis* flowers. This finding is consistent with findings regarding the pollination ecology of the spring wildflower community in a temperate deciduous forest. Motten (1986) found that the majority of woodland wildflower species are pollinated by flies and solitary bees. He also noted a prevalence of white flowers at the height of the blooming season. The creamy white filaments of *H. canadensis* are therefore likely to attract pollinators, particularly small bees; thus, lack of pollination is unlikely as a potential threat to the taxon. There are no research data that indicate species dependence upon specific pollinators.

Sinclair and Catling (2000a) note that the frequent occurrences of *Hydrastis canadensis* in isolated patches suggest potential limitations to its spread. These constraints may include dispersal of the species. Several authors have noted that the fruits disappear upon ripening and that few are found on the ground (Sinclair and Catling 2000a, Eichenberger and Parker 1976). This suggests that animals consume and disperse the fruits. The fact that the fruits are bright red and are positioned atop the leaves suggests that birds are the primary consumers of the fruits (Welty 1962). Confirmation of this assumption requires further research regarding *H. canadensis* dispersal.

In the small isolated patches under natural conditions, *Hydrastis canadensis* does not seem to be beset by many pests or diseases. However, under cultivation, it is sometimes subject to a leaf blight caused by a species of *Botrytis*. Other diseases reported to attack goldenseal under cultivation include alternaria, rhizoctonia, and fusarium (Davis and McCoy 2000). The most serious pests of *H. canadensis* are slugs that can eat the seed, the seedling or even entire older plants (Beyfuss 1999). In New England, herbivory by slugs has been documented at CT .002 (Plainville), CT No EO # (Guilford) (Sharp, personal observation) and MA .003 (West Stockbridge) (Paul Somers, Massachusetts Natural Heritage and Endangered Species Program [MANHESP], personal communication). Root knot nematodes, if present in the soil, will attack *H. canadensis* and will reduce the growth and root yield of the plant (Davis and McCoy 2000).

Economic Importance

Hydrastis canadensis is a valued medicinal plant that has become increasingly popular within the last decade (Foster 2000, Sinclair and Catling 2001, Sanders and McGraw 2002). Its rhizomes and roots contain the alkaloids hydrastine, berberine, canadine, and canadaline. Berberine produces antibiotic effects against bacteria and protozoa, while hydrastine acts as a uterine hemostatic and antiseptic. Canadine acts as a sedative and muscle relaxant (Purdue University 2002). During the early 1990s, goldenseal made the leap from the health and natural food market to the mass market; since then, the demand for its products has increased dramatically (Foster 2000). Goldenseal is considered to be among the top six most popular medicinal herbs in the U.S. (Sinclair and Catling 2001). Limited supplies and growing demand

have resulted in ever-increasing prices. Wholesale prices of *H. canadensis* rose from about \$8.00 per pound to over \$100.00 per pound between 1990 and 2000 (Foster 2000). Shortages and price fluctuations are not new and between 1858 and 1908, the price for goldenseal increased by 2500 percent while during that same period, the price for ginseng increased 1400 percent (Sheldon et al. 1997). Although cultivation is encouraged in order to relieve the pressures on wild populations, there remain valid concerns regarding the continued survival of *Hydrastis canadensis* in the wild. It was this concern that led to the CITES listing of the taxon in Appendix II.

HABITAT/ECOLOGY

Hydrastis canadensis ranges throughout a large portion of eastern United States from Vermont to Michigan and Minnesota, south to North Carolina, Tennessee, and Arkansas (Fernald 1950, Gleason and Cronquist 1991). The species also occurs in the southern portion of the province of Ontario, Canada. Throughout its range, *H. canadensis* is consistently described as a plant of nutrient rich, mesic deciduous forests that grows in soils with plentiful amounts of leaf mold (Lloyd and Lloyd 1894-1897, Fernald 1950, Gleason and Cronquist 1991, Magee and Ahles 1999, Sinclair and Catling 2000a, Penskar et al. 2001).

With respect to habitat size and *Hydrastis canadensis*, Sinclair and Catling (2000b) noted a significant negative relationship between habitat size and number of stems. *Hydrastis canadensis* has been observed to have relatively larger populations in relatively smaller areas. The researchers further found that the occurrence of the taxon near forest edges or paths was greater than expected. This suggests that extensive undisturbed habitats are not a requisite for the occurrence of *H. canadensis* and that the plant may be adequately protected in relatively small areas that are subject to periodic minor disturbances. Reznicek (1987) advocates the preservation of small reserves for plants and states that a species with populations protected at several sites, albeit small sites, is less susceptible to catastrophe than a species with a single protected population on a large site.

Habitat of Hydrastis canadensis Outside New England

In southwestern Ontario, *Hydrastis canadensis* is found in deciduous woodlands near floodplains and vernal flooded plateaus (Sinclair and Catling 2000a). In the same area, *H. canadensis* on upland sites is found in slightly acidic soils (pH 5.4 to 6.3) sandy loam or loam soils, whereas on lowland sites, it occurs on slightly acidic to slightly basic clay or sandy loam soils (pH 5.7 to 7.8) (Sinclair and Catling 2000a). Associated species at the Ontario sites include *Quercus rubra*, *Acer saccharum*, *Crataegus* sp., *Fraxinus* sp., *Carya ovata*, *Ostrya virginiana*, and *Tilia americana*. In Michigan, *H. canadensis* occurs in mesic woods, often near vernal pools, along streams and within floodplain forests (Penskar et al. 2001). Canopy species associated with *H. canadensis* include *Acer saccharum*, *Fagus grandifolia*, *Quercus*

rubra, *Tilia americana*, and *Juglans cinerea*. Some of the woodland herbs noted include *Arisaema triphyllum*, *Erythronium americanum*, *Carex plantaginea*, *Claytonia virginica*, and *Asarum canadense* (Penskar et al. 2001).

