New England Plant Conservation Program

Oxalis violacea L.
Violet Wood-Sorrel

Conservation and Research Plan for New England

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SUMMARY

Violet Wood-Sorrel (*Oxalis violacea* L., Oxalidaceae) is a low-growing herbaceous, self-incompatible perennial that produces violet flowers in May, June and again in September. Reproduction is both sexual (with pollination mostly by bees), and asexual (by way of runners). The species is widely distributed in the United States but is rare in New England. *Oxalis violacea* is an obligate outcrosser: the species is distylous, meaning that there are two flower morphs (pin and thrum), with a given plant producing one morph, not both. Pin flowers are more common than thrum flowers. In New England, the habitat varies from dry to moist, and for populations to remain vigorous forest canopies must remain partially open. Succession, the growth of plants leading to shading, is a factor contributing to decline of *O. violacea* in New England, as are invasive species and habitat fragmentation. Fire benefits this species, in part by removing competitors. Human consumption of the leaves has been reported.

Oxalis violacea has a Global Status Rank of G5, indicating that it is demonstrably widespread, abundant and secure. In Massachusetts, it is ranked as Threatened; five occurrences are current (in four towns among three counties) and 10 are historic. In Connecticut, it is listed as a species of Special Concern; 10 occurrences are current (in ten towns among six counties) and 19 are historic. In Rhode Island, it is ranked as Endangered; four occurrences are current (in three towns among three counties) and two are historic. In Vermont, it is known only from two historic records. In Massachusetts, Connecticut and Rhode Island, there are approximately 30 historic occurrences, mostly in separate towns. In New England, the number of occurrences probably decreased within the last century. However, botanists are regularly discovering new occurrences in Connecticut: seven since 1990.

Emphasis should be placed on maintaining and repeatedly surveying all 19 current occurrences, finding new occurrences, and botanical exploration at historic stations. Management to benefit this species should involve either controlled burns or mechanical canopy thinning and removal of underbrush, where shading due to succession is taking place. A comparison of these two methods is proposed. Private land owners should be contacted and informed, and tax easements for maintenance of occurrences should be negotiated if possible. Cultivation and transplantation is not recommended at this time, given the number of recently discovered populations, and that resources should be put into management to save existing occurrences. However, if the number of occurrences decreases, seeds or bulbs removed from an existing New England population could be used to start cultivated plants, and plants could be transplanted to either: 1) an historical site, or 2) a site where numbers have been dwindling, or 3) a new site selected for its partial canopy providing filtered light, southwest to east-facing aspect, and bedrock of basalt or gabbro. Research investigating the biology of this species and methods of propagation will likely aid future conservation efforts.

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.

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I. BACKGROUND

INTRODUCTION

Violet Wood-Sorrel (*Oxalis violacea* L., Oxalidaceae) grows only in North America, where it is widely distributed (Denton 1973) and is a common member of some prairie communities. Henry D. Thoreau commented about the handsomeness of this species (Thoreau Home Page 2002).

Oxalis violacea lacks upright stems. Some of the scapes (leafless peduncles arising at ground level) are upright and these may, at first inspection, be confused with stems. The leaf stalks (petioles) arise directly from slender horizontal stems at or very near the soil surface. Growth and subsequent rooting of these stems (runners) propagates the plant asexually. A given plant or clone (genet) produces one of two flower morphs. One morph has long styles and shorter stamens, and the other morph has short styles and longer stamens, a condition known as distyly (Figure 1). Distyly serves as an outcrossing mechanism, as does the self-incompatibility exhibited by this species. The corolla is violet, blooming takes place in the spring and again in the early fall in our region (May, June, and September), and pollination is mainly be bees. The leaflets of *O. violacea* fold down for the night and rise back up again for the day (Haddock 2000) as do the leaflets of most *Oxalis* species (Darwin and Darwin 1898).

Living populations of *Oxalis violacea* exist in three New England states: Massachusetts (state status: Threatened); Connecticut (state status: Special Concern); and Rhode Island (state status: Endangered). This species grew in Vermont historically (state status: Historic). Some New England populations of *O. violacea* are threatened by: growth of woody plants causing shading; invasive species; and habitat fragmentation caused by development. Emphasis should be placed on maintaining all 19 current occurrences, finding new occurrences, botanical exploration at historic stations (Table 2; Appendix 2), regular surveys of existing occurrences, and study of the biology of this species.

Oxalis violacea produces small subterranean bulbs that survive fire, and fire benefits the species by removing competitors (Bernhardt 1990, 1993). Management for this species should include controlled burns or mechanical removal of selected woody plants so that the canopy is open enough to provide filtered light, and shading is not caused by understory shrubs. Mechanical killing (with a chain saw) of shrubs and selected trees at known occurrences would partly simulate fire, which may have been important historically in keeping woodlands open. It is likely that at least a few new occurrences will be found if actively sought, suggested by the discovery of seven new occurrences since 1990 in Connecticut.

The purpose of this Conservation and Research Plan is to review the status of and threats to existing populations, and to recommend actions that need to be taken to insure the persistence of *Oxalis violacea* in New England well into the future.

DESCRIPTION

Oxalis violacea is a perennial, herbaceous, colonial, finely stoloniferous, bulbous herb lacking upright stems (see cover illustration and Figure 1). The petioles arise directly from slender horizontal stems at or very near the soil surface. The description below is from Denton (1973), Radford et al. (1964), and Bernhardt (1990); parts are *verbatim*. Petioles are 7-13 cm long and glabrous. Leaflets are 0.6-1.3 cm long (from notch to base), and are sometimes partially purple. The scape is usually glabrous and usually overtops the leaves. Flowers are all chasmogamous. Sepals are 4-7 mm long, glabrous, each with an orange gland at the apex; sepals are sometimes described as "callous-tipped" because of the orange gland. Petals are purple to white and 1-2 cm long. There are 10 stamens, in two whorls; only the outer whorl has nectaries at the base of each filament. The capsule is globose and 4-6 mm long. Seeds are 1-1.5 mm long and 0.8-1 mm wide. The haploid chromosome number is $n = 14$ (Weller and Denton 1976).

Short-styled flower. Stamens of the shorter whorl are (3.5-) 4-5 mm long; the filaments are entire. Stamens of the longer whorl are 4.5-6 mm long; the filaments are entire or slightly appendaged. The gynoecium is 2.5-3.5 mm long; the styles are 0.5-1 mm long and glabrous or with sparse warty non-septate hairs. Stigmas are 0.2-0.4 mm wide.

Long-styled flower. Stamens of the shorter whorl are 2-3 mm long; the filaments are entire. Stamens of the longer whorl are 2.5-3.5 mm long; the filaments are entire, slightly or fully appendaged. The gynoecium is 4.5-6 mm long; the styles are 2.5-4 mm long. Stigmas are 0.2-0.6 mm wide.

There are five species of *Oxalis* in New England (Magee and Ahles 1999). *Oxalis violacea* is easily separated from other *Oxalis* species. In New England, the only somewhat similar species is *O. acetosella* L. (*O. montana* Raf. in some works), which also lacks aboveground stems. *Oxalis acetosella*, however, lacks bulbs and callous-tipped sepals, and peduncles are one-flowered, while *O. violacea* has bulbs, callous-tipped sepals and peduncles are two-to-several-flowered (Fernald 1950). These characters are easily seen on herbarium specimens (Mione, personal observation).

