New England Plant Conservation Program

Zizia aptera (Gray) Fern.
Heart-leaved Golden Alexanders

Conservation and Research Plan
for New England

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Approved, Regional Advisory Council, May 2003

SUMMARY

Zizia aptera (Gray) Fern. (Apiaceae), is a perennial, herbaceous plant of moist meadows and open woods. In New England, the plant is known from only three sites in Connecticut, and is ranked as Division 2 (Regionally Rare) by the *Flora Conservanda* of the New England Plant Conservation Program. Elsewhere in its extremely broad range, the plant is considered more secure, ranked G5 (globally secure) by NatureServe. However, it is state-listed (S1 to S3) in seven states and one province of the 38 total where it occurs. The taxon ranges from Connecticut in the northeast, south to subtropical Florida, west to the Rocky Mountains and the Pacific Northwest of Canada.

The plant is distinguished from its relatives by its heart-shaped, dark green leaves. Non-reproductive plants form compact rosettes up to 15 cm in diameter. Reproductive plants may attain heights of 80 cm, and produce compound umbels of small, bright yellow flowers from May to July. These protogynous flowers are pollinated by a variety of bees and flies, some species of which focus exclusively on *Zizia* species. Although the plant produces defensive compounds, including the unique furanocoumarin "apterin" (named for the species), a number of insect species are herbivores on leaves, stems, and seeds of *Zizia aptera*.

In the heart of its range, the plant inhabits prairies, mid-successional fields, river shores, and glades with moist to dry soils that are principally derived from calcareous bedrock. In Connecticut, curiously, the plant occurs on widely disparate sites along the south coast within a few kilometers of Long Island Sound, overlying acidic granitic and gneissic bedrock. However, a commonality among all three sites — a cemetery along a river, a brackish marsh edge, and a coastal forest — is the presence of Native American shell middens underlying the plants, which would create locally circumneutral conditions. Native American activity has been intense throughout the southern coast of New England for over 4,000 years, and past herbarium collections from Fairfield through Groton, Connecticut and South Kingstown, Rhode Island may coincide with old settlements.

Threats to New England populations of *Zizia aptera* include trampling, inappropriate mowing; competition from native and invasive species, shading, habitat conversion, sea level rise, and population isolation. Actions to address these threats include: 1) notifying new landowners of extant occurrences of the existence and importance of the plant; 2) removing invasive species to reduce competition; 3) cordoning off plants and re-routing footpaths to reduce risk of trampling; 4) collecting seed for viability studies; 5) evaluating the need to augment one particularly tenuous population; and 6) conducting studies of pollination, herbivory, resource limitation; reproduction, and possible uses of fire or tree girdling to maintain a mid-successional assemblage around the plants. These steps, together with concerted *de novo* searches in promising historical locations, will accomplish the proximate objective of maintaining all three extant Connecticut occurrences at 100 plants (with a mean of 20% reproductive) and the long-term objective of having multiple populations in Connecticut and Rhode Island (reflecting the plant's historical range) over the next twenty years.

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:

Farnsworth, Elizabeth J. 2003. *Zizia aptera* (Gray) Fern. (Heart-leaved Golden Alexanders) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

I. BACKGROUND

INTRODUCTION

Zizia aptera (Gray) Fern. (Apiaceae), heart-leaved golden alexanders, is a perennial, herbaceous plant that produces a rosette of heart-shaped leaves and umbels of bright-yellow flowers on stems up to 80 cm tall. Throughout its range, the plant can be found in a range of habitats from moist to dry prairies, limestone glades and barrens, early- to mid-successional woods, mesic river shores, and fields showing low to intermediate levels of disturbance. In New England, the only three extant sites along the southern shore of Connecticut share a notable feature: the presence of Pequot-Mohegan shell middens underlying the plants that create locally circumneutral conditions conducive to the growth of calciphiles. The plant is formerly known from herbarium collections in southern Rhode Island, from Fairfield to Groton, Connecticut, and a single inland occurrence in Farmington, Connecticut. Although the plant is relatively widespread in the limestone-belt areas of New York bordering Massachusetts and Connecticut, it has not been collected from the Berkshire highlands, which is surprising given its apparent affinity for calcium-rich sites. It is possible that searches for the plant in several promising historical localities and in areas of known Native American settlements would reveal more populations of this inconspicuous plant and more information on its origins in New England.

Little is known of the biology of the plant in New England. However, studies from other parts of its range reveal a wealth of pollinators, including several species-specific insects. A low percentage of plants flower in any given year, but it is not known whether light availability or other resource limitation hinders reproduction. The plant, like other members of the Apiaceae, produces a range of defensive secondary compounds. Unlike its relatives, however, *Zizia aptera* does not produce several compounds known to kill insect predators, and thus, it is attacked by a suite of generalist herbivores. The plant is perennial but not known to be clonal. Its seeds appear to undergo dormancy, and could persist in the soil for many years. Extant populations have been known from their current localities for more than ten years, and may date back over a century to herbarium specimens collected in the late 1800s.

Threats to *Zizia aptera* at the three sites in Connecticut include: trampling; habitat conversion; shading and competition by invasive species and woody perennials; and tidal flooding, deposition of tide-borne debris, and sea-level rise. Mowing at inappropriate times (i.e., during fruiting) has reduced populations at two of three sites in the past; however, landowners and managers have worked cooperatively with conservation organizations over the years to adopt more consistent and helpful mowing regimes that ameliorate competition. One of these sites has recently come under new private ownership; the tenuous population there is in need of strong, cooperative long-term management and may require augmentation by

outplanting seeds at a nearby town park if plant numbers drop precipitously. The two other sites are under the ownership of universities; one is being managed explicitly as a conservation and educational resource. Thus, the prospects for protecting the three extant populations are good, but conscientious management will be required.

This Conservation and Research plan reviews in detail the conservation status of *Zizia aptera*, its biology, its biogeography, and the actions that are necessary to ensure its persistence in New England. These actions, including removal of invasive species, protection of plants from trampling and disturbance, targeted searches of historical sites and promising Native American sites, consistent quantitative monitoring yielding estimates of minimum viable population size, and species biology research, are designed to achieve two overall conservation objectives: 1) the maintenance of the three extant populations at 100 or more plants with an average of 20% reproducing in a given period and 2) the long-term maintenance of multiple populations along southern Connecticut and Rhode Island, reflecting the species' historical distribution in the region.

DESCRIPTION

The following description is compiled from Britton and Brown (1970), Gleason and Cronquist (1991), Magee and Ahles (1999), and personal observations. *Zizia aptera* is an herbaceous perennial reaching heights of 30 to 80 cm when in flower, otherwise occurring as a compact rosette up to 15 cm in diameter. The basal leaves (and lower leaves along the stem) are simple, deltoid- or round-ovate to oblong-ovate, and deeply cordate where they meet the long (to 10cm), slender petioles. Basal leaves are highly variable in size, ranging from 3 to 10+ cm long. Several light-green veins emanate from the petiole juncture, giving the bright green, glabrous leaves a textured or occasionally leathery look. The leaf margins are crenate. The cauline compound leaves are shorter-petioled, once or twice-ternate (borne in threes; rarely in fives), with lance-ovate to obovate-oblong leaflets. The stem is generally glabrous and branching.

The compound umbels consist of 7-16 ascending rays 1-5 cm long. The umbellets contain numerous ±5 mm-wide, 5-parted flowers on pedicels of variable lengths, with the central flower frequently sessile. Involucral bracts are not present; bractlets are few, short, and lance-linear. The flowers consist of bright yellow petals (hence the common name, "golden alexanders"), and small, green sepals. Unlike other members of the Apiaceae, the base of the style is not enlarged to form a stylopodium.