Habitat in New England

In New England, the extant populations of *Hydrastis canadensis* are found in typical habitats of the rest of its range. In Vermont, one location is described as a rich, mesic mixed hardwood forest with a north-northeast aspect. Associated species include *Adiantum pedatum*, *Aralia nudicaulis*, *Asarum canadense*, and *Prenanthes altissima*. A second site is described as a mesic oak-hickory northern hardwood forest on limestone cobble. Associated plant species include *Acer saccharum*, *Tilia americana*, *Ulmus* sp., *Carya ovata*, *Rhamnus cathartica*, *Aralia racemosa*, *Geranium robertianum*, *Elymus hystrix*, *Circaea alpina*, and *Smilacina racemosa*. This population contains two subpopulations, the southern one under approximately 80 percent canopy closure and the northern one under about 50 percent cover. A third population occurs within a mature sugarbush in rich, calcareous soils. The general topography is flat and the plants grow in a slight depression. Associated species include *Acer saccharum*, *Fraxinus americana*, *Fagus grandifolia*, *Allium tricoccum*, *Sanguinaria canadensis*, *Menispermum canadense*, *Caulophyllum thalictroides*, *Tilia americana*, *Carya ovata*, *Dirca palustris*, and *Cinna latifolia*. All occurrences are located within the Champlain Lowlands ecoregion of Vermont (Anne Turner, Vermont Nongame and Natural Heritage Program, personal communication).

There are two extant populations in Massachusetts. One location is within the Vermont Piedmont ecoregion of Massachusetts (Commonwealth of Massachusetts, Executive Office of Environmental Affairs 2001). This occurrence is found near a brook in a rich, mesic hardwood forest. Associated species include *Acer saccharum*, *Carya* spp., *Athyrium felix-femina*, *Arisaema triphyllum*, *Urtica dioica*, *Asarum canadense*, *Sanguinaria canadensis*, and *Matteuccia struthiopteris*. The other occurrence is situated within the Western New England Marble Valley ecoregion (Commonwealth of Massachusetts, Executive Office of Environmental Affairs 2001). The habitat of this population is described as rich, mesic forest in mull soils at the base of a dolomitic limestone ledge. Other species present include *Acer saccharum*, *Carex platyphylla*, *Cystopteris bulbifera*, *Thalictrum dioicum*, *Dryopteris marginalis*, and *Fraxinus americana* saplings.

Connecticut has three extant populations, one of which was discovered in the spring of 2002. Two populations are found within the Southeast Hills ecoregion and one occurs within the North-central Lowlands ecoregion (Dowhan and Craig 1976). The recently discovered population grows in damp soils near wetlands. Associated species include *Acer saccharum*, *A. rubrum*, *Quercus rubra*, *Ilex verticillata*, *Vitis* sp., *Rosa multiflora*, *Lonicera japonica*, *Elymus hystrix*, and *Polystichum acrostichoides* (Sharp, personal observation). A second population grows in similar habitat near a stream. This population is under a canopy of *Acer*

saccharum and *Fraxinus americana* with scattered *Carpinus caroliniana*. *Polystichum acrostichoides*, *Thelypteris noveboracensis*, and *Carex* spp. are associated herbaceous species (Sharp, personal observation). The third population (found in the North-central lowlands) grows at the base of a traprock ridge in rich, mesic deciduous woods near a small watercourse. The dominant species at this location are *Quercus rubra*, *Acer saccharum*, *Fraxinus americana*, *Lindera benzoin*, *Viburnum acerifolium*, *Asarum canadense*, *Caulophyllum thalictroides*, *Arisaema triphyllum*, and *Erythronium americanum* (Sharp, personal observation).

There appear to be several common denominators amongst these New England populations with respect to habitat. Nearly all are located in moist sites near streams or wetlands. The associated species are somewhat similar at each location and are indicative of the rich loamy soils that *Hydrastis canadensis* seems to prefer. There are many locations within New England that constitute rich, mesic deciduous woodlands; therefore lack of habitat is probably not a limiting factor for *H. canadensis* in the region. Nonetheless, loss of habitat due to the conversion of forestland, along with overharvesting, has been blamed for the plant's rarity since the late 19th century (Lloyd and Lloyd 1894-1897). In the text of Bulletin No. 30, Bulletin of the Lloyd Library, the authors state, "It is the common report from all botanists that the plant is becoming scarcer every year. In many places where it formerly grew abundant, it is now reported rare."

Growing Conditions

Hydrastis canadensis is harvested mainly from the wild; however, it is now subject to CITES regulations, which require that harvesting remain not detrimental to the species and that propagated goldenseal be used for export from the U.S. and Canada. In response to this, there has been increased interest in its cultivation. In order to acquire a greater understanding of growing conditions, several researchers have studied growth requirements in both wild and cultivated populations. Sinclair and Catling (2001) found that *H. canadensis* grows best in mixed hardwood forests under 60 to 65 percent shade in moist, sandy loam soils that are high in organic matter. In their study of 21 natural populations, the optimal soil pH ranged from 5.7 to 6.3. *Hydrastis canadensis* grown in pots of forest soil exhibited the highest root weight when grown in soils with a pH of 5.5 and the greatest flowering, fruit set, plant height and leaf size with a pH of 5.5 to 6.5 (Davis 1995, 1996). Plants fertilized with differing inputs of nitrogen and phosphorus showed decreasing root weight with increasing nitrogen and the greatest growth with a phosphorus application of 0.3kg/m³. Davis and McCoy (2000) recommend that *H. canadensis* be grown in the shade, which can be provided artificially or by a natural forest canopy. They further state that, to date, the best plant growth has occurred under 63 to 80 percent shade and that plant stand counts and survivability have been highest under 47 and 63 percent shade (Davis and McCoy 2000).