The leaves of *Oxalis violacea* apparently senesce in the late summer or fall; Radford et al. (1964) remarked that late-flowering plants are without foliage. In contrast, the leaves of *O. acetosella* do not senesce synchronously. Some leaves senesce in the spring following the year they were produced, while other leaves survive for far less than one growing season (Mahall and Bormann 1978, J. Tessier, Central Connecticut State University, personal communication).

The leaflets of *O. violacea* exhibit sleep movements, folding down for the night and rising back up again for the day (Haddock 2000). Leaflets of *O. acetosella* do the same (Darwin and Darwin 1898).

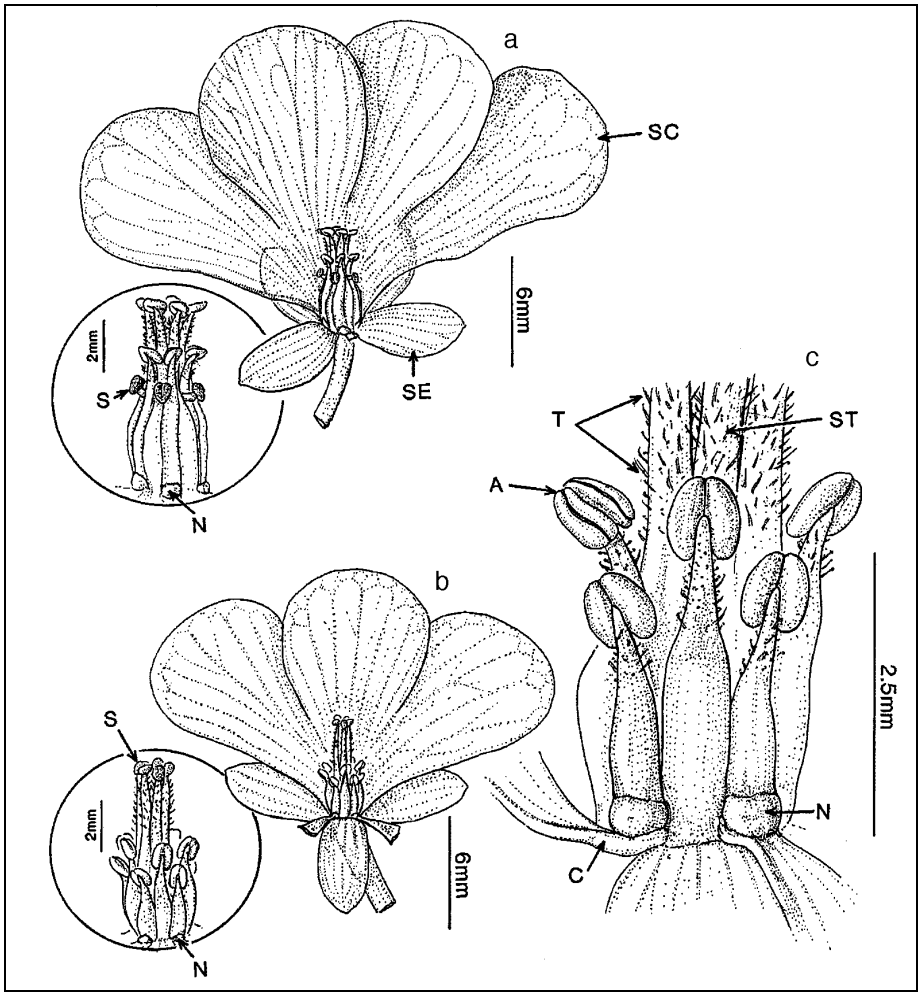

Figure 1. The two floral morphs of *Oxalis violacea*. a. Short-styled flower (note stigmas protruding between staminal filaments). b. Long-styled flowers, petals removed to expose reproductive organs and nectaries. c. Relationship of styles, androecium, nectaries and petal claws in the long-styled flower. Key to symbols: A - Dehiscent anther, C - petal claw, N - nectary, S - stigma, SC - subcoalescent corolla, SE - sepal, ST - style, T -trichomes. (Illustration by John Myers, reprinted with permission from Dr. Peter Bernhardt and Springer-Verlag; from *Plant Systematics and Evolution*, volume 171, page 150, 1990).

No mention of cleistogamy has been found for *Oxalis violacea*, and Radford et al. (1964) commented that all flowers are chasmogamous. In contrast, *O. acetosella* produces both chasmogamous and cleistogamous flowers, producing most of its seeds from cleistogamous flowers (Eiten 1963, Packham 1978).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Oxalis violacea L. (Oxalidaceae) was described by Linnaeus in 1753. The following Latin names are listed as synonyms of *O. violacea* by Denton (1973) in her monograph of the North American species of *Oxalis* section *Ionoxalis*.

Acetosella violacea (L.) Kuntze. 1891.
Ionoxalis violacea (L.) Small. 1903.
Oxalis violacea L. forma *albida* Fassett. 1933.
Oxalis violacea L. var. *trichophora* Fassett. 1937.
Ionoxalis violacea (L.) Small var. *trichophora* (Fassett) Moldenke. 1943.

Thus, Denton (1973) did not recognize intraspecific categories for *Oxalis violacea*. In earlier works, Fernald (1950) and Steyermark (1963) recognized O. *violacea* var. *violacea* f. *albida*, *O. violacea* var. *violacea* f. *violacea*, and *O. violacea* var. *trichophora*. In recent floras of our region, neither Seymour (1982), Gleason and Cronquist (1991) nor Magee and Ahles (1999) recognized intraspecific categories.

Some bulbous *Oxalis* specimens collected in the Andes are sometimes identified as *O. violacea* (e. g., Rusby 1889) but recent authorities have identified these as *O. debilis* var. *corymbosa* (E. Emshwiller, Field Museum of Chicago, personal communication).

Mention of hybridization with related species has not been found, and so it appears that hybridization does not complicate the taxonomy or the identification of this species.

SPECIES BIOLOGY

Reproduction

Oxalis violacea reproduces both asexually and sexually, and is described as clonal and colonial because of asexual reproduction (Radford et al. 1964, Bernhardt 1990). Small subterranean bulbs produce fine stolons. When plants go dormant, it is the bulbs that survive, and as a consequence this species has been described as a geophyte in Raunkiaer's life form classification (Withrow 1932). The bulbs survive fire, and populations subjected to prescribed burns flower more prolifically compared to nearby unburned populations (Bernhardt 1990, 1993). Populations are capable of increasing in size by both stolons and seeds (Bernhardt 1990). The small subterranean bulbs are able to survive plowing (Rice and Penfound 1954); thus movement of the bulbs by seasonal running water or digging animals may increase the area occupied by a population.

In addition to reproducing asexually, *Oxalis violacea* is assumed to reproduce sexually because seeds are produced (studies testing for agamospermy or documenting seed dispersal

and/or dormancy were not found for this species). In southwestern Illinois, 28 species of insects, mostly small bees, visited *O. violacea* during eight nonconsecutive days (Robertson 1893). Hilty (2002) provides an extensive list of insects that visit the flowers of *O. violacea* in Illinois, including numerous species of both long-tongued and short-tongued bees, and one species each of fly, butterfly, skipper and beetle. According to Hilty, beetles feed on pollen but are non-pollinating. Bernhardt (1990) documented visits by insects of three orders (Hymenoptera, Diptera, Lepidoptera), with bees being the primary pollinators. Thus, *O. violacea* is not specialized for pollination by one or a few insect species, and relies primarily on bees for pollination.