The fruit, a schizocarp, is oblong-ovate, and 3-4 mm long, flattened laterally, and bearing 5 ribs along each carpel. These ribs are unwinged, in contrast to other members of the Apiaceae; hence, the species epithet, *aptera* ("without wings"). The receptacle forms an axis between the carpels in the schizocarp, and is bifid, or split in two, for half its length. The chromosome count is n=11 (Bell and Constance 1957, Mulligan 1984).

The common name of *Zizia aptera,* "heart-leaved golden alexanders," highlights the feature that distinguishes it from its co-occurring congener in New England, *Zizia aurea* (L.) Koch. The latter, "common golden alexanders," has twice-ternate compound lower leaves (rather than entire, cordate leaves), and ternate to irregularly compound upper leaves, all of which are finely serrate with teeth averaging 5-10 per cm along the margin (Gleason and Cronquist 1991). Although *Z. aurea* is more often described from slightly more mesic habitats than *Z. aptera* (Gleason and Cronquist 1991, Magee and Ahles 1999), the two can overlap at sites, and flower at similar times of year (May-June). Thus, they can be confused in the field if one does not inspect the basal leaves closely. Smooth meadow parsnip, *Thaspium trifoliatum* (L.) Gray is another member of the Apiaceae that could potentially range into the southern coast of New England to overlap with *Z. aptera;* it is reported from Rhode Island and New York, but not Connecticut (USDA Plants National Database 2002). Its umbels are much sparser and are arrayed on longer peduncles than those of *Z. aptera,* and its fruits are winged (Gleason and Cronquist 1991). Likewise, another rare member of the Apiaceae, *Taenidia integerrima* (L.) Drude, yellow pimpernel, overlaps in range with *Z. aptera*, but is readily distinguished by the sweet, celery-like smell of its foliage, sheathing petioles, and entire leaflets (Gleason and Cronquist 1991, Werier 2002).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Zizia aptera Gray (Fern.) is a member of the Apiaceae (formerly, Umbelliferae), in the tribe Apieae. The genus *Zizia* encompasses three species: *Z. aptera, Z. aurea,* and *Z. trifoliata* (USDA, NRCS 2002). While the first two species co-occur throughout much of their ranges, *Z. trifoliata* (Michx.) Fern. is a distinctly southeastern species, extending from Florida to Maryland. No hybrids have been reported for the genus.

The basionym of the taxon is *Thaspium trifoliatum* var. *apterum* A. Gray, first described by Gray (1856: 156). Two infraspecific varieties have been described: *Zizia aptera* var. *aptera* and *Z. aptera* var. *occidentalis* (Fernald 1939, Hitchcock 1984). *Zizia aptera* var. *aptera*, synonymous with *Zizia cordata* (Walt.)DC (Britton and Brown 1970), is the variety that occurs in New England (Gleason and Cronquist 1991). Currently, the varieties are treated as synonyms and subsumed under one taxon, *Zizia aptera* (USDA, NRCS 2002).

SPECIES BIOLOGY

Zizia aptera is a perennial plant that can exist for several years as a rosette of leaves until it reaches reproductive maturity. The plant possesses a stout, fleshy-fibrous rootstock (Hemingson 1990), but is not known to be rhizomatous (Farnsworth, personal observation). Populations appear to be relatively long-lived at a given site. For example, all extant populations in Connecticut have persisted at their present sites for 8 to 28 years (Table 2), and

possibly over a century, if herbarium specimens from the early 1900's can be ascribed to the extant populations.

The plant produces dozens of small but showy yellow flowers per umbel from early May to mid-July throughout its range (Gleason and Cronquist 1991, Missouri Botanical Garden 2002, New England herbarium records, and personal observation). In New England, it is among the earliest species to flower in the habitats in which it occurs. The pollination biology specific to *Zizia aptera* has not been documented in published studies, but studies of its close congeners with comparable floral structure and phenology, *Zizia aurea* and *Z. trifoliata*, are illuminating. Lindsey (1984) and Lindsey and Bell (1985) report that the umbels contain both staminate and bisexual flowers. The outer whorl of flowers on each umbellet are typically hermaphroditic. The luminosity of pollen and stigmas on this outer whorl of flowers contrasts with that of the petals, drawing insects in by a mechanism of "edge attraction" (Lindsey and Bell 1985). The bisexual flowers are strongly protogynous (maturing female parts first). The density of flowers in each umbel declines rapidly after the onset of female receptivity, meaning that insects must visit many umbels (and separate plants) to gather pollen and nectar. This phenology and architecture favors outcrossing by ensuring that hermaphroditic flowers receive pollen primarily from flowers in other umbels. However, insect foraging during the early spring is intense and the mechanism is not fool-proof; geitonogamous pollinations within plants have been reported in species of both *Zizia* and *Thaspium* (Lindsey and Bell 1985).

Zizia flowers are visited by a diversity of insects, and may represent an important resource to specialized pollinator species that concentrate on early-blooming members of the Apiaceae. According to Robertson (1899) and Lindsey and Bell (1985), the most frequent visitors to flowers of *Zizia trifoliata* are flies and solitary bees of the Andrenidae (Hymenoptera). *Andrena ziziae* Robertson, a solitary bee with a broad range in eastern North America (including New England), almost exclusively visits Apiaceous flowers with "zizioid" umbels, making it a particularly reliable pollinator where it co-occurs with the plants (Ribble 1968, Krombien et al. 1979). Hilty (2002), summarizing work of Robertson (1899) and others, documents 175 species of insects visiting *Zizia aptera* flowers in the prairies of Illinois, many of which have ranges that extend to New England. The insects include 19 species of long-tongued bees; 41 species of short-tongued bees (including *Andrena* spp.); 31 wasps; 1 sawfly; 62 fly species; 4 butterfly taxa; 1 noctuid moth; 13 beetle species; and 3 plant bugs. Only a small subset of this diverse fauna may actually effect pollination, however. Lindsey and Bell (1985) noted that only three insect species, including the oligolege, *Andrena ziziae*, accounted for over 90% of pollination events in *Zizia trifoliata* in North Carolina and Virginia. Cloudy weather precluded observations of pollinators when I visited the extant three Connecticut populations of *Zizia aptera*. However, I did observe syrphid flies visiting flowers of *Z. aptera* at CT .002 (Ledyard).

Insect pollination varies widely in efficiency in *Zizia aptera*; 10-80% of all flowers observed were setting fruit on umbellets at CT .002 (Guilford), indicating a moderate success rate for pollination. This accords with Lindsey and Bell's (1985) calculation of fruit sets in *Z.*

trifoliata ranging from 50-70%, and follows from the high pollen:ovule ratios reported for *Zizia* species in the literature.

Fruit set occurs from June onward in *Zizia aptera* in New England, with most fruits dehisced by early August. Seed dispersal mechanisms are not described for this species. The schizocarp opens to release the seeds passively from the carpels. The un-winged seeds do not possess specialized structures favoring ballistic, wind, or animal dispersal. Thus, the majority of seeds probably fall within a few meters of the parent plant. In sites where the plants occur very close to water (as at CT .001 [Guilford]), a few may be carried off by tides or spring floods, but it is unknown how long they can survive in the water column.

Little is known about the longevity of *Zizia aptera* seeds in nature. However, *ex situ* germination studies indicate that seeds can survive dormancy in excess of 150 days, and that seeds benefit from a period of cold stratification (Greene and Curtis 1950). Seed collected from Midwest prairie populations exhibited 51% germination rates when stratified at 18-21^{o}C for 5 months, whereas only 6% of seeds germinated when they had been stratified for only two months. Scarification (using sandpaper) did not enhance germination percentages in Greene and Curtis' study. Thus, it appears likely that seeds can and possibly need to overwinter for at least one season and that digestion or handling by animals is not prerequisite to germination.