THREATS TO TAXON

In New England, eight former populations of *Hydrastis canadensis* no longer exist and many of the extant populations appear to be declining. Despite the fact that this plant has been used medicinally for hundreds of years, there is surprisingly little information concerning its biology, particularly with respect to its rarity. In New England, some reasons for its scarcity could be due to external factors such as changes in land use, collection of the roots, and loss of seed dispersers. There may also be intrinsic factors such as reproductive limitations, lack of genetic variability, or special requirements, as yet unknown. For the New England populations, a number of potential threats that may be affecting the different occurrences have been identified. These include in order of perceived importance:

- Human disturbances, development
- Habitat loss
- Invasive species
- Canopy closure
- Herbivory
- Collecting from wild populations and removing plants or seeds for cultivation
- Logging, agricultural activities

Human Disturbances, Development

Human disturbances associated with development are having an impact on several *Hydrastis canadensis* populations in New England. Human disturbance or collecting may account for the disappearance of *H. canadensis* from MA .001 (Hingham), although the precise reasons for the demise of this population are unclear. Development is proposed on land just east of MA .003 (West Stockbridge) (Somers, personal communication). Numbers of stems have declined at CT .001 (Killingworth) since the nearby subdivision development has occurred. At CT .002 (Plainville), there is a new subdivision in close proximity to the element. A trail system, apparently created by off road vehicles, passes close to two of the subpopulations at this site (Sharp, personal observation). It should be noted that Sinclair and Catling (2000b) have found healthy populations of *Hydrastis canadensis* occurring along forest edges and near paths. They have concluded that *H. canadensis* may respond positively to some forms of human disturbance. In contrast, Sanders and McGraw (2002) found severe declines of the species in an Indiana oak-hickory forest over a span of twenty-six years. They attribute the decline, in part, to disturbance of the canopy possibly due to ice damage, in interior portions of the forest. This does not represent human disturbance though. Additional research is likely necessary to determine the response of *H. canadensis* to certain types of human disturbance.

Habitat Loss

Habitat loss accounts for the disappearance of at least one of the historic sites in Southington, Connecticut (CT .003) and possibly the site in Lynn, Massachusetts (MA .004) where little suitable habitat remains (Nancy Putnam, MANHESP, personal communication). Several authors have noted that habitat loss through deforestation has been partially responsible for the increasing scarcity of *Hydrastis canadensis* throughout its natural range.

In New England, most of the extant populations are in private ownership. Therefore, the future land uses for these New England populations are unknown. Activities such as intensive logging, farming, or land development could have devastating impacts upon the populations of *H. canadensis*.

Invasive Species

Invasive species have been documented at six of the sites in New England. At VT .004 (Weybridge), *Rhamnus cathartica* was observed by Robert Popp and Gioia Kuss on August 1, 2001. The Charlotte site, VT .005, has several invasive species growing nearby including *Rhamnus cathartica*, and *Berberis thunbergii* (Unpublished data from Vermont Element Occurrence Record [EOR], 2003). A number of invasive species grow at MA .002 (Gill) including *Berberis thunbergii*, *Rosa multiflora*, *Lonicera morrowii*, *Celastrus orbiculatus*, and *Solanum dulcamara* (Unpublished data from Massachusetts EOR, 2000). In July of 2001, Paul Somers (personal communication) observed *Alliaria petiolata*, *Berberis thunbergii*, and *Rhamnus cathartica* in close proximity to *Hydrastis canadensis* at MA .003 (West Stockbridge). In Connecticut, *Alliaria petiolata* is spreading near the EO at CT .002 (Plainville) and several exotics, including *Lonicera japonica*, *Rosa multiflora*, and *Rubus phoenicolasius*, grow near the population at CT No EO # (Guilford). Competition from non-native, aggressive species has the potential to result in further decline of populations, particularly those already considered to be marginal.

Canopy Closure

Several authors have noted that *Hydrastis canadensis* grows well under a somewhat open canopy of 60 to 80 percent closure (Davis and McCoy 2000, Sinclair and Catling 2001). Sinclair and Catling (2001) found that a natural population of *H. canadensis* displayed low plant vigor under a 90 percent shaded canopy and that the healthiest of the populations that they studied was at a forest edge in 30 percent shade. At CT .001 (Killingworth), canopy closure may account for the low plant vigor and lack of flowering observed in recent years. At VT .005 (Charlotte), shading may be a problem, particularly due to beech regeneration. Robert Popp, with owner permission, removed some small beech saplings in June of 2003. At MA .003 (West Stockbridge), property owners have cleared all mature trees immediately adjacent to one

side of the population. Following the clearing, stem count and flowering of *H. canadensis* increased slightly (Somers, personal communication). Whether or not the tree removal contributed to the increase is not known; however, it does lend support to potential threats to the taxon from canopy closure. Shading may explain decline at several of the New England sites and future management of *H. canadensis* populations should address this factor.

Herbivory

Herbivory is a potential problem at several New England sites. In 1981, Bruce Sorrie (MANHESP) reported that a woodchuck burrow was near the EO at MA .001 (Hingham) and that some leaves of *Hydrastis canadensis* had been grazed. Slugs have been observed at MA .003 (West Stockbridge), CT .002 (Plainville) and CT No EO # (Guilford), and are reported in the literature as pests on *Hydrastis canadensis*. Other suspected herbivores in New England include rabbits, wild turkey, and deer (unpublished field form). Additional research is needed to determine to what extent herbivory is impacting the species.

Collecting from Wild Populations and Removing Plants or Seeds for Cultivation

Hydrastis canadensis is in wide use today as a medicinal plant. Its wholesale value in the United States reportedly increased 600 percent between 1991 and 1996 (Sinclair and Catling 2001). Goldenseal is nearly always collected from the wild, although there is an increasing recognition of the need for cultivated supplies. For potential growers, at least three to six years are required for the plant to reach saleable size; therefore, those in the trade have found collecting to be more economical. There is also a preference for the wild plants because consumers believe them to be more effective. As the demand for goldenseal has increased, its supply has decreased, and there is a perceived risk of species extinction due to the overharvesting of wild populations (Sinclair and Catling 2001). The potential risk to species survival has led to its CITES listing in 1997. CITES regulations require that only propagated *H. canadensis* be exported from the United States and Canada (Federal Register 1999).

The extent to which collecting has impacted the New England populations is not well known; however, collecting may have been the reason for the disappearance of some of the historic populations. In 1986 at MA .001 (Hingham), plants were uprooted, although observers were not certain as to whether they were dug by animals or humans. At CT .001 (Killingworth), one of the owners has noted that some plants have been dug in past years (Albrecht, personal communication). If population sites are revealed to the public, collecting may become even more of a serious threat.