Oxalis violacea is distylous (Figure 1; Trelease 1882 1892, Denton 1973). In *Oxalis* section *Ionoxalis,* distyly evolved from tristyly (Ornduff 1964, Weller and Denton 1976). Eiten (1963: 284) reported that a midstyled form is "very rare," but Bernhardt (1993: 80) reported that the "missing third form" has not been seen during over 100 years of botanical exploration in the Midwest. Multiple herbarium specimens of *O. violacea* must be studied for distyly to be evident (Mione, personal observation), because each genet would be expected to produce flowers of one morph (pin or thrum), not both. On living plants, Trelease counted 81 flowers: 51 were long-styled with shorter stamens and 30 were short-styled with longer stamens. Similarly, Bernhardt (1990) counted 117 umbels: 72 had flowers with long styles and 45 had flowers with short styles. Thus, long-styled (pin) colonies appear to be more common and/or more floriferous than short-styled (thrum) colonies. In a Kansas population, long-styled flowers were more likely to produce capsules, and only 13 to 17% of flowers formed capsules (Bernhardt 1990). Robertson (1893) pointed out that the long-styled form will not spontaneously self-pollinate, but the short-styled form may self-pollinate if pollen falls on the stigmas. *Oxalis violacea* is self-incompatible (Bernhardt 1990), as are heterostylous species in general (Proctor et al. 1996), and so short-styled flowers probably rarely, if ever, self-fertilize.

Nectaries are located at the base of the filaments, on only the outer whorl of stamens, on both pin and thrum flowers (Bernhardt 1990). Nectaries produce nectar that serves as a reward to pollinators (Trelease 1882, Berhardt 1990). Styles of the short-styled morph curve, so that the stigmas are positioned where they can be contacted by the bodies of visiting insects (Bernhardt 1990).

Oxalis violacea is reported to be self-incompatible, as mentioned. However, stigma compatibility has not been assessed in New England and self-incompatibility reported from one part of a large distribution cannot be assumed to exist everywhere (e.g., Rick et al. 1979). Mixed compatibility has been found within numerous angiosperm species (B. Igic, University of California, personal communication) but the breakdown of heteromorphic incompatibility is quite rare (K. Holsinger, University of Connecticut, personal communication).

Floral Phenology

In New England, flowering takes place in May, June and September (Mione, personal observation of herbarium specimen labels). In the Carolinas, *Oxalis violacea* flowers April through May, and again in August through October; flowering is sporadic (Radford et al. 1964). In southwest Louisiana, *O. violacea* flowers in "late winter to early spring and again in fall" (Allen and Vidrine 2002). The Missouri Botanical Garden (2002) reports that flowers "appear in the spring" and "a repeat bloom will sometimes occur in the fall." Thus, vernal and autumnal flowering is characteristic of this species.

Pathogens

Various *Oxalis* species, including *O. violacea*, serve as one of two alternating plant hosts to fungal rusts; maize often serves as the other host (Eiten 1963). Arthur and Fromme (1920, cited in Eiten 1963) reported aecia (a cuplike structure in which fungal spores are produced) on *O. violacea*. Eiten (1963), however, surveyed 112 herbarium specimens of *O. violacea* and found no aecia. Eiten concluded that aecia are infrequent even on species that can produce them. Alternate stages of another rust were found on *O. violacea* and *Berberis repens* in the Sandia Mountains of New Mexico (Long and Harsch 1918).

Uses for Food, Medicine, and Horticulture

Leaves of *Oxalis violacea* can be added to a salad or an omelet but should be consumed only in moderation because of the oxalic acid they contain (McPherson and McPherson 1977). As well, leaves may be cooked as a potherb (Facciola 1990). Native American children ate the leaves, flowers, and bulbs (Yanovsky 1936). As well, Native Americans used *O. violacea* as an anthelmintic, antiemetic, as a "blood medicine," to treat early stages of cancer, and to treat hook worms (Moerman 1998). Some groups of Native Americans fed bulbs to horses to make them run faster (Moerman 1998). *Sturtevant's Edible Plants of the World* merely lists this species as "edible" (Hedrick 1972).

Oxalis violacea can be grown in the "woodland garden in moisture-retentive, humus-rich soils with shade or dappled sunlight" (Huxley 1992) and in "rock gardens, border fronts, native plant gardens or naturalized plantings" (Missouri Botanical Garden 2002).

HABITAT/ECOLOGY

In New England, the habitat of *Oxalis violacea* varies from dryish to moist, is almost always forested, and receives filtered light through trees. For example, an herbarium specimen collected at MA .003 (South Hadley) reads "dry rocky lower slopes in semi-shaded to open

areas" (*Sorrie & Rohman 1945* NEBC). A specimen from Hadley/South Hadley, MA was collected in "wet pockets of open ledge, south slope" (*Hubbard & Torrey 339*, Appendix 2). Similarly, for one Massachusetts locality, the habitat is described as "a steep and very rock site…. in the configuration of water runoff" (Williams 1990; MA .005 [Holyoke]). In the *Flora of the Northeast*, the habitat is described as "rich, moist to dry woods" (Magee and Ahles 1999). A specimen from New London, Connecticut, may be the only New England specimen collected from a treeless area, although this is not known with certainty; it was collected from "open moist ground" (*Graves* s.n. GH). Gleason (1968) described that habitat as "dry upland woods and prairies." This statement was repeated in Gleason and Cronquist (1991), which treats a region that extends from New England out to the Midwest. Although the New England habitat is rarely treeless, *O. violacea* grows in treeless habitats throughout much of its range (e.g., Cedar Glades in Kentucky [Baskin and Baskin 1978]; Curtis Prairie, Wisconsin [Anderson and Schelfhout 1980]; Konza Prairie, Kansas [Bernhardt 1993]; Cajun Prairie of Louisiana [Allen and Vidrine 2002]; southeast corner of North Dakota [Northern Prairie Wildlife Research Center 2002]).

Elevation

The elevation of *Oxalis violacea* varies from 30 to 3100 meters throughout its range (Denton 1973), and from 1 to 274 meters of elevation in New England. Some occurrence records lack elevation data, and only two herbaria were visited; sampling more specimens (at additional herbaria) might increase the known elevational range in New England.

Aspect

In New England, the aspect is South, Southwest, Southeast, East-Southeast or East, when specified on Element Occurrence Reports (EORs) and specimen labels. At five occurrences, the aspect is South, Southwest or Southeast (MA .001 [Concord], MA .002 [Concord], MA .003 [South Hadley], CT .002 [Derby], and an MA herbarium specimen *Hubbard & Torrey 339*, Appendix 2). At two occurrences, the aspect is East-Southeast or East (MA .005 [Holyoke], CT without number [Granby]). Of course, "aspect" is not applicable when "flat," "flood plain" or "summit of a hill" was recorded (RI .001 [Jamestown], CT .001 [Middletown], CT .004 [Woodbury], respectively). In summary, the aspect varies, but has not been reported as North, Northwest, Northeast nor West. Apparently, *Oxalis violacea* occupies relatively warm sites at the northern edge of its range.