Insects are important herbivores on leaves, stems, and fruits of *Zizia* species. In turn, many members of the Apioid subfamily of the Apiaceae possess unusual secondary compounds that have long been thought to function as defenses against herbivores. Steck and Wetter (1974) isolated an abundant, water-soluble glucoside, apterin, from *Zizia aptera,* that can impart a pungent odor and bitter taste to leaves. Apterin is resistant to enzyme cleavage (making it difficult to break down digestively); however, seeds of *Zizia aptera* were found to produce a glycosidase that hydrolyzes the compound, a process that may be necessary for embryo growth or germination (Steck and Wetter 1974). Fischer and Svendsen (1976) subsequently isolated apterin from nine other species of the Apiaceae. Berenbaum (1980, 1981) later characterized an entire suite of furanocoumarins from various *Zizia* species. These are benz-2-pyrone compounds that, when consumed in their linear molecular form, become toxic upon exposure to UV light and can kill insects. While other *Zizia* species are rich in these compounds, *Zizia aptera* plants from Ithaca, New York populations studied by Berenbaum lacked both angular and linear furanocoumarins, and were visited mainly by generalist herbivores. This chemical profile contrasts with other members of the Apiaceae, but is similar to other species of the Apiaceae that typically inhabit woodlands (Berenbaum 1981). Two umbellifer-specialist insect species and three generalist feeders were found on stems of *Z. aptera* at this site. Tortricid moth larvae (*Eulia fratria, Agonopterix clemensella, Atchips purpuranus*) were common leaf rollers on *Zizia aptera* in New York (Berenbaum 1981). Homoptera, phloem-sucking insects, have also been noted on plants; *Philaenus spumarius* (Cercopidae) was reported by Berenbaum (1981). The species is also described as a food plant for the larvae of the tiger swallowtail butterfly *P. polyxenes,* which occurs in New England (Savela 2002).

I also noted herbivorous insects on *Zizia aptera,* exclusively at the CT .001 (Guilford) site in June, 2002; the other two extant populations do not appear to be affected by herbivory. I observed a pupal case and frass of an unidentified lepidopteran larva in the sheathing stipule of leaves of one plant at Guilford. The pedicel of one umbel on this plant was swollen and discolored, and parts of the umbel had been shredded. I also observed one leafhopper (Homoptera: Cicadellidae) on a plant at CT .001 (Guilford). Moreover, scale insects (Homoptera: Diaspididae) were present on one stem at this site, causing minor injury. On the larger of two plants found very close to the marsh edge at this site, several of the developing fruits appeared to have been bitten off their pedicels. On six umbellets checked, an average of 61% of pedicels exhibited this damage. The seed predator is unknown, but existing frass suggests a lepidopteran larva. I also observed a slug on one plant at CT .002 (Ledyard), which did not appear to be damaging leaves. Leaves at all sites showed minimal herbivory (less than 1% of leaf area damaged).

The presence of secondary compounds such as apterin may contribute to the potential medicinal value of *Zizia* species. *Zizia aurea* roots have been used by Native Americans as a tea to cure fevers, and the plant has been referred to as a vulnerary (wound-healing) agent (Foster and Duke 1990). This species has also been used to induce sleep and for alleviating syphilis (Foster and Duke 1990). However, the specific medicinal properties of *Zizia aptera* have not been documented. The species is featured at a web site of the Southwestern School of Botanical Medicine (Moore 2002), but its curative powers are not described. If the species possesses medicinal value and has been used by Native Americans and/or early colonial settlers, this feature could in part explain its curious distribution in Connecticut (see below).

HABITAT/ECOLOGY

Range-wide Habitats

Zizia aptera is known range-wide principally as a species of the tallgrass prairie, with clear affinities to circumneutral soils. Data on the various habitats of *Zizia aptera* suggest that the plant is a strong calciphile, specializing on bedrock types that are rich in calcium (as well as magnesium and other nutrients). Appendix 2 summarizes data from regional floras and field guides that give some insight as to the species' habitat preferences. As a plant with a very wide geographic distribution throughout North America, one would expect its climatic and edaphic tolerances to be very broad. *Zizia aptera* is not classified as an obligate wetland inhabitant, although it is described from the margins of streams and rivers and from mesic to dry habitats. This indicates a wide tolerance for a variety of moisture conditions.

Range-wide, the species appears to inhabit mid-successional habitats or areas maintained in a semi-open condition by disturbance events, including fire (Hemingson 1990). The Wisconsin Floristic Quality Assessment of the Wisconsin State Herbarium (2002) rates

Zizia aptera with a "Coefficient of Conservatism" of 9. The Coefficient of Conservatism is: "a number on a scale from 0 to 10 that represents an estimated probability that a plant species is likely to occur in a landscape relatively unaltered from what is believed to be a pre-settlement condition. A C-score of 0 indicates the probability is almost nil, while a C of 10 indicates the plant is almost certain to be found only in an undegraded natural community" (Swink and Wilhelm 1994, Wilhelm and Masters 1995, Wisconsin State Herbarium 2002). Such an undegraded natural community is not static; rather, it will be subject to natural ecological disturbances such as fire. In a similar vein, Dix (1959) noted that *Zizia aptera* was found almost exclusively in ungrazed thin-soil prairie stands in Wisconsin, and assigned it a high index of susceptibility to mortality in the event of grazing (9 of a top score of 10).

It is of interest to know whether *Zizia aptera* is a fire-adapted species in order to determine if fire is required for its conservation. Pruka (1995) lists its close congener, *Z. aurea*, as among the best indicators of oak savannahs, oak woodlands, and prairies, indicating its strong affinity for fire-prone areas, and *Z. aptera* is reported from such habitats in many regional floras (Appendix 2). Prairies, shallow-to-bedrock glades, and open woodlands in the heart of the species' range are frequently subject to brief, intense burns caused either by lightning or human activity, with a return rate as frequent as every 2-4 years (Pyne 1984, Guyette and Cutter 1991). Fire consumes plant litter; in these systems, litter accumulates faster than it decomposes, reduces primary productivity, and can influence species composition by favoring more shade-tolerant species (particularly at mesic sites). Fire can also release nitrogen quickly from leaf litter, which is captured and utilized by plants; some fire-adapted *Quercus* species, for example, exhibit higher levels of foliar nitrogen following fires (Reich et al. 1990). No specific morphological characteristics strongly suggest that *Zizia aptera* is strictly dependent upon fire for seed germination, stimulation of flowering, or other critical life-history functions. However, it is clear that fire uniquely maintains the open habitats with a low intensity of competition that the species requires. The species responds favorably to spring burning of prairies in Minnesota, Ohio, and Indiana (Hemingson 1990).

Habitats in New England

In New England, *Zizia aptera* occupies a very narrow set of seemingly unrelated habitats, namely three sites exclusively in south-central Connecticut. The sites are characterized by thin soils overlying schistose, gneissic, and/or quartzite bedrock (Rodgers 1985). Such parent material should give rise to acidic or at best subacidic soils; therefore, on first glance, it seems unusual to find it in these areas. As a calciphile, the species would be expected to occur in the calcium-rich regions of northwestern Connecticut and, possibly, Massachusetts. The species does occur in eastern New York, just over the border from the Berkshire plateau, in a limestone-rich belt of the Hudson Highlands (New York Flora Association 2001). It seems unusual that *Zizia aptera* is found over 100 km away from New York in New England woodlands and shores that have been subject to heavy anthropogenic disturbance, including a cemetery, a picnic area, and a trail. This apparent departure from a high Coefficient of

Conservatism may be both an artifact and a cause of the species' current limited distribution; in other words, we are only observing a fraction of its former distribution across habitats that have now been eliminated through irreversible human alteration. It is also possible that the species simply has not been detected during botanical surveys to date.