As mentioned previously, there is active interest in the cultivation of *Hydrastis canadensis*, particularly since the CITES listing in 1997. Cultivation of the species initially requires either seed or parts of the root from native populations. Nancy Murray of the

Connecticut DEP Natural Diversity Database Program stated in a 1997 letter to Charles Dane of the U.S. Fish and Wildlife Service that she had been contacted by a number of people interested in “wildcrafting,” which can involve the harvesting of plants from the wild and the replanting of them elsewhere. Root or seed harvesting for cultivation purposes could have negative impacts on marginal populations. Populations established in New England without the knowledge of state biologists could confuse state record keepers and introduce new genes into New England populations. Whether or not this would have negative impacts is unknown.

Logging, Agricultural Activities

Hydrastis canadensis is an obligate forest species and is therefore vulnerable to silvicultural practices such as logging. Forest thinning could be beneficial to populations, but there are concerns about avoiding direct impacts to populations from logging equipment, skid roads, log landings, and the like. Agricultural activities including crop farming and cattle grazing could also devastate populations. Logging and sugaring activities have been documented at sites in both Vermont and Massachusetts. VT .005 (Charlotte) is located within a sugarbush and plastic tubing is installed throughout the site. There are no known problems at the site; however, inadvertent trampling of plants could occur as a result of forest management associated with tapping activities.

DISTRIBUTION AND STATUS

General Status

The global rank of *Hydrastis canadensis* is G4 and its national rank is N4 (The Nature Conservancy and Association for Biodiversity Information 1999), meaning that the species is considered to be “apparently secure” both globally and nationally. In North America, it occurs in a total of twenty-seven states and in Canada it is found in the province of Ontario. It is ranked as S1 in only two states outside of New England, Mississippi and Minnesota, where it is at the western limits of its range. Most other state rankings are S2 (imperiled), S3 (vulnerable) or S4 (apparently secure). In Kansas, Louisiana and Ohio, it is ranked SR (reported in the state but without persuasive documentation to provide a basis for accepting or rejecting the report) and in New Jersey, it is SH (state historic). In *Flora Conservanda* (Brumback and Mehrhoff et al. 1996), *H. canadensis* is ranked as a Division 2 or regionally rare species “with fewer than 20 occurrences (seen since 1970) within New England.” Its Connecticut, Massachusetts, and Vermont rankings are “S1” meaning that there are five or fewer occurrences in the states.

Hydrastis canadensis ranges throughout much of eastern North America from Vermont to southern Ontario, Minnesota and Nebraska, south to Georgia, Alabama and Arkansas. Its range extends westward to Kansas and Oklahoma although the Oklahoma report

is considered questionable (NatureServe 2002). The species is most abundant in Ohio, Illinois, Indiana, and eastern Kentucky, the core of its range (Davis and McCoy 2000). Table 1 and Figure 1 (below) summarize the status and distribution of *H. canadensis* in North America.

Table 1. Occurrence and status of <i>Hydrastis canadensis</i> in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED or UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Alabama (S2)	Arkansas (S?, not listed)	Kansas (SR)	New Jersey (SH)
Connecticut (S1, E): 3 extant and 4 historic occurrences	Illinois (S4)	Louisiana (SRF)	
Delaware (S2)	Indiana (S3)	Ohio (SR)	
Georgia (S2, E)	Iowa (S3)	Oklahoma (SU)	
Maryland (S2, T)	Kentucky (S4)		
Massachusetts (S1, E) 2 extant and 2 historic occurrences	Missouri (S5)		
Michigan (S2, T)	Nebraska (S?)		
Minnesota (S1, E)	Pennsylvania (S4)		
Mississippi (S1)	Tennessee (S3)		
New York (S2, T)	Virginia (S3)		
North Carolina (S2, E)	West Virginia (S4)		
Vermont (S1, E) 3 extant and 2 historic occurrences	Wisconsin (S3S4)		
Ontario (S2)			