Soil pH and Bedrock

At several New England occurrences, the underlying bedrock is basalt (Williams 1990, New England Botanical Club 1997; Mione, personal observation of herbarium specimen

labels). Soils derived from basalt tend to be less acidic than most New England soils. However, the soil at a given locality may be associated with the bedrock several kilometers to the north (or north-northwest or north-northeast) because of movement by glaciers of the parent material from which the soil is derived (C. Dimmick, Central Connecticut State University, personal communication). Thus, soil pH and underlying bedrock are not always associated. In New York, *Oxalis violacea* seems to prefer circumneutral soils and bedrock (S. Young, New York Natural Heritage Program, personal communication). In Missouri, Steyermark (1931) found *O. violacea* growing in subalkaline soil of a limestone hill, where he measured a pH of 8.45. In contrast, other characterizations of the soils on which *O. violacea* grows are: "usually acid soils" (Steyermark 1963) and "dryish, acidic soils" (Missouri Botanical Garden 2002). I measured a pH of 5.7 at CT .009 (Cromwell; with a Shindengen digital pH meter, model KS701), and a pH of 5.6 was recorded at CT .010 (Windham) according to the Element Occurrence Record (EOR).

Associated Species

From EORs and correspondence with W. Moorhead (Consulting Botanist), I made a matrix of all taxa listed as being associated with *Oxalis violacea* (historic and extant) at the 12 occurrences for which data were available, and made a tally of how many occurrences at which each taxon was observed, taking into account synonyms. *Acer saccharum* and *Ostrya virginiana* were reported at five occurrences, and so were the most common associates. The following species were reported at four occurrences: *Fraxinus americana, Quercus rubra, and Toxicodendron radicans*. The following taxa were reported at three occurrences: *Arisaema triphyllum, Carex pennsylvanica, Carya glabra, Carya ovata, Carya* sp., *Celastrus orbiculatus, Oxalis stricta, Rosa caroliniana,* and *Solidago caesia.* The following taxa were reported at two occurrences: *Acer rubrum, Aquilegia canadensis, Aster divaricatus, Cornus florida, Elymus hystrix, Geranium maculatum, Lonicera morrowii, Maianthemum canadense, Parthenocissus quinquefolia, Poa compressa, Prunus serotina, Quercus* sp., *Solidago arguta,* and *Viola tribola*. One hundred and one species were reported from a single occurrence each.

THREATS TO TAXON

Shading and Invasive Species

Shading and invasive species are contributing to the decline and loss of some populations. Shading is caused by closure of the canopy during succession, and more generally by the growth of vegetation in semi-open habitats. The problem of shading and/or the need for canopy thinning was described in EORs for MA .001 (Concord), MA .002 (Concord), MA .005 (Holyoke), MA .015 (Granby), and was implied on RI .005 (Jamestown). Pruka (1997) lists *Oxalis violacea* among the species that are "best indicators" in Wisconsin of savannas (10

to 50% canopy) or former savannas, and open woodlands (50 to 80% canopy) or former open woodlands. He adds that where the forest canopy is closed, the presence of light-dependent understory species such as *O. violacea* indicates recent closure of the canopy (Pruka 1997). *Celastrus orbiculatus*, an invasive species, shades populations at MA .002 (Concord) and is encroaching at CT .009 (Cromwell). Competition by invasive species almost certainly contributed to the recent, probable extirpation of both MA .001 (Concord) and RI .005 (Jamestown). In Great Smoky Mountains National Park, some populations of *O. violacea* are disturbed by rooting by the European wild boar (Bratton 1974).

Lack of Fire

After fire, *Oxalis violacea* grows luxuriantly (Bernhardt 1993). In New England, suitable habitats for *O. violacea* may have been maintained by fire. It is likely that fires were more frequent historically than during the last century in New England. Indians regularly burned near their villages (Cronon 1983). Because the fires were frequent, little dead plant matter accumulated between burnings; fires were of low intensity and did not kill trees. Some trees were deliberately killed with fire to clear for agriculture. In eastern Massachusetts, colonists generally described the forest as open oak woodland (Cronon 1983). Suppression of fire has been the policy of the U. S. government for most of the twentieth century (Gurevitch et al. 2002).

Development

At two historic occurrences (MA .007 [Waltham], MA .013 [Lincoln]), development may have destroyed the habitat where *Oxalis violacea* once grew. Historically, in New England we can be reasonably sure that each population lasted a few years to a few centuries, and gave rise to some number of new populations at new locations before dying out. Development, by destroying potential habitat and fragmenting the landscape, is potentially limiting the ability of this species to become established at new localities in New England. Fragmentation of landscapes results in an increased dependence on relatively rare long-distance dispersal events (Kutner and Morse 1996). Habitat destruction and fragmentation are probably part of the cause of the decline of *O. violacea* in New England.

Foot Traffic

Foot traffic was described as a problem at MA .003 (South Hadley) and CT .002 (Derby). At the latter occurrence, plants were described as being trampled by deer and people.

DISTRIBUTION AND STATUS

General Status

Oxalis violacea is widely distributed in the United States (Figure 2), occurring (currently or historically) in 41 states (Natureserve Explorer 2001, Table 1). Having a Global Status Rank of G5 and a National Status Rank of N5? (Natureserve Explorer 2001) the species is demonstrably widespread, abundant and secure. The question mark that follows the National designation presumably indicates some degree of uncertainty about this designation. Outside of New England, *O. violacea* is described as common on Ordovician limestone of cedar glades in the Central Basin of Tennessee (P. Somers, Massachusetts Natural Heritage and Endangered Species Program, personal communication). It is uncommon to fairly common at several localities in the Mississippi Valley (Benke 1932). It is common in the vicinity of Fargo, North Dakota and adjacent Minnesota (Stevens 1921). *Oxalis violacea* is common in open parts of the woods in southeastern Missouri (Uphof 1922), and rare on the margins of fens in Northeastern Iowa (Nekola 1994). Thus, this species is widely distributed, and common or rare, depending on the region and habitat.

In New England, the following number of current occurrences are known in each state: five in Massachusetts, ten in Connecticut, and four in Rhode Island (Figure 3). Vermont has one historic and one other possible historic occurrence, and a designation of SH (known from historical records only) (Vermont NonGame and Natural Heritage Program 1996) (Figure 4). In New England, *Oxalis violacea* is listed as Division 2, indicating that the taxon is regionally rare and fewer than 20 current occurrences have been documented within New England since 1970 (Brumback and Mehrhoff et al. 1996). *Oxalis violacea* has the following official state-level endangerment statuses in New England: Massachusetts, Threatened (Sorrie 1987, Szczebak et al. 1999); Rhode Island, Endangered (R. Enser, Rhode Island Natural Heritage Program, personal communication); and Connecticut, Special Concern (Connecticut Department of Environmental Protection 2002). *Oxalis violacea* does not occur in Maine (it is not listed in the *Flora of Maine*, Haines and Vining 1998), nor does it occur in New Hampshire (Natureserve Explorer 2001).

Table 1. Occurrence and status of *Oxalis violacea* in the United States and Canada based on information from Natural Heritage Programs and NatureServe 2002.