A closer look at the sites where *Z. aptera* occurs, however, may resolve the apparent conflict with its range-wide habitat preferences. Two of the three sites are located in close proximity to Long Island Sound: one (CT .001 [Guilford]) within three meters of the high tidal zone (dominated by *Spartina alterniflora* Loisel. and other brackish marsh species). The CT .003 (Branford) site lies approximately 100 meters from the coast of Connecticut. Sites so close to oceanic influence usually have alkaline soils that are enriched in calcium borne by salt spray. Indeed, several other rare, calciphilic plant species (some characteristic of prairie remnants) occur close to *Zizia aptera* at these two sites (Brown 2002, Werier 2002). The third site, CT .002 (Ledyard) occurs within 10 meters of the shore of the Thames River. As the plants are growing on a graveyard, it is impossible to determine whether they occur on soils derived *in situ* from the country rock, glacial outwash transported from elsewhere (or fill artificially brought it), or even bones.

A key characteristic shared by the Guilford and Branford sites is the presence of large shell mounds underlying the plants. Copious numbers of mussel and clam shell fragments are exposed in the soil around the plants at these two sites. Likewise, shell fragments were noted on the soil surface during my visit at the Ledyard site (where it was not possible to see an exposed soil profile). These shells would lend calcium to the soil, creating locally circumneutral conditions. While it is possible that these shell piles represent feeding debris from sea birds, or areas where river flooding, tidal action, or sea level rise has eroded ancient mudflats, it is most likely that they are ancient Native American middens. Native American activity was intense all along the southern shore of central Connecticut, with the Niantic tribes focused on the mouth of the Connecticut River and the Mohegan-Pequot tribes inhabiting the Ledyard area (Sultzmann 1997). Numerous Late Woodland midden sites dated around 4,000 BP are documented from coves along the Thames River in Ledyard, particularly where stream tributaries meet the main stem (Harold Juli, Connecticut College Department of Archaeology, personal communication). As Juli (1994: 25) notes, midden evidence suggests "sustained sequences of occupation in the region during at least the last 4,000 years, as well as the presence of several site forms including coastal and inland villages of various sizes and ubiquitous riverine and coastal shell middens." Low, flat terraces of the Thames River were preferentially occupied during Spring to Fall, when foragers exploited rich shellfish beds and anadromous fish. Similarly, Quinnipiac Indians were known to create extensive middens around the Branford (CT .003) site (Camacho et al. 2002). A sample size of three populations is too small to assume that the species is restricted to these sites, but the coincidence is suggestive.

Why would *Zizia aptera* now exhibit such an apparent affinity for these types of middens? Without further surveys, it is unknown whether *Zizia aptera* is genuinely restricted to midden sites, and whether it existed naturally at a number of Connecticut sites and has persisted

only at middens, or whether it was specifically introduced with Native American settlements. Given the medicinal value of *Zizia* species, it is possible that Native American tribes brought seeds of the species to the region. The Mohegans and Pequots migrated east to Connecticut around the year 1500 from the Hudson River Valley in New York, where *Zizia aptera* is known to occur (New York Flora Association 2001), and could conceivably have transported seeds here, either accidentally or purposely. Work reviewed by Juli (1992) and Tantaquidgeon (1977) indicates that Late Woodland peoples practiced at least minimal horticulture (of maize, bean, and squash crops and medicinal plants) in the area beginning around 1,000 years ago. In any case, such a finding indicates that Native American middens near tidal rivers may be promising areas in which to focus searches initially for *Zizia aptera* (along with other rare species with which it co-occurs elsewhere in its range, including *Oxalis violacea, Solidago rigida,* and its close relative, *Taenidia integerrima*).

THREATS TO TAXON

From an assessment of the populations of *Zizia aptera* in Connecticut as well as its range-wide biology, the following issues (listed in order of importance) present the greatest threats to the taxon in the region. Because *Z. aptera* is a calciphilic species that demands relatively high-light conditions, the primary threats to it include limited habitat availability, lack of management that meets its requirements, and competition with species that can outcompete it for resources. Stressors operating at existing sites include trampling, drought (and salt stress), and herbivory.

Lack of Needed Habitat Management

Zizia aptera is a plant of prairie habitats throughout its range. As such, it requires a certain level of natural disturbance, possibly including fire, to maintain semi-open, early and mid-successional plant assemblages dominated by herbaceous species. Wholesale habitat destruction for residential and commercial development — particularly along the southern coast of New England — has eliminated many of these habitats. Where land has not been developed, afforestation is proceeding and canopies are closing, reducing light availability to species like *Z. aptera*, and favoring the expansion of shade-tolerant species and many invasive exotic species. These issues confront *Z. aptera* at all sites in which it occurs in Connecticut. At CT .001 (Guilford), a few plants persist under the shade (and protection) of a pitch pine (*Pinus rigida*) tree and immediately along the upper edge of a salt marsh, covering an area no more than a few tens of square meters in extent. Expansion opportunities are nearly non-existent at this site. Inappropriately-timed mowing has been noted as a threat in the past (1994) to the plants at CT .001. At CT .003 (Branford), plants are scattered along a trail in a newly-protected natural area, but occur under a mature tree canopy with numerous species of invasive plants in close proximity. Finally, at CT .002 (Ledyard), the plants are restricted to a small portion of an old cemetery. Mowing and assiduous hand-weeding have kept woody and invasive species from

overtaking the *Z. aptera*, but even the mowing regime itself has been problematic over the years. Ill-timed mowing of the cemetery plot has killed or stunted plants and wiped out reproduction in several of the years in which the plants have been observed. It is critical to design and adhere to a mowing and/or burning regime at these sites that will promote the growth and reproduction of the plants while inhibiting the expansion of other competing species.

Invasive Species

I noted the presence of many competing species at all sites, especially *Celastrus orbiculatus* (oriental bittersweet), which is proliferating at both CT .003 (Branford) and CT. 002 (Ledyard). *Lonicera japonica* and *Phragmites australis* have been noted at CT .001 (Guilford) in 2002. *Eleagnus umbellata* (autumn olive) and *Populus grandidentata* (bigtooth aspen) are also encroaching on *Z. aptera* at CT .002 (Ledyard). *Toxicodendron radicans* (poison ivy) is also rife at CT .001 (Guilford), intermixed among the *Zizia*. *Berberis thunbergii* (Japanese barberry), *Cynanchum loiseae* (black swallowwort), and *Rosa multiflora* (multiflora rose) are abundant in the understory near the plants at CT .003 (Branford).