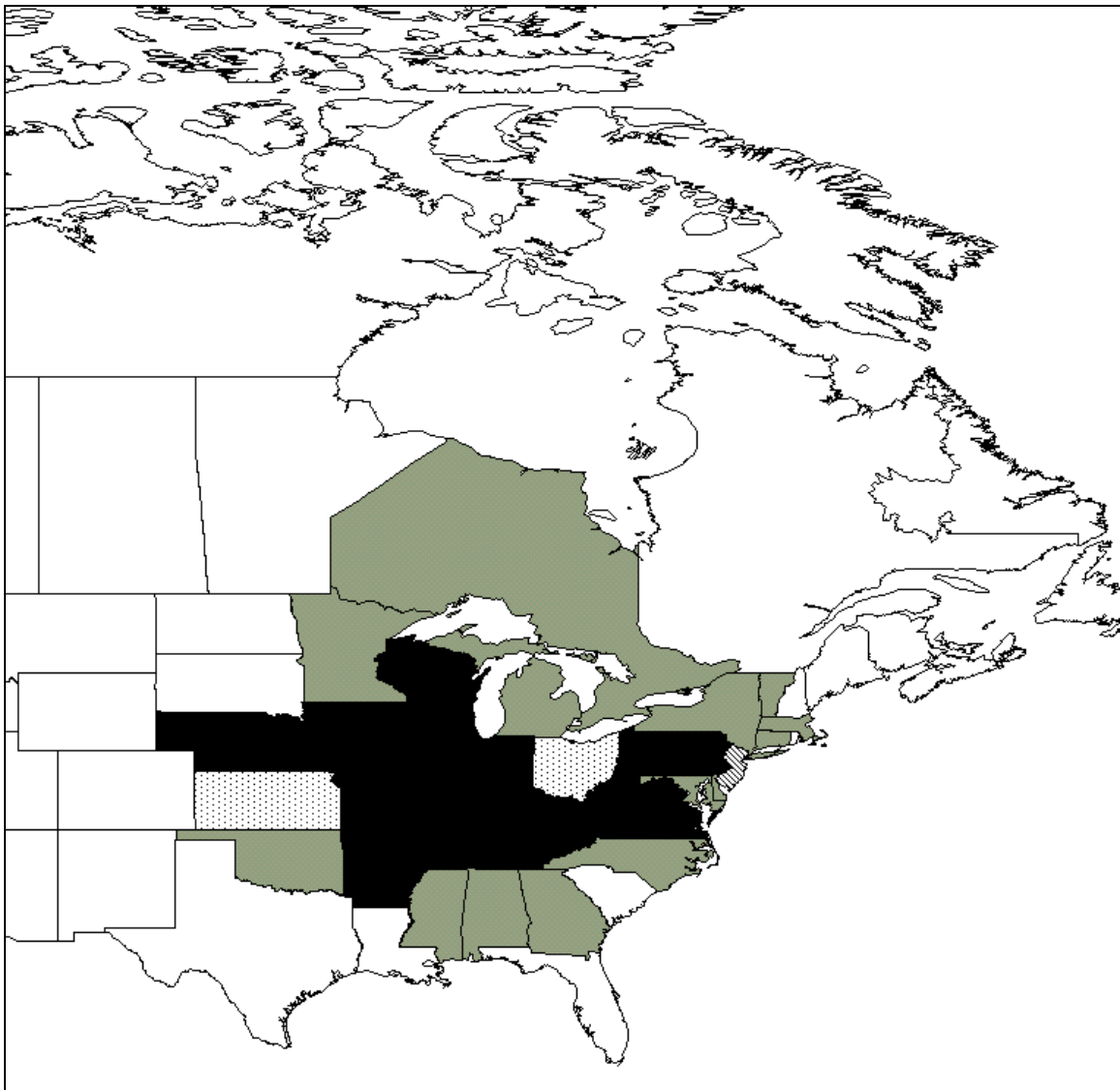


Figure 1. Occurrences of *Hydrastis canadensis* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. The state (New Jersey) with diagonal hatching is designated "historic," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix for explanation of state ranks.

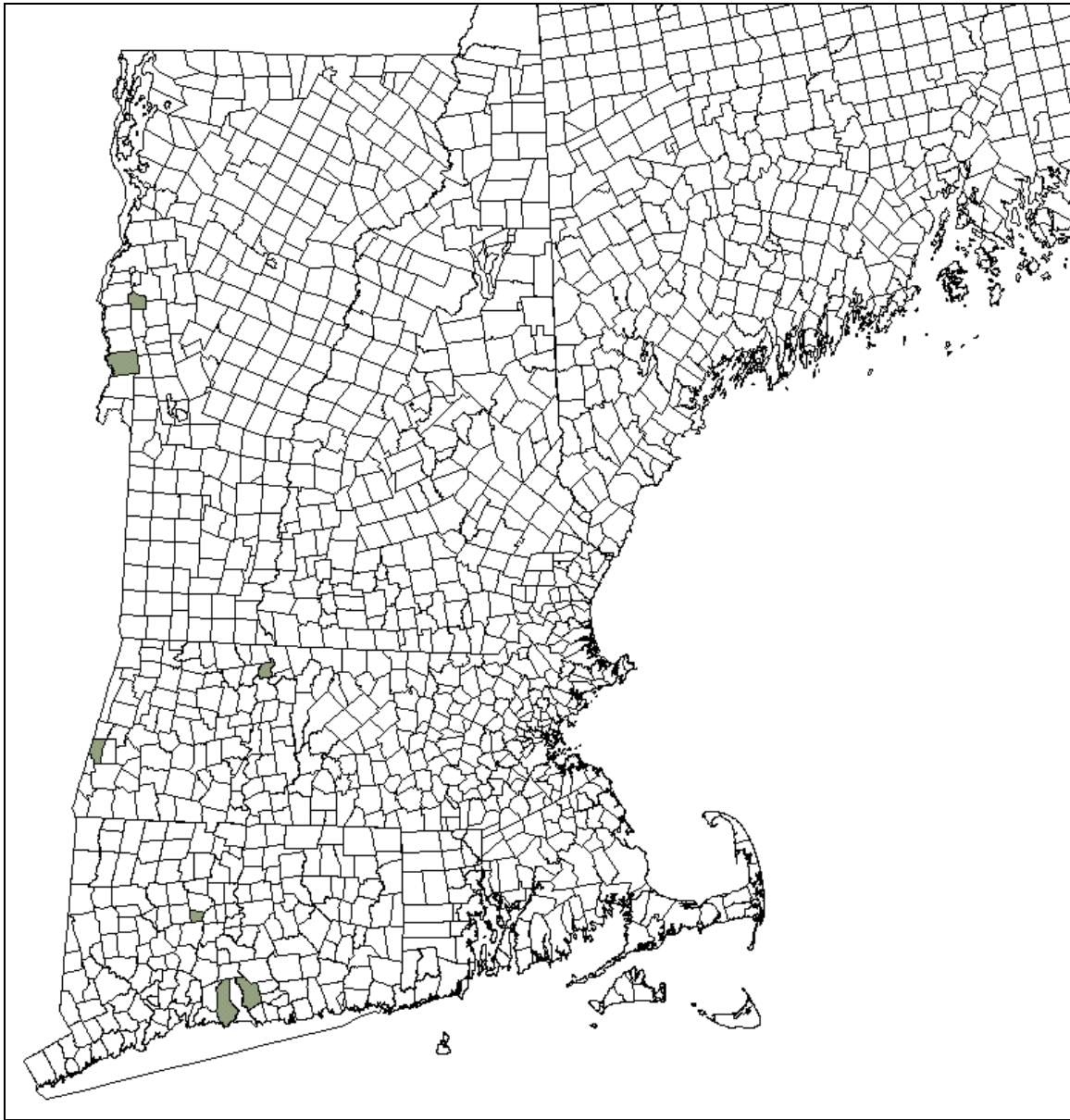


Figure 2. Extant occurrences of *Hydrastis canadensis* in New England. Town boundaries for New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