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Connecticut (S2, SC): 10 current and 19 historic (Appendix 2)	Delaware (S4)	Alabama (SR). Quite common throughout state (A. Schotz, Alabama Natural Heritage Program, personal communication)	Vermont (SH): 2 historic
Massachusetts (S1, T): 5 current and 10 historic (Table 2 and Appendix 2)	District of Columbia (S?)	Arizona (SR)	
Michigan (S1)	Georgia (S4, J. Allison and T. Patrick, Georgia Natural Heritage Program, personal communications)	Arkansas (SR)	
New York (S2): 11 current and 30 historic (S. Young, New York Natural Heritage Program, personal communication)	Illinois (S?)	Colorado (SR)	
Rhode Island (S1, E): 4 current and 2 historic	Iowa (S4)	Florida (SR)	
	Kansas (S5, C. Freeman, McGregor Herbarium, personal communication)	Indiana (SR)	
	Kentucky (S5, N. Drozda, Kentucky State Nature Preserves Commission, personal communication)	Maryland (SR). Common in the ridge and valley province in a variety of woodland habitats and occurs somewhat sparingly as far east as the coastal plain over calcareous substrates (C. Frye, Maryland Natural Heritage Program, personal communication)	

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OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
	Louisiana (S5, C. Reid, Louisiana Natural Heritage Program, personal communication)	Minnesota (SR). Fairly common (A. Cholewa, Bell Museum of Natural History, personal communication)	
	Nebraska (S5, G. Steinauer, Nebraska Natural Heritage Program, personal communication)	Mississippi (SR)	
	New Jersey (S3S4)	Missouri (SR)	
	New Mexico (S5, P. Tonne, New Mexico Natural Heritage Program, personal communication)	North Dakota (SR)	
	North Carolina (S4)	Ohio (SR)	
	Pennsylvania (S?)	Oklahoma (SR). Not uncommon (A. Buthod, Oklahoma Biological Survey, personal communication).	
	Tennessee (S5, C. Bailey, Tennessee Division of Natural Heritage, personal communication)	Oregon (SR)	
	Texas (S5, J. Poole, Texas Parks and Wildlife Department, personal communication)	South Carolina (SR)	
	Virginia (S5, J. Townsend, Virginia Department of Conservation and Recreation, personal communication)	South Dakota (SR)	
	West Virginia (S?)	Wisconsin (SR)	
	Wyoming (SE)		

Figure 2. Occurrences of *Oxalis violacea* in North America. States 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. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified) or "SE" (status exotic, Wyoming). See Appendix 3 for explanation of state ranks.

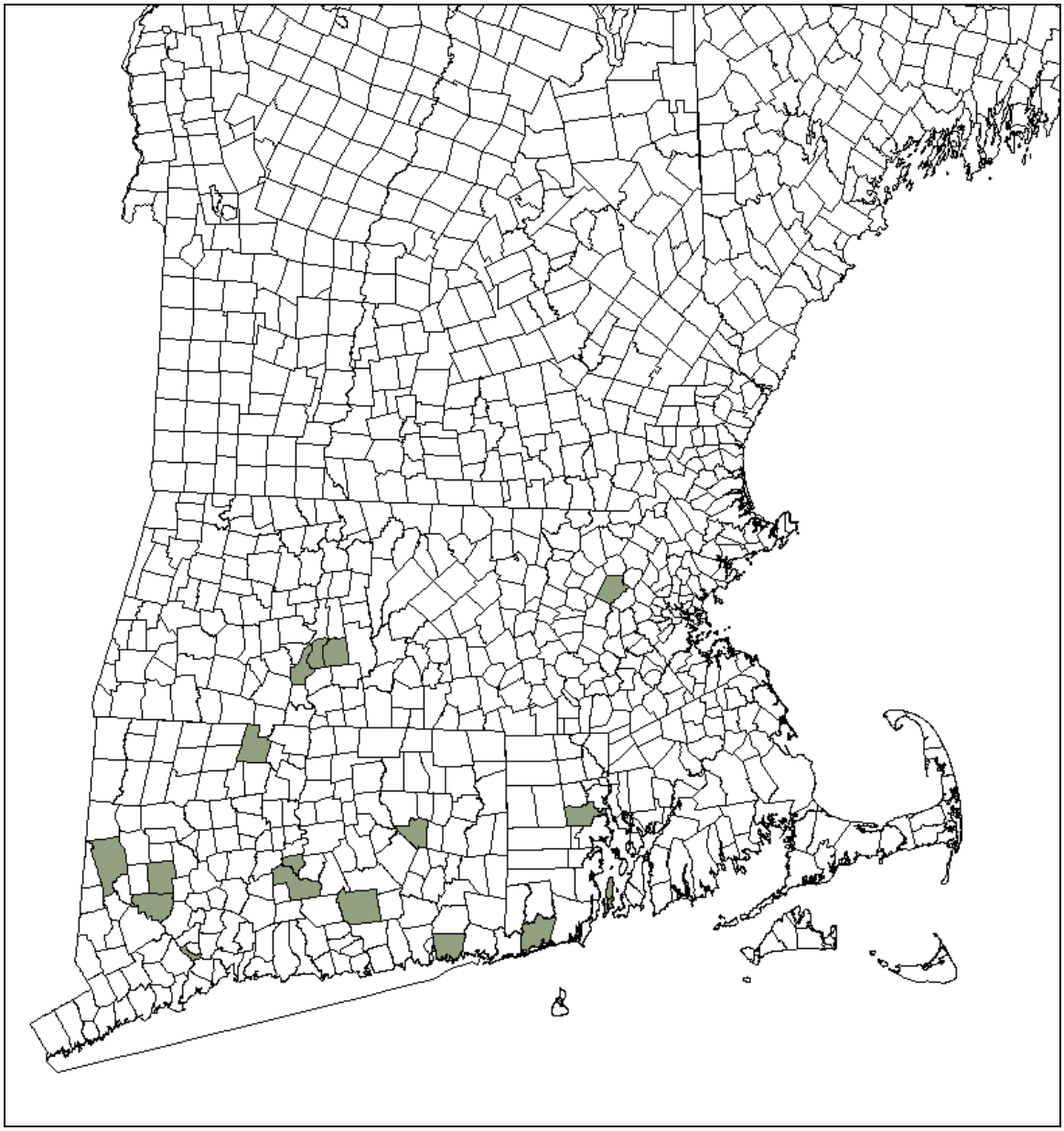

Figure 3. Extant occurrences of *Oxalis violacea* in New England. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five confirmed, current occurrences of the taxon.