Habitat Loss

Zizia aptera appears to be quite specialized in its habitat preferences, growing best on calcium-rich substrates in shallow-to-bedrock, mid-successional, herbaceous-dominated communities. Habitat specialists are more likely than generalist species to suffer extinction due to land conversion. Throughout southern New England, rare plant species that are specialists on coastal and circumneutral sites are disproportionately threatened (Metzler and Wagner 1998). Inspection of herbarium specimens reveals that the plant formerly had a broader distribution along the southern coast of New England, encompassing South Kingstown in Rhode Island and extending west to Groton, Old Saybrook, and Fairfield in Connecticut (see Table 2 below). Urbanization and habitat conversion in these areas has likely extirpated the majority of these populations. Further inland, the plant has been collected from Farmington and Fairfield, Connecticut, where suburban development is likely to have fragmented or destroyed populations. While we likely have only a sketchy idea of the true distribution of its populations in New England (its biogeography cannot be reliably assessed without more intensive searches), its known existing populations occur in densely-populated coastal and river-shore towns that are subject to intense development pressure. If *Zizia aptera* once occurred more widely, particularly on midden sites, its current pattern of occurrence probably reflects the destruction of these sites following colonial resettlement. Fortunately, two of the three sites where the plant occurs enjoy some protection from future development. For example, CT .003 (Branford) is managed as a natural area by a local university. As a cemetery, CT .002 (Ledyard) is unlikely to be converted to other uses. This level of protection mitigates habitat loss somewhat as a threat for the time being. However, CT .001 (Guilford) continues to be privately owned and used. The site could be sold for development. In addition to anthropogenic disturbance, sea

level rise (widely documented for the east coast and expected as climate warms), tidal overwash from major storms, and boat wakes pose a risk to the small, tenuous population there, by killing plants outright with a dose of high salinity or by erosion of the area due to tidal turbulence. Bank erosion has also been noted as a potential long-term threat to the plants at CT .002 (Ledyard) on previous field forms (Beth Lapin, The Nature Conservancy, notes on 1990 field form).

Trampling

Zizia aptera plants at all three Connecticut sites are vulnerable to inadvertent trampling by visitors, because at least limited public access is permitted there. The CT .001 (Guilford) site was formerly a picnic area and backyard used by the private owner, and trampling was noted as a threat on previous years' field forms. Plants at the CT .002 (Ledyard) site may be impacted by visitors to the cemetery and to the adjacent boating club. Plants line a well-used walking trail at the CT .003 (Branford) site, and a few even occur in the trail itself. Walkers along this trail, especially those with pets, could easily step on the inconspicuous plants if not sensitized to their presence.

Drought

Zizia aptera is not a wetland obligate (USDA, NRCS 2002), but is typically noted from mesic sites throughout its range (Table 1, Appendix 2). Thus, drought can pose a threat to plants, especially when it is severe and prolonged (as it has been in the past three years in New England). Unusually dry soils were stressing the population at CT .001 (Guilford) in 2002; plants appeared withered and smaller here than at other sites in Connecticut where more mesic conditions prevailed. Because the plants at CT .001 occur on well-drained, shallow-to-bedrock outwash sands and are not very protected from winds off Long Island Sound, they are particularly susceptible to mortality from drought. More widespread drought associated with changing regional climatic conditions (New England Regional Assessment Group 2001) may present a long-term issue for the persistence of *Zizia aptera*.

Grazing and Herbivory

My observations at CT .001 (Guilford) suggest that insect herbivory may reduce seed set and growth of individual plants. The population at this site appears especially stressed in general, and hence may be more susceptible than normal to insect attack. The impacts of insect predation on reproductive output and fitness need to be assessed through future research. Deer browsing and rodent foraging were not apparent at the sites and have not been mentioned as threats on previous field forms, and it is not known if deer would feed on this species. Deer

populations are increasing in Connecticut, however, and thus pose a potential threat to *Zizia aptera* populations throughout the state.

Small Population Size and Isolation

While it may seem a truism to say that small populations are inherently vulnerable to extinction, the small size and physical isolation of the *Zizia aptera* populations in Connecticut are cause for concern. Although *Z. aptera* is not necessarily an obligate outcrosser, genetic heterogeneity may be eroded in populations that are shrinking (as with CT .001 [Guilford]) and that are isolated from other populations by more than 10 km (exceeding mean flight distances for most pollinators, for example). Whether this represents a true threat to these plants or reflects the fact that the plant has never been very common in New England would have to be assessed through genetic analysis.

DISTRIBUTION AND STATUS

General Status

Zizia aptera (*sensu lato*) has a very broad geographic distribution, encompassing 37 states and seven Canadian provinces, stretching from northeast Canada to subtropical Florida, to the montane west and Pacific northwest (Table 1). According to NatureServe (2002), the species is globally ranked as G5 ("Secure: common, widespread, and abundant [although it may be rare in parts of its range, particularly on the periphery]; not vulnerable in most of its range; typically with considerably more than 100 occurrences and more than 10,000 individuals" according to The Nature Conservancy definition). Its National Rank is N5 in the United States and N? (rank not yet assessed) in Canada.

The species is ranked as S1 to S3 in seven of the states and one of the Canadian provinces in which it occurs, and is regarded as historic in Rhode Island. Its restriction to a single county in Florida also suggests it should be surveyed, vouchered, and considered for listing as rare in that state, where it reaches the southern end of its range. Elsewhere, its rarity status is less well-known; five states list the species as S? (subnation rank not yet assessed) and many more rank it as "SR" (element reported but not yet reviewed locally). Herbaria and floras give additional information about the distribution of the species in some of these states (Table 1). Figure 1 depicts the spatial distribution of the taxon in North America.

Table 1. Occurrence and status of *Zizia aptera* in the United States and Canada based on information from Natural Heritage Programs, the USDA Plants National Database (2002), and other sources as noted below

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 (S1, E): 3 extant occurrences and up to 21 historic records	Arkansas (S1S3): occurs in 1 county in northwest	Alabama (SR)	Rhode Island (SH): 1 historic record
Delaware (S1)	District of Columbia (S?)	Colorado (SR)	
Indiana (S2)	Illinois (S?): Occurs in the northern 17 counties (Illinois Plant Information Network 2002)	Florida (SR): 1 county in northwest (University of South Florida 2002)	
Michigan (S1S2): 1 county in southwest	Iowa (S3): Northern 7 counties	Georgia (SR): 16 counties in northwest/central (Jones and Coile 1988: 201)	
Ontario (S1)	Kentucky (S?): 27 counties throughout state	Idaho (SR)	
	North Carolina (S5): reported from 37 counties throughout the state	Maryland (SR)	
	Pennsylvania (S?)	Minnesota (SR)	
	West Virginia (S?)	Mississippi (SR)	
	Alberta (S5)	Missouri (SR): reported from 24 counties throughout	
	Manitoba (S5)	Montana (SR)	
	Saskatchewan (S5)	Nevada (SR)	
		New Jersey (SR)	
		New York (SR): Recorded from 17 counties (New York Flora Association 2001)	
		North Dakota (SR): occurs in 32 counties	
		Ohio (SR)	
		Oklahoma (SR)	
		Oregon (SR)	
		South Carolina (SR): reported from 10 northern counties	
		South Dakota (SR): reported from 9 counties in eastern and	

Table 1. Occurrence and status of *Zizia aptera* in the United States and Canada based on information from Natural Heritage Programs, the USDA Plants National Database (2002), and other sources as noted below

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
		western sectors	
		Tennessee (SR): records from 34 counties in central part of state (University of Tennessee Herbarium 2002)	
		Utah (SR): known from 6 counties in central mountain ranges of state (Utah State University 2002)	
		Virginia (SR)	
		Washington (SR)	
		Wisconsin (SR): reported from 21 counties in southeast and northwest (Wisconsin State Herbarium 2002)	
		Wyoming (SR)	
		British Columbia (SR)	
		Quebec (SR)	
		Yukon (SR)	