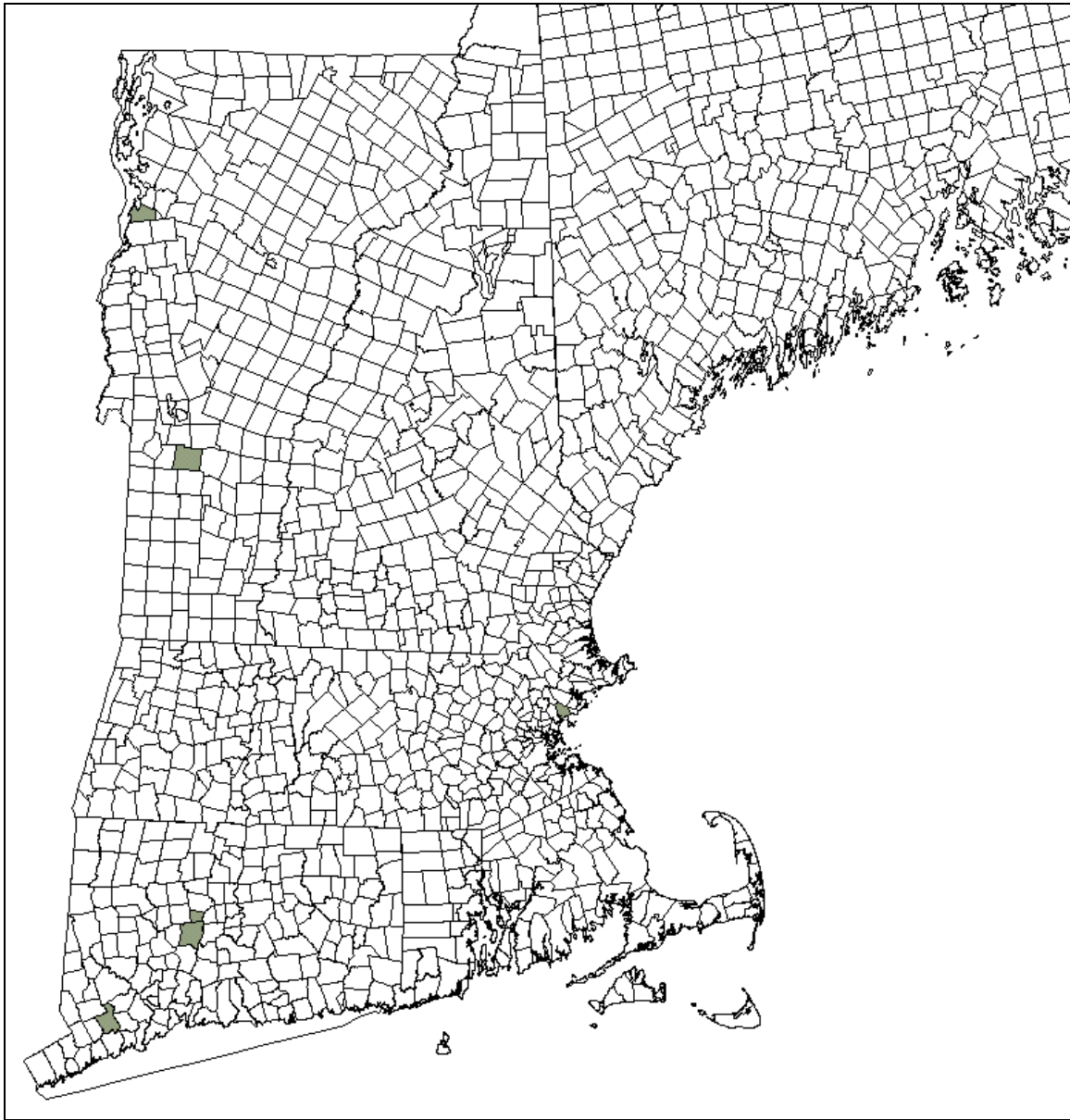


Figure 3. Historical occurrences of *Hydrastis canadensis* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 2. New England Occurrence Records for <i>Hydrastis canadensis</i>. Shaded occurrences are considered extant.			
State	EO Number	County	Town
VT	.001	Addison	Orwell
VT	.002	Rutland	Wallingford
VT	.003	Chittenden	Shelburne
VT	.004	Addison	Weybridge
VT	.005	Chittenden	Charlotte
MA	.001	Plymouth	Hingham
MA	.002	Franklin	Gill
MA	.003	Berkshire	West Stockbridge
MA	.004	Essex	Lynn
CT	.001	Middlesex	Killingworth
CT	.002	Hartford	Plainville
CT	.003	Hartford	Southington
CT	.004	Hartford	Plainville
CT	.005	Hartford	Southington
CT	.006	Fairfield	Easton
CT	No EO #	New Haven	Guilford

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Hydrastis canadensis is a regionally rare, Division 2 species in New England (Brumback and Mehrhoff et al. 1996). Globally, the species is considered to be apparently secure. In New England, eight sites documented by the state Natural Heritage programs have been extirpated and are considered historic. In Vermont, the extant sites have remained relatively stable although one of the sites has recently shown decline. The population in the recently discovered site has not been in the data base long enough to understand trends. In Massachusetts, one population has disappeared within the past two decades, the numbers of a very small population have fluctuated over time, and another population appears to be declining. In Connecticut, of the two long established extant populations, one appears to be declining and the other is beset by a number of potential threats. A recently discovered population was only observed during one growing season; therefore no conclusions can be drawn regarding population trends.

The primary conservation objectives in New England for *Hydrastis canadensis* are to protect and restore vigor to existing populations and to maintain a minimum of ten occurrences. This latter objective would approach the historic levels of *H. canadensis* in New England, thereby ensuring its continued presence as an element of the New England flora. The number ten has been selected somewhat arbitrarily and is based primarily upon historic data regarding occurrences. The number is also based upon the author's opinion of what constitutes a realistic goal. It is envisioned that this objective will be fulfilled primarily through discoveries from *de novo* and record-based searches. The finding of a new populations in Vermont and Connecticut during the summer of 2002 indicates that such discoveries are indeed possible. Suitable habitat for rediscovery of *H. canadensis* is available in Vermont, Massachusetts, and Connecticut. Undisturbed woodlands along the bases of the traprock ridge systems in Connecticut and Massachusetts are potential locales for *de novo* searches as are limestone regions in Vermont, Massachusetts and Connecticut. Populations within the ten occurrences should be maintained at a minimum of 50 to 250 stems for sustainability. This number is based upon the numbers in the most robust of the populations in New England and generalized estimates of minimum viable population sizes for herbaceous perennial species (Falk et al. 1996).