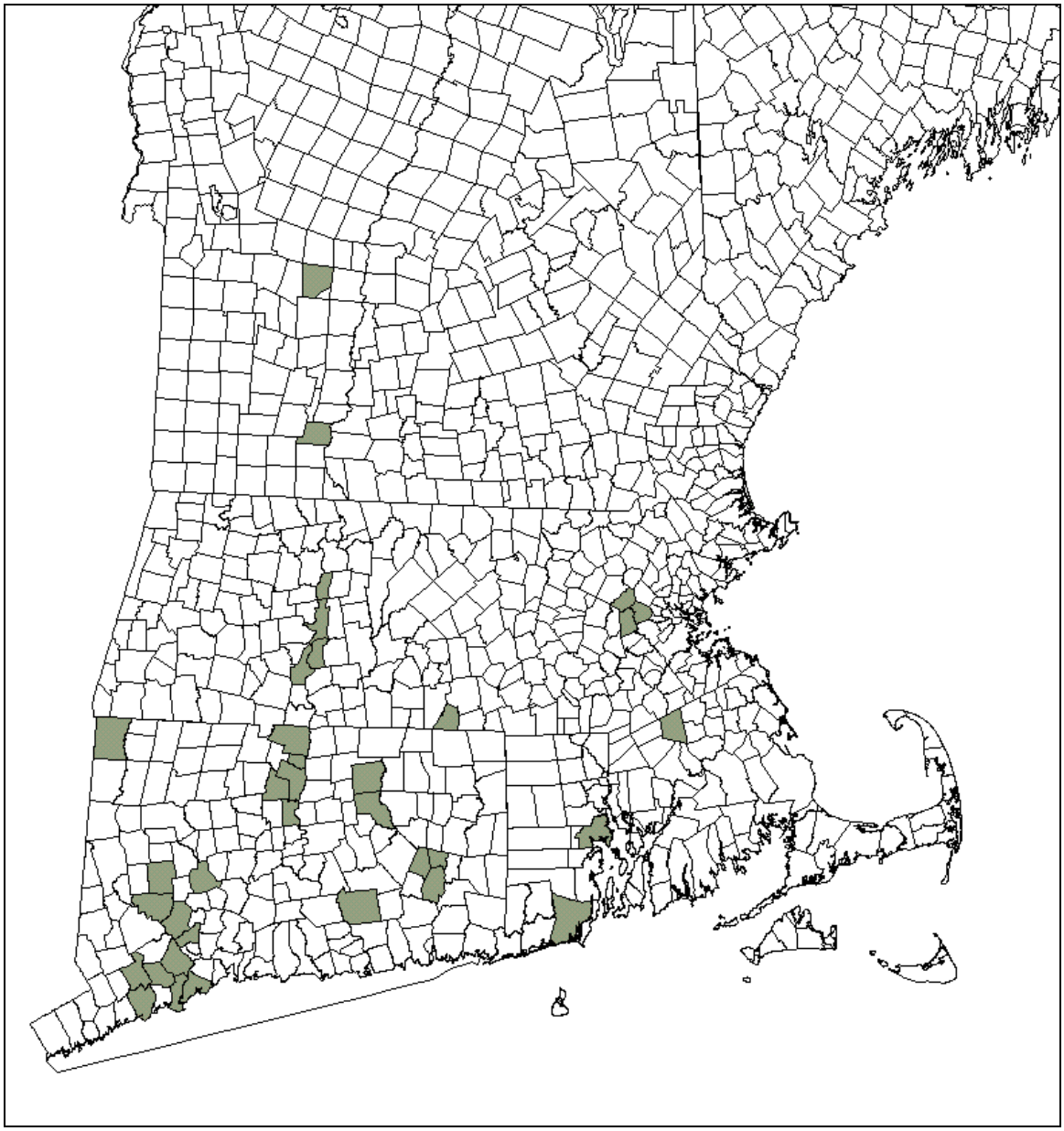

Figure 4. Historic occurrences of *Oxalis violacea* in New England. Towns shaded in gray have one to five historic records of the taxon.

All occurrences tracked by New England state Natural Heritage Programs are summarized in Table 2 below.

Table 2. New England Occurrence Records for *Oxalis violacea*. Shaded occurrences have been seen since 1975. Occurrences that are both historic and lack occurrence numbers are listed in Appendix 2.

State	EO #	County	Town
VT	.001	Windsor	Cavendish
MA	**.001**	**Middlesex**	**Concord**
MA	**.002**	**Middlesex**	**Concord**
MA	**.003**	**Hampshire**	**South Hadley**
MA	**.005**	**Hampden**	**Holyoke**
MA	.006	Hampshire	Hadley
MA	.007	Middlesex	Waltham
MA	.008	Hampden	Holyoke
MA	.009	Worcester	Southbridge
MA	.010	Middlesex	Weston
MA	.011	Franklin	Sunderland
MA	.012	Essex	Ipswich
MA	.013	Middlesex	Lincoln
MA	.014	Bristol	Easton
MA	**.015**	**Hampshire**	**Granby**
RI	**.001**	**Newport**	**Jamestown**
RI	.002	Washington	South Kingstown
RI	.003	Kent	Warwick
RI	**.004**	**Washington**	**Charlestown**
RI	**.005**	**Newport**	**Jamestown**
RI	**.006**	**Providence**	**Scituate**
CT	**.001**	**Middlesex**	**Middletown**
CT	**.002**	**New Haven**	**Derby**
CT	**.003**	**Middlesex**	**East Haddam**
CT	**.004**	**Litchfield**	**Woodbury**
CT	**.007**	**New Haven**	**Southbury**
CT	**.008**	**New London**	**Groton**
CT	**.009**	**Middlesex**	**Cromwell**
CT	**.010**	**Windham**	**Windham**
CT	**New**	**Litchfield**	**New Milford**
CT	**New**	**Hartford**	**Granby**

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Oxalis violacea is widespread in North America: it is distributed from New England to North Dakota, and south to Florida and Arizona. This species is common in parts of its widespread range but is rare in New England. We can be reasonably sure that it has never been common in New England, but is apparently now more rare than in centuries past. *Oxalis violacea* may have increased with burning by Native Americans, and may have declined with increased shading in the absence of fire.

The primary conservation objectives for *Oxalis violacea* in New England are as follows.

1) **Maintain all 19 existing occurrences.** This species thrives after fire, and so management to benefit this species should involve controlled burns and/or mechanical canopy thinning and mechanical removal of shrubs, wherever shading due to succession is closing the canopy. We do not yet know how best to maintain existing occurrences, and so I propose an experiment to determine the best management practice (see "Habitat or site management" on the following page).

2) **Land ownership should be determined** for occurrences for which site ownership is currently unknown. Private land owners should be contacted and met for discussion, and easements for maintaining occurrences should be negotiated where possible.

3) **Two historic occurrences should be investigated every year** for possible rediscovery. Botanical surveys should be encouraged because living plants may exist at historic localities and discovery of new occurrences is possible. Investigating historic occurrences may provide a better understanding of the reasons for the loss of populations.

4) **All current occurrences should be surveyed every other year**.

5) **Consider reintroduction or translocation if the number of current occurrences drops below 19 by 2023.** Cultivation and reintroduction are not essential at this time in part because: a) seven new occurrences of *Oxalis violacea* have been discovered in New England since 1990, and b) resources should be put into management to save existing occurrences.

III. LITERATURE CITED

Allen, C. M. and M. F. Vidrine. 2002. Flowering phenology of Cajun Prairie Plants. Abstract submitted for the 2002 North America Prairie Conference, Kirksville, MO. Available at http://www.napc2002.org/abstracts.htm (Accessed: June 10, 2002).

Anderson, R. C. and S. Schelfhout. 1980. Phenological patterns among tallgrass prairie plants and their implications for pollinator competition. *American Midland Naturalist* 104: 253-263.

Anonymous. 1899. On the plants introduced by Minot Pratt at Concord, Massachusetts. *Rhodora* 1: 168-172.

Baskin, J. M. and C. C. Baskin. 1978. Plant ecology of cedar glades in the big barren region of Kentucky. *Rhodora* 80: 545-557.

Benke, H. C. 1932. Earliest spring-flowering plants. *The American Midland Naturalist* 13: 89-109.

Bernhardt, P. 1990. Pollination ecology of *Oxalis violacea* (Oxalidaceae) following a controlled grass fire. *Plant Systematics and Evolution* 171: 147-155.