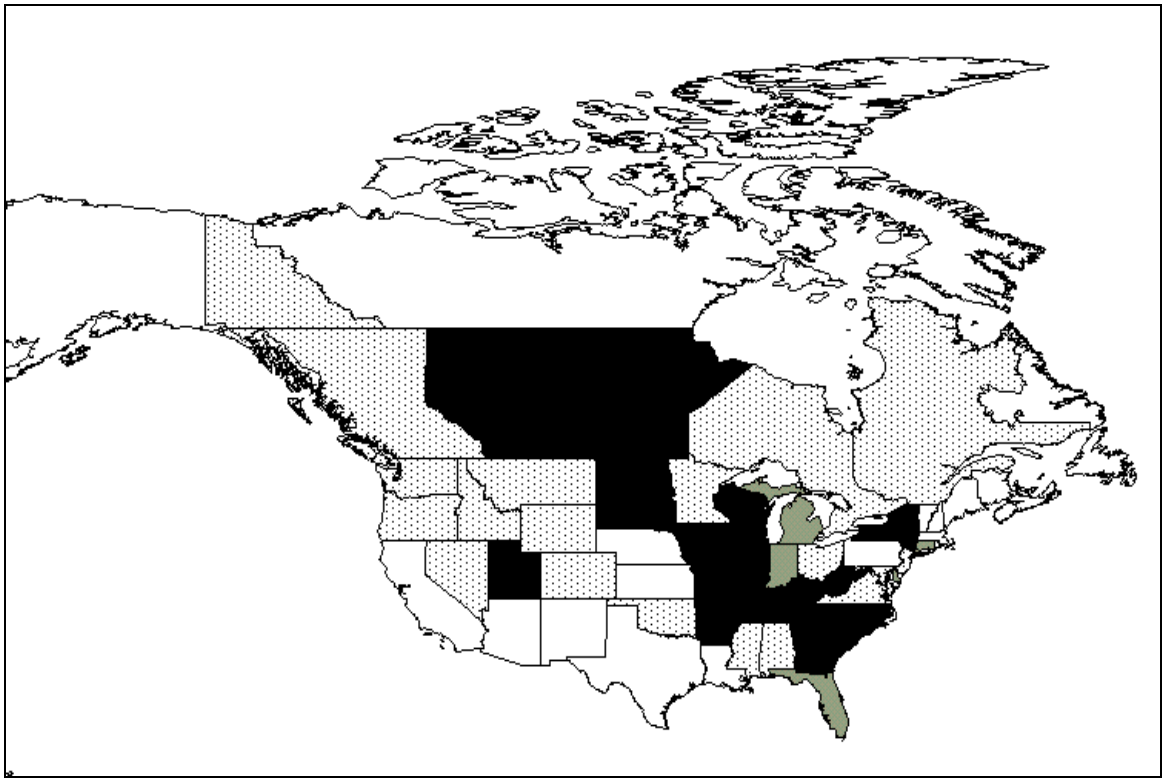

Figure 1. Occurrences of *Zizia aptera* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. The state (Rhode Island) with diagonal hatching is designated "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.

Status of All New England Occurrences — Current and Historical

The *Flora Conservanda* (Brumback and Mehrhoff et al. 1996) ranks *Zizia aptera* as a Division 2 (Regionally Rare) taxon. While the species reaches its northeastern extent in southern New England, there is no reason *a priori* to expect that the taxon reaches an absolute climatic or edaphic limit here; it is reported from provinces and states north and west of New England and from high elevations (Table 1) that far exceed New England in climatic extremes. The species is recorded as extant in only one New England state (Connecticut), and is ranked as historic (SH) in Rhode Island. The total number of towns from which the species has been recorded has declined from seven in the late 1800s and early 1900s to three today. Evidence is scanty that the species was ever substantially more common in New England. Table 2 summarizes the data on all known occurrences in New England. Figures 2 and 3 depict the spatial distribution of extant and historic occurrences in the region, respectively.

Zizia aptera has recently been planted in a natural area in Massachusetts (although it is likely to be common in gardens throughout the state). Volunteers of the Great Barrington Land Conservancy have planted numerous calciphilic herbaceous species along the "Housatonic River Walk," a greenway laboriously renovated in downtown Great Barrington (Great Barrington Land Conservancy 2003). The source of these plants is not given by the Conservancy. However, they are not listed under plants propagated from local sources, and are likely to have been obtained from outside New England. Given the proximity of these plants to water, it is reasonable to expect them to disperse down-river to additional sites in coming years. The location of the planted source population should be mapped and recorded with the Massachusetts Natural Heritage and Endangered Species Program and assigned a status of "introduced." Newly-recruited populations should be noted in botanical surveys of the area.

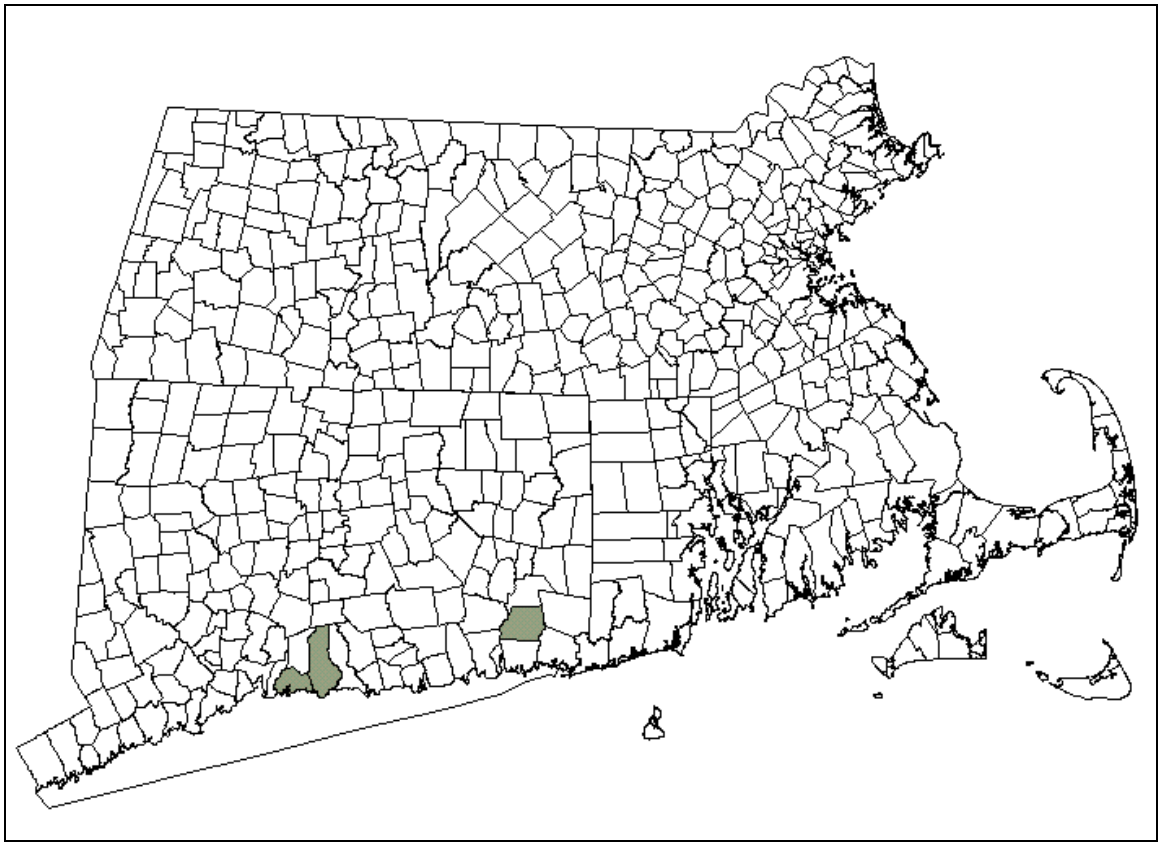

Figure 2. Extant occurrences of *Zizia aptera* in New England. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