Although each population will require site-specific management, vigor may be restored to declining populations by judicious thinning of the canopy and protection of plants from herbivory. Permanent protection for the species should be provided for all known population sites in New England and for any new sites that may be discovered. Owners of the areas that support the extant populations should be identified and contacted.

III. LITERATURE CITED

- Baskin, C. C. and J. M. Baskin. 2001. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, San Diego, California, USA.
- Bissell, H. 1899 *Hydrastis canadensis* L., a New England plant. *Rhodora* 1: 157.
- Bowers, H. 1891. A contribution to the life history of *Hydrastis canadensis*. *Botanical Gazette* 16: 73-82.
- Brainerd, E. 1899. *Hydrastis canadensis* L. in Vermont. *Rhodora* 1: 200.
- Brumbach W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda: New England*. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.
- Beyfuss, R. L. 1999. Growing Ginseng and Goldenseal in Your Forest. Bulletin of Cornell Cooperative Extension of Greene County, Cairo, New York USA.
- Charette, L. A. 1964. *Hydrastis canadensis* L. in New England. *Rhodora* 66: 94-96.
- Commonwealth of Massachusetts, Executive Office of Environmental Affairs. 2001. BioMap: Guiding Conservation for Biodiversity in Massachusetts. Executive Office of Environmental Affairs, Boston, Massachusetts, USA.
- Cronquist, A. 1981. *An Integrated System of Classification of Flowering Plants*. New York Botanical Garden, Columbia University Press, New York, New York, USA.
- Davis, J. M. 1995. Goldenseal notes. *Hortscience* 30: 789.
- Davis, J. M. 1996. Goldenseal notes. *Hortscience* 31: 673.
- Davis, J. M. and J. A. McCoy. 2000. *Commercial Goldenseal Cultivation*. Department of Horticultural Science, College of Agriculture and Life Sciences, North Carolina State University, Raleigh, North Carolina, USA.
- Dowhan, J. J. and R. J. Craig. 1976. Rare and endangered species of Connecticut and their habitats. *Report of investigations 6*, State Geological and Natural History Survey of Connecticut, the Natural Resources Center, Department of Environmental Protection, Hartford, Connecticut, USA.

Eichenberger, M. D. and G. R. Parker. 1976. Goldenseal (*Hydrastis canadensis* L.) distribution, phenology and biomass in an oak-hickory forest. *Ohio Journal of Science* 76: 204-210.

Falk, D. A., C. I. Millar, and M. Olwell (Editors). 1996. *Restoring Diversity, Strategies for Reintroduction of Endangered Plants*. Island Press, Washington D.C. and Covelo, California, USA.

Federal Register: April 26, 1999 (Volume 64, Number 79) Page 20320-20321. From the Federal Register Online via GPO Access. Available at <http://wais.access.gpo.gov> (accessed November 4, 2002).

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

Flora of North America. 2002. Flora of North America Web Site. Available at <http://hua.huh.harvard.edu/FNA/> (accessed November 4, 2002).

Foster, S., 1991. Goldenseal, *Hydrastis canadensis*, Botanical Series No. 309, American Botanical Council, Austin, Texas, USA.

Foster, S. 2000. Goldenseal's Future. Publication of Stephen Foster Group Fayetteville, Arkansas, USA.

Gagnon, D. D. 1999. A review of the ecology and population biology of goldenseal, and protocols for monitoring its populations. Final report to the Office of Scientific Authority of the U.S. Fish and Wildlife Service. Montreal, Quebec, Canada.

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

Hoot, S. B. 1991. Phylogeny of the Ranunculaceae based on epidermal microcharacters and macromorphology. *Systematic Botany* 16: 741-755.

Lloyd, J. U. undated. *Hydrastis canadensis*. Reproduced by permission of the Western Druggists, Chicago and reprinted from the *Eclectic Medical Journal*, Cincinnati.

Lloyd, J. U. and C. G. Lloyd 1894-1897. Drugs and Medicines of North America. *Hydrastis Canadensis*, Part 1. Bulletin of the Lloyd Library, Bulletin # 30. Lloyd Library and Museum, Cincinnati, Ohio, USA.

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

Mitchell, R. S. and J. K. Dean. 1982. *Ranunculaceae (Crowfoot Family) of New York State*. Contributions to the Flora of New York State IV, Bulletin No. 446. The State University of New York, Albany, New York, USA.

Motten, A. F. 1986. Pollination ecology of the spring wildflower community of a temperate deciduous forest. *Ecological Monographs* 56: 21-42.

NatureServe Explorer: An online encyclopedia of life [web application]. 2001. Version 1.6 Arlington, Virginia, USA: NatureServe. Available at: <http://www.natureserve.org/explorer> (accessed September 1, 2002).

Penskar, M. R., E. G. Choberka and P. J. Higman 2001. Special plant abstract for *Hydrastis canadensis* (goldenseal). Michigan Natural Features Inventory, Lansing, Michigan, USA.

Purdue University. 2002. Purdue University Web Site. Available at <http://www.hort.purdue.edu/newcrop/med-aro/factsheets/GOLDENSEAL.html> (accessed November 4, 2002).

Reznicek, A. A. 1987. Are small reserves worthwhile for plants? *Endangered Species Update* 5: 1-3.

Sanders, S. M. and J. B. McGraw. 2002. Distribution, abundance, and population dynamics of Goldenseal (*Hydrastis canadensis* L.) in an Indiana Nature Preserve, USA. *Natural Areas Journal* 22: 129-134.

Sheldon, J. W., M. J. Balick, and S. A. Laird. 1997. Medicinal plants: can utilization and conservation coexist? *Advances in Economic Botany* 12, New York Botanical Garden Scientific Publication Department, New York, USA.

Sinclair, A. and P.M. Catling. 2000a. Status of Goldenseal, *Hydrastis canadensis* (Ranunculaceae), in Canada. *Canadian Field-Naturalist* 114: 111-120.