Bernhardt. P. 1993. *Natural Affairs: A botanist looks at the Attachments Between Plants and People*. Villard Books, a division of Random House, Inc., New York, USA and Toronto, Canada.

Bertin, R. I. 2000. *Vascular Flora of Worcester, Massachusetts.* Special Publication of the New England Botanical Club. Special Publications Committee, New England Botanical Club, Harvard University Herbaria, 22 Divinity Ave., Cambridge, MA 02138-2020.

Bratton, S. P. 1974. The effect of the European wild boar (*Sus scrofa*) on the high-elevation vernal flora in Great Smoky Mountains National Park. *Bulletin of the Torrey Botanical Club* 101: 198-206.

Brumback, W. E. and C. W. Fyler 1996. Small whorled pogonia (*Isotria medeoloides*) transplant project. Pages 445-451 in D. A. Falk, C. I. Miller and M. Olwell (Editors), *Restoring Diversity: Strategies for Reintroduction of Endangered Plants.* Island Press, Washington, D. C., USA.

Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New

England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.

Connecticut Department of Environmental Protection. 2002. Endangered, Threatened & Special Concern Species. Available at http://dep.state.ct.us/cgnhs/nddb/species.htm (Accessed: June 10, 2002) and http://dep.state.ct.us/cgnhs/nddb/info.htm (Accessed: July 3, 2002).

Cook, M. P. 1899. Some additions to the "Flora of Middlesex County, Massachusetts." *Rhodora* 1: 80-82.

Cronon, W. 1983. *Changes in the Land: Indians, Colonists, and the Ecology of New England*. Hill and Wang, New York, USA.

Darwin, C. and F. Darwin. 1898. *The Power of Movement in Plants.* D. Appleton and Company, New York, New York, USA.

Denton, M. F. 1973. A monograph of *Oxalis* section *Ionoxalis* (Oxalidaceae) in North America. *Publications of the Museum, Michigan State University, Biological Series* 4: 455-615.

Eiten, G. 1963. Taxonomy and regional variation of *Oxalis* section *Corniculatae*. I. Introduction, Keys and Synopsis of the Species. *The American Midland Naturalist* 69: 257-309.

Facciola, S. 1990. *Cornucopia: A Source Book of Edible Plants.* Kampong Publications, Vista, California.

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

Gleason, H. A. 1968. *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada*. The New York Botanical Garden, Hafner Publishing Company, Inc., New York, USA.

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.

Gurevitch, J., S. M. Scheiner, and G. A. Fox. 2002. *The Ecology of Plants.* Sinauer Associates, Inc., Sunderland, Massachusetts, USA.

Haddock, M. 2000. Violet Wood Sorrel. Kansas Wildflowers and Grasses. Available at http://www.lib.ksu.edu/wildflower/woodsorrel.html (Accessed: 10 June 2002).

Haines, A. and T. F. Vining. 1998. *Flora of Maine: a Manual for Identification of Native and Naturalized Vascular Plants of Maine*. V. F. Thomas Co., Bar Harbor, Maine, USA.

Hedrick, U. P. 1972. *Sturtevant's Edible Plants of the World*. Dover Publications, Inc., New York, USA.

Hessl, A. and S. Spackman. 2002. Effects of fire on threatened and endangered plants: an annotated bibliography. U.S. Fish & Wildlife Service. National Biological Service Information and Technology Report 2. Available at http://fire.r9.fws.gov/ifcc/T&EPlants.htm (Accessed: October 21, 2002).

Hilty, J. 2002. Insect Visitors of Prairie Wildflowers in Illinois. Available at http://www.shout.net/~jhilty/ and http://www.shout.net/~jhilty/plants/vlt_sorrel.htm (Accessed: June 10, 2002).

Huxley, A. 1992. *The New RHS Dictionary of Gardening*. MacMillan Press, London, UK.

Jackson, J. 1909. *A Catalogue of the Flowering Plants and Ferns of Worcester County, Massachusetts.* Worcester Natural History Society, Worcester, Massachusetts.

Jones, L. R. 1906. The Vermont Botanical Club. *Rhodora* 8: 23-24.

Kutner, L. S. and L. E. Morse. 1996. Reintroduction in a changing climate. Pages 23-48 in D. A. Falk, C. I. Miller and M. Olwell (Editors), *Restoring Diversity: Strategies for Reintroduction of Endangered Plants.* Island Press, Washington, D. C., USA.

Linnaeus, C. 1753. *Species Plantarum*, volume 1, page 434, London, UK.

Long, W. H. and R. M. Harsch. 1918. Aecial stage of *Puccinia oxalidis*. *Botanical Gazette* 65: 475-478.

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.

Mahall, B. E. and F.H. Bormann. 1978. A Quantitative description of the vegetative phenology of herbs in a northern hardwood forest. *Botanical Gazette* 139: 467-481.

McPherson, A. and S. McPherson. 1977. *Wild Food Plants of Indiana*. Indiana University Press, Bloomington, Indiana, USA.

Missouri Botanical Garden. 2002. Available at http://www.mobot.org/gardeninghelp/plantfinder/codea/L340.shtml (Accessed: June 10, 2002).

Missouri Flora Website. 2002. *Oxalis violacea* L. Available at http://www.missouriplants.com/Bluealt/Oxalis_violacea_page.html (Accessed: June 10, 2002).

Moerman, D. E. 1998. *Native American Ethnobotany*. Timber Press, Portland, Oregon, USA.

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: June 7, 2002).

Nekola, J. C. 1994. The environment and vascular flora of northeastern Iowa fen communities. *Rhodora* 96: 121-169.

New England Botanical Club. 1997. Available at http://www.huh.harvard.edu/nebc/Summaries/1997/Jun97sum.html (Accessed: June 10, 2002).

Northern Prairie Wildlife Research Center. 2002. Available at http://www.npwrc.usgs.gov/resource/literatr/wildflwr/species/oxalviol.htm (Accessed: June 10, 2002).

Ornduff, R. 1964. The breeding system of *Oxalis suksdorfii*. *American Journal of Botany* 51: 307-314.

Packham, J. R. 1978. Biological Flora of the British Isles. *Journal of Ecology* 66: 669-693.

Proctor, M., P. Yeo, and A. Lack. 1996. *The Natural History of Pollination*. Timber Press, Portland, Oregon, USA.

Pruka, B. W. 1997. Indicator plant species of recoverable oak savannas and open oak woodlands in southern Wisconsin. Available at http://www.epa.gov/grtlakes/oak/oak95/app-d.htm (Accessed: June 10, 2002).

Radford, A. E., H. E. Ahles and C. R. Bell. 1964. *Manual of the Vascular Flora of the Carolinas*. The University of North Carolina Press, Chapel Hill, North Carolina, USA.

Rice, E. L and W. T. Penfound. 1954. Plant succession and yield of living plant material in a plowed prairie in Central Oklahoma. *Ecology* 35: 176-180.

Rick, C. M., J F. Fobes, and S. D. Tanksley. 1979. Evolution of mating systems in *Lycopersicon hirsutum* as deduced from genetic variation in electrophoretic and morphological characters. *Plant Systematics and Evolution* 132: 279-298.

Robertson, C. 1893. Flowers and insects XI. *Botanical Gazette* 18: 267-274.

Robinson, J. 1880. *The Flora of Essex County, Massachusetts.* Essex Institute, Salem, Massachusetts, USA.