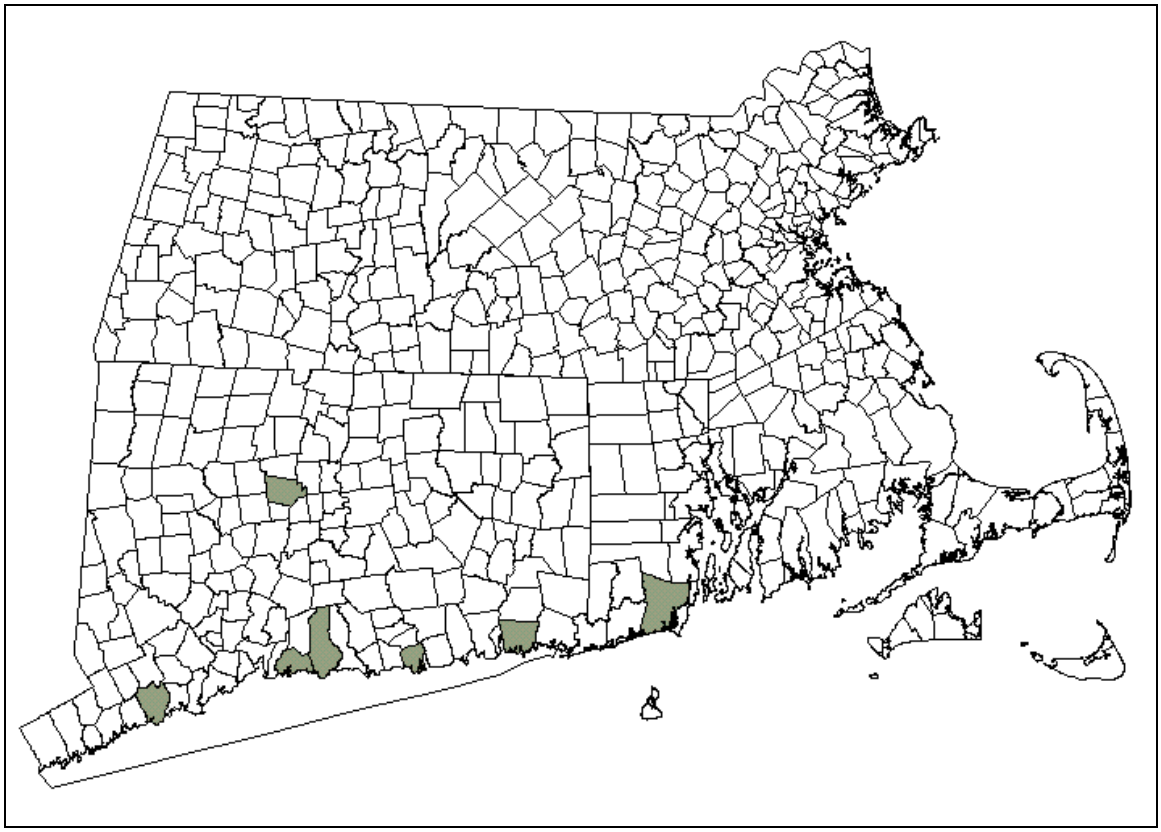

Figure 3. Historical occurrences of *Zizia aptera* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 2. New England Occurrence Records for *Zizia aptera*. Shaded occurrences are considered extant.

State	EO Number	County	Town
RI	No #	Washington	South Kingstown
CT	**.001**	**New Haven**	**Guilford**
CT	**.002**	**New London**	**Ledyard**
CT	**.003**	**New Haven**	**Branford**
CT	.005	Fairfield	Fairfield
CT	.006	Middlesex	Old Saybrook
CT	No #	New Haven	Guilford
CT	No #	New Haven	Branford
CT	No #	Fairfield	Fairfield
CT	No #	Fairfield	Fairfield
CT	No #	New London	Groton
CT	No #	New Haven	Guilford
CT	No #	New Haven	Branford
CT	No #	New Haven	Branford
CT	No #	New Haven	Madison?
CT	No #	Hartford	Farmington

Additional herbarium records noted in the Natural Diversity Database of Connecticut DEP, with no additional information:
Branford, Connecticut (1895) housed at NEBC
Branford, Connecticut (1919), housed at Smithsonian
Fairfield, Connecticut (1895) housed at Smithsonian
Fairfield, Connecticut (1895) at Gray**
Fairfield, Connecticut (1898) housed at Yale
Fairfield, Connecticut (1898) housed at NEBC**
Farmington, Connecticut (undated) at Gray**

Additional herbarium records (with no site information) noted in searches by Arthur Haines as part of the Herbarium Recovery Project of the New England Wild Flower Society:
Fairfield, Connecticut (1892) housed at Hodgdon Herbarium, collected by E. H. Eames on 9 September in fruit; annotated 1960 by A. J. Poole.
Branford, Connecticut (1895) housed at NEBC (#534), collected by L. Andrews in fruit on 31 July.

** An asterisk above and in Comments column of table indicates that the specimen has been verified by Arthur Haines as part of the Herbarium Recovery Project of the New England Wild Flower Society.

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The conservation objectives for *Zizia aptera* in New England call at a minimum for maintaining the three populations known from Ledyard, Branford, and Guilford, Connecticut at numbers approaching a temporal mean of 100 plants per population with an average of 20% seed-bearing stems over a three-year period. Such an objective will entail substantive and immediate efforts at CT .001 to conserve a tenuous population, and judicious management at the other two sites, where the plants are more vigorous. These population numbers are based empirically on a median size across the three extant populations that are known from herbarium specimens to have persisted for over 50 years in Connecticut. There is no reliable "formula" for deriving a theoretical minimum viable population size of 100 plants (MVP *sensu* Shaffer 1987). Rather, most conservation biologists have had to derive empirical estimates for MVP based upon long-term demographic modeling and evaluation of Allee effects (e.g., Damman and Cain 1998, Hackney and McGraw 2001). Figure 4 demonstrates exponential population increases (only in the CT .002 [Ledyard] population) only after numbers of plants exceeded 100-200 in 1993. Prior to that, and in the other two, very small populations, plants have been vulnerable to crashes due to mortality from disturbances such as early mowing. Because population-level reproductive rates are characteristically low in these populations (see above), and because all populations are separated by a minimum of several miles (and consequently, gene flow is likely to be low or nil), I err on the large side (10^2 order of magnitude) for estimating the number of rosettes that should be maintained in each population.

A long-range objective for the taxon in New England would be to regain the regional scope of the former distribution of *Zizia aptera*, with occurrences in Connecticut (in or near towns of Groton, Fairfield, Farmington, Old Saybrook in addition to current sites) and Rhode Island (in or near South Kingstown). Based on a conservative interpretation of herbarium specimens, the taxon may have been known from eight sites in Connecticut and one in Rhode Island. This long-range goal attempts to capture the species' former geographic coverage with populations spaced closely enough to permit possible gene flow. To meet this goal, strategies should emphasize searches of promising habitats rather than reintroduction to former sites. Over the next twenty years, concerted searches for *Zizia aptera* should take place at historical localities and previously unsearched areas with appropriate habitat in both Connecticut and Rhode Island in an effort to locate additional populations. Given that populations seem long-lived at their current sites and can form seed banks *in situ*, there is substantial potential to relocate historical sites based on herbarium specimens and archaeological reconstruction. It is also possible that populations of *Zizia aptera* have been overlooked or confused with the common congener or related species during informal surveys.