Sinclair, A. and P. M. Catling. 2000b. Ontario Goldenseal, *Hydrastis canadensis*, populations in relation to habitat size, paths, and woodland edges. *Canadian Field-Naturalist* 114: 652-655

Sinclair, A. and P. M. Catling. 2001. Cultivating the increasingly popular medicinal plant, Goldenseal: review and update. *American Journal of Alternative Agriculture* 16: 131-140.

Sinclair A., Catling P. M., and Dumouchel, L. 2000. Notes on the pollination and dispersal of Goldenseal, *Hydrastis canadensis* L., in Southwestern Ontario. *Canadian Field-Naturalist* 114: 499-501.

Takhtajan, A. 1969. *Flowering Plants, Origin and Dispersal*. Smithsonian Institution Press, Washington, DC, USA.

Tobe, H. and R. C. Keating. 1985. The morphology and anatomy of *Hydrastis* (Ranunculales): Systematic Reevaluation of the Genus. *The Botanical Magazine, Tokyo* 98: 291-316.

UNEP-WCMC. 2003 *UNEP-WCMC Species Database: CITES-Listed Species*. Available at <http://quin.unep-wcmc.org/isdb/cites/taxonomy/index.cfm> (accessed 3 January, 2003).

Welty, J. C. 1962. *The Life of Birds*. W. B. Saunders Company, Philadelphia, Pennsylvania, USA.

IV. APPENDICES

1. Herbarium Sheets for *Hydrastis canadensis*
2. Additional References Useful in Preparation of the Conservation Plan
3. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe

1. Herbarium Sheets for *Hydrastis canadensis*

HERBARIUM	COLLECTOR	DATE	LOCATION	COMMENTS
Yale University	L. A. Charette (L.A.C., John Daniels and Joyce Bates)	1963-5-18	Addison County, Orwell Township, VT	In Orwell Township, in openings of a mixed woodland off VT State Rte No. 22-A. Forming a pure stand of about 1000 plants in luxuriant condition with at least a quarter of the plants in bloom. See <i>Rhodora</i> 66:94-96. (Note: a reprint of <i>Rhodora</i> article is clipped to specimen).
Yale University	John R. Reeder	1938-5-4	Michigan, Ingham County	Rich woods near E. Lansing
Yale University	S.C. Wadmond	1908-5- 21	Racine Co., Wisconsin	Rare
Yale University	George Vasey	1859-61	Illinois	Menard Co. – E. Hall
Yale University	G.W. Letterman	1887-5-5	Allentown, Missouri	Altitude 500 feet
Yale University	W.E. Safford	1885-7-27	Chillicothe, Ohio	
Yale University	D.C. Eaton	1859-5-7	St. Louis, Missouri	
Yale University	C.J. Wheeler	Undated	Hubbardstown, Michigan	
Connecticut Botanical Society	M. L. Pickhardt	1968-5-15	Cow Hill Road Killingworth	Growing in very black, very loose soil with patches of sphagnum in hollows nearby – stream 10 feet away. Apparently moisture underneath.
Connecticut Botanical Society	M. L. Pickhardt	1968-5-15	Killingworth	Rich woods east of Cow Hill Road, near stream in damp area.
Connecticut Botanical Society	C. H. Bissell	1918-5-12	Plainville	Rocky woods in rich soil, Plainville, CT
Connecticut Botanical Society Connecticut Botanical Society	C. H. Bissell	1898-6-30	Southington	Rich woods, rare. Root from foot of Hanging Hills off Savage Street
Connecticut Botanical Society	C. H. Bissell	1899-5-15	Southington	From plants in grounds of E.R. Newell of which roots had been transplanted from rich woods off Savage Street.

1. Herbarium Sheets for *Hydrastis canadensis*

HERBARIUM	COLLECTOR	DATE	LOCATION	COMMENTS
Torrey Herbarium of the University of Connecticut	H. H. Taylor	1932 5-20	Easton	Rich hillside woods. Was cultivated many years ago and is now spread freely in new areas more or less remote. Most flowers now with pistils only. This plant with 2 stems, the rhizome here split.
Torrey Herbarium of the University of Connecticut	H. H. Taylor	1932-7-9	Easton	Rich, rather dry upland woods. Fruit green, seeds black and ripe. Another similar stem on branch of same rhizome. No root leaves.
Torrey Herbarium of the University of Connecticut	Henry H. Taylor	1933-5-18	Easton	Rich woods, where widely spread from former cultivation.
Torrey Herbarium of the University of Connecticut	Henry H. Taylor	1933-7-12	Easton	Rich woods, where widely spread from former cultivation.
Torrey Herbarium of the University of Connecticut	Henry H. Taylor	1937-9-10	Easton	Rich woods. Fruit mostly fallen, but these somewhat dried and much darker than usual
Torrey Herbarium of the University of Connecticut	Leslie J. Mehrhoff	1989 8-31	Killingworth	Connecticut: Middlesex Co., Killingworth. Woods along creek east of Cow Hill Road.

2. Additional References Useful in Preparation of the Conservation Plan

Bertin, R. I. and O. D. V. Sholes. 1993. Weather, pollination and the phenology of *Geranium maculatum*. *American Midland Naturalist* 129: 52-66.

Braun, E. L. 1950. *Deciduous Forests of Eastern North America*. Hafner Publishing Company, New York, New York, USA.

Clancy, K. 1993. Selected rare and historical vascular plants of Delaware. *Bartonia* 57: 75-92.

McAvoy, W. 1997. Noteworthy native plant collections from the Delmarva Peninsula. *Bartonia* 60: 23-25.

Menges, E. S. 1990. Population viability analysis for an endangered plant. *Conservation Biology* 4: 52-62.

Seymour, F. C. 1969. *The Flora of New England*. First Edition. Charles E. Tuttle Company, Inc., Rutland, Vermont, USA.

USDA, NRCS. 2001. The Plants Database, version 3.1. National Plant Data Center, Baton Rouge, Louisiana 70874-4490 USA. Available at <http://plants.usda.gov> (accessed September 1, 2002).

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

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

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

G1, for example, indicates critical imperilment on a range-wide basis -- that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction -- i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

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

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

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

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