Rusby, H. H. 1889. An enumeration of the plants collected by Dr. H. H. Rusby in South America, 1885-1886. VI. *Bulletin of the Torrey Botanical Club* 16: 153-160.

Seymour, F. C. 1982. *The Flora of New England*. Second Edition. *Phytologia Memoirs* V. H. N. Moldenke and A. L. Moldenke, Plainfield, New Jersey, USA.

Sorrie, B. A. 1987. Notes on the rare flora of Massachusetts. *Rhodora* 89: 113-192.

Stevens, O. A. 1921. Plants of Fargo, North Dakota, with dates of flowering. I. *American Midland Naturalist* 7: 54-62.

Steyermark, J. A. 1931. A study of plant distribution in relation to the acidity of various soils in Missouri. *Annals of the Missouri Botanical Garden* 18: 41-54

Steyermark, J. A. 1963. *Flora of Missouri*. The Iowa State University Press, Ames, Iowa, USA.

Szczebak, D., A. Maher, H. Dinkeloo, P. Huckery, J. Collins, H. Woolsey and C. Blais. 1999. Massachusetts Natural Heritage Atlas 2000-2001 Edition. Natural Heritage & Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts.

Tester, J. R. 1989. Effects of fire frequency on oak savanna in east-central Minnesota. *Bulletin of the Torrey Botanical Club* 116: 134-144.

The Nature Conservancy. 2002. State Success Stories, Massachusetts Fire Management Program. Available at http://www.tncfire.org/maprof.htm (Accessed: October 15, 2002).

Thoreau Home Page. 2002. Available at http://walden.org/thoreau/default.asp?MFRAME=/thoreau/writings/journal/1857/5706.htm (Accessed: June 10, 2002).

Trelease, W. 1882. The heterogony of *Oxalis violacea*. *American Naturalist* 16: 13-17.

Trelease, W. 1892. Observations suggested by the previous paper. *Transactions of the Academy of Science of St. Louis* 5: 286-291.

Uphof, J. C.Th. 1922. Ecological relations of plants in Southeastern Missouri. *American Journal of Botany* 9: 1-17.

Vermont NonGame and Natural Heritage Program. 1996. Vermont's Rare and Uncommon Native Plants. Available at http://www.anr.state.vt.us/fw/fwhome/nnhp/vt_plant.html#key (Accessed: June 10, 2002).

Weatherbee, P. B. 1996. *Flora of Berkshire County, Massachusetts.* The Studley Press, Inc., Dalton, Massachusetts, USA.

Weller, S. G. and M. F. Denton. 1976. Cytogeographic evidence for the evolution of distyly from tristyly in the North American species of *Oxalis* section *Ionoxalis*. *American Journal of Botany* 63: 120-125.

Williams, A. H. 1990. Two rare taxa rediscovered at Mt. Tom, Holyoke, Hampden Co., Massachusetts. *Rhodora* 92: 205-206.

Withrow, A. P. 1932. Life forms and leaf size classes of certain plant communities of the Cincinnati region. *Ecology* 13: 12-33.

Yanovsky, E. 1936. Food Plants of the North American Indians. United States Department of Agriculture, Miscellaneous Publication No. 237, Washington, DC, USA.

IV. APPENDICES

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1. Historical Stations of *Oxalis violacea* Lacking Occurrence Numbers

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

1. Historical Stations of *Oxalis violacea* Lacking Occurrence Numbers.

State	County	Town & locality	Collector & number	Date	Herbarium
VT	Windham	Dummerston		See Jones (1906)	
MA	Hampshire	Hadley/South Hadley	H. G. Jesup and/or F. Blanchard *s.n.*	28 May 1872	HNH
MA	Hampshire	Hadley/South Hadley	R. H. Osmun *s.n.* (handwriting open to interpretation)	4 May 1903	GH
MA	Hampshire	Hadley/South Hadley	F. T. Hubbard & G. S. Torrey 339	17 May 1913	NEBC
CT	Fairfield	Easton	E. H. Eames 8993	23 May 1915	CONN
CT	Fairfield	Fairfield	E. H. Eames 2339	6 June 1893	CONN
CT	Fairfield	Oxford	E. B. Harger 457	17 May 1902	NEBC
CT	Fairfield	Stratford	E. F. Williams *s.n.*	9 June 1901	NEBC
CT	Fairfield	Stratford	E. H. Eames *s.n.*	6 June 1893	NEBC
CT	Fairfield	Stratford	E. H. Eames 2340	24 June 1893	CONN
CT	Fairfield	Stratford	E. H. Eames 2341	5 June 1898	CONN; without collection number but same date at HNH
CT	Fairfield	Shelton		24 May 1941	Field Trip Report of the Connecticut Botanical Society (no editor, no author given).
CT	Fairfield	Trumbull	E. B. Harger 4561	23 May 1903	NEBC
CT	Hartford	Hartford	W. M. Kellogg *s.n.*	11 June 1887	CONN
CT	Hartford	North Bloomfield	H. S. Clark *s.n.*	12 June 1897	CONN
CT	Hartford	Suffield	Jesse F. Smith *s.n.*	26 May 1931	CONN
CT	Hartford	Windsor	G. S. Torrey 4748	13 May 1951	CONN
CT	Middlesex	East Haddam	C C. Hanmer *s.n.*	23 June 1907	CONN; POSSIBLY SAME LOC. AS E.O. CT .003
CT	Middlesex	East Haddam	E. J. Thompson	6 June 1909	CONN; POSSIBLY SAME LOC. AS E.O. CT .003

1. Historical Stations of *Oxalis violacea* Lacking Occurrence Numbers.

State	County	Town & locality	Collector & number	Date	Herbarium
CT	New Haven	Milford	E. H. Eames 2342	12 June 1898	CONN; without collection number but same date at GH, NEBC
CT	New Haven	Seymour	H. S. Clark *s.n.*	7 June 1903 or 1908	CONN
CT	New Haven	Southbury	H. S. Clark *s.n.*	9 June 1906	CONN; POSSIBLY SAME LOC. AS E.O. CT .007
CT	New Haven	Southbury	C. A. Weatherby 1735	6 June 1906	NEBC; POSSIBLY SAME LOC. AS E.O. CT .007
CT	New Haven	Waterbury	A. E. Blewitt 851	30 May 1911	NEBC
CT	New London	Franklin	R. W. Woodward *s.n.*	3 June 1916	GH
CT	New London	Franklin	R. W. Woodward *s.n.*	5 June 1912	NEBC
CT	New London	Norwich	G. H. Leland	June 1888	NEBC
CT	New London	Sprague	C. B. Graves *s.n.*	7 September 1901	GH
CT	Litchfield	Salisbury	L S P, *s.n.*	2 June 1911	CONN
CT	Litchfield	Woodbury	C. C. Hanmer *s.n.*	12 May 1910	CONN
CT	Litchfield	Woodbury	E. H. Eames *s.n.*	1 October 1934	CONN; POSSIBLY SAME LOC. AS E.O. CT .004
CT	Tolland	Coventry	E. B. Harger 7573	14 June 1930	NEBC
CT	Tolland	Coventry	d. W. P, *s.n.*	23 May, year not given	CONN
CT	Tolland	Unknown	A. Weatherby 5284	27 May 1924	NEBC

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

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

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

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

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

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

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

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that 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.