The feasibility and costs of such objectives must be weighed against the urgency of decline and the probability of success (Holsinger 1992). With only three populations known to exist in New England, the need is great; with ample experience in maintaining the plant (in the Rare Plant Garden at the New England Wild Flower Society and other nurseries and through careful land management at existing sites), the prospects of success are good. Widespread availability of potential habitat raises the probability that *Zizia aptera* will persist if such efforts are successful, an important criterion for setting conservation priorities (Holsinger 1992). Furthermore, actions taken in this region to better understand its biology and to protect and foster growth of its populations can inform range-wide conservation efforts for many plant species of this prairie guild, including *Solidago rigida* (Brown 2002) and *Taenidia integerrima* (Werier 2002).

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IV. APPENDICES

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1. **Habitats of *Zizia aptera* Throughout Its North American Range**

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

1. Habitats of *Zizia aptera* Throughout its North American Range

State, province, or region	Habitat description	Citation
Alabama	Reported from limestone glades: natural open areas of pavement, rock, gravel limestone or shallow soil < 25 cm deep dominated by low-growing herbaceous species. Dominant plants are C_4 summer annual grasses, summer annual and perennial herbaceous dicots, mosses, and lichens. High soil temperatures in summer, high irradiance, high extremes in soil moisture (with inundation during late autumn to early spring to below to permanent wilting point in late summer and early autumn).	Baskin et al. 1995
Alberta	Moist meadows.	Moss 1983: 434
Carolinas	Mixed deciduous forests, roadsides, and clearings; scattered localities, chiefly mountains and piedmont. Also on bluffs on the coastal plain and wet piedmont soils dominated by the Iredell series (mafic parent material), found with *Zizia aurea, Thalictrum revolutum, Camassia scilloides, Geranium maculatum, Podophyllum peltatum, Saxifraga virginiensis.*	Radford et al. 1978: 775 Hemingson 1990
Colorado	Localized in wet meadows of the West Mountain Valley and North Park (Eastern slope of Rocky Mountains).	Weber 1990: 53
Delaware and eastern shore of Maryland	Frequent in fields and open woods of the Piedmont.	Tatnall 1946: 192
Great Plains region	Prairies, open wooded hillsides, thickets.	Great Plains Flora Association 1986: 603
Illinois	Wet prairies in the north, limestone glades in the south. Upland forest, rocky woods, dry/dry-mesic/mesic/wet-mesic thickets, typical prairie, glades, limestone bluffs, successional fields and roadsides	Hemingson 1990 Illinois Plant Information Network 2002
Indiana	Only specimen is from an open, wooded slope in Harrison County about 3 miles east of Elizabeth. Dry, thinly forested limestone slopes and glades.	Deam 1984: 722 Hemingson 1990
Iowa	Dry to mesic prairies with a circumneutral soil.	Hemingson 1990
Manitoba	Very dry and dry forest areas.	Rowe 1956

1. Habitats of *Zizia aptera* Throughout its North American Range

State, province, or region	Habitat description	Citation
Michigan	Very rare and local, on dry, shaded bluffs. Steep and gravelly hillside prairies with *Bessya bullii, Bouteloua curitpendula, Quercus prinus, Heuchera* sp., *Andropogon* sp., and other prairie species. A northern population covers several acres of man-made mesic clearings on calcareous glacial till with *Achillea millefolium, Carex crawei, C. capillaris, C. castanea, Juncus balticus, Lilium philadelphicum, Potentilla fruticosa, Prunella vulgaris, Rudbeckia hirta.*	Voss 1985: 670 Hemingson 1990
Mid-Appalachian region	In woods and along river banks.	Clovis et al. 1972: 151
Minnesota	Wet mesic to mesic prairie but also dry mesic and dry prairies and dry woods. In areas dominated by *Stipa spartea* in driest communities of tallgrass prairie.	Hemingson 1990 Smeins and Olsen 1970
Missouri	Open canopy, rocky alluvial deposits in bottoms along intermittent stream at 250 m elevation.	Missouri Botanical Garden 2002
Montana	Relatively widespread in moist habitats...in moist, brushy thickets, very near or on the banks of watercourses.	Hemingson 1990
New Jersey	Most abundant in dampish soil or seepage areas on trap rock or diabase and in similar conditions in limestone region.	Hemingson 1990
New York: Cayuga Lake Basin	Dry upland slopes, open woods, and thickets, in gravelly and stony, rather heavy, acid or neutral soils; locally common; most abundant about the crests of the ravines and lake-shore cliffs.	Weigand and Eames 1925: 325
North Dakota	Common in coulees and moist meadows.	Stevens 1950: 218
Ohio	In several southern counties; prairie patches, woodland openings and borders. Grassy or barren opening over thin, calcareous soil, with *Andropogon gerardii, A. scoparius, Bouteloua curipendula, Silphium terebinthianaceum, Solidago rigida.* Also on talus below an exposure of low-grade limestone and on glacial till exposed on an eroded bluff above a stream. On hilltop lens of calcareous clay soil in transitional prairie in Buffalo Beats region	Cooperrider 1995: 222 Hemingson 1990 Hardin 1988
Pacific Northwest	Moist or wet places, generally in low ground, tolerant of alkali soils; in Rocky mountains, northwest Oregon, and Northeast Nevada.	Hitchcock and Cronquist 1973: 338

1. Habitats of *Zizia aptera* Throughout its North American Range

State, province, or region	Habitat description	Citation
Pennsylvania	Woods, wooded slopes, clearings, and roadsides, Facultative wetland plant (FAC). One site on limestone bluff in calcareous rocky summit community with *Quercus alba, Q. rubra, Q. velutina, Carya laciniosa, Juniperus virginiana, Ostrya virginiana, Staphylea trifolia, Saxifraga virginiensis, Hypoxis hirsuta, Potentilla simplex, Chrysogonum virginianum, Dodecatheon meadia.* Moist meadow along Penn's Creek.	Rhoads and Klein 1993: 271 Hemingson 1990 Moldenke 1946
Saskatchewan	Optimal development on sandy soils with high water table, pH 7.0-8.0. All stands examined are high in carbonates, some stands also saline, with *Triglochin maritima, Calamoagrostis sp., Danthonia sp., Achillea millefolium, Agropyron trachycaulum, Agrostis scabra, Aster laevis, Campanula rotundifolium, Galium boreale, Gentiana amarella, Heuchera richardsonii, Poa pratensis, Potentilla arguta, Sisyrinchium angustifolium, Solidago rigida, Potentilla gracilis.*	Looman 1963
South Dakota	Found on poorly-drained calcareous glacial till (Flom series soil) with *Pinus ponderosa, Populus tremuloides, Corylus cornuta.*	Hemingson 1990
Tallgrass Prairie region	Drier prairies.	Ladd 1995: 132
Virginia	Circumneutral to basic soils with associates *Polygala senega, Scutellaria leonardii.* In circumneutral soils (pH 6.3) at Potts Creek, with *Brachyelytrum erectum, Dicanthelium dichotomum, Viburnum acerifolium, Pinus strobus.* Riverbank Outcrop Barren (Calcareous Type) - frequently flood-scoured, rocky river-shore habitats supporting *Andropogon gerardii, Panicum virgatum, Muhlenbergia cuspidata, Hasteola suaveolens, Solidago rupestris, Baptisia australis, Galium boreale,* and *Cerastium arvense.*	Hemingson 1990 Mueller 1999 Fleming 2002
Washington (southeastern and adjacent Idaho)	Thickets by streams.	St. John 1963: 326
Wisconsin	Cedar Glade, Oak Barrens, Oak Opening, Oak Woodland, and Bedrock Glade; prairies maintained by periodic fires; *Quercus macrocarpa* savannah on Niagara dolomite exposures.	Curtis 1959
Wyoming	Wet meadows and stream banks.	Dorn 1988: 41

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.