New England Plant Conservation Program

Taenidia integerrima (L.) Drude
Yellow Pimpernel

Conservation and Research Plan for New England

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SUMMARY

Taenidia integerrima (L.) Drude (Apiaceae), yellow pimpernel, is secure throughout most of its eastern and central North American range. In New England, it is regionally rare with 10 extant and 23 historic occurrences. Six of the 10 extant occurrences have over 50 individuals and only two have over 200 individuals. Nine of the extant populations are in Vermont and the other one is in Connecticut. It is also known from an old, unverified report from Massachusetts, and there is one historic occurrence in Rhode Island. Intensive development has most likely extirpated most of the historic populations of *T. integerrima* in southern New England. It also appears to be vulnerable to competition with other plants.

In New England, *Taenidia integerrima* often grows on banks and bluffs adjacent to large bodies of water and rivers. The species prefers dry, rocky, calcareous open or partially wooded areas that present limited competition from other herbaceous or shrubby flora. It prefers sites that remain open over time such as rocky slopes and areas where the soil is shallow to bedrock. In the southern part of its range, and perhaps in southern New England, it persists on non-calcareous habitat.

The conservation objectives for *T. integerrima* in New England, are a minimum of nine populations in Vermont and two populations in southern New England, with a minimum of 50 to 100 ramets per population, and with over 50% of ramets producing umbels annually. Threats that need to be resolved in order to achieve these goals include invasive species, herbivory, competition by other herbaceous plants, densely shaded canopies, and human/residential development.

In Vermont, the main actions that need to occur are management of the habitat of a few extant populations. This management mostly involves opening the canopy and herbaceous layers to allow the plants to fruit and germinate. These sites might normally allow for this process to happen naturally through wind throw and fire, but due to the small population size, immediate action is desirable. Ongoing monitoring of all extant sites is also needed to prevent declines from leading to extirpation at a particular site. Research is also needed to understand how the seed bank functions to maintain populations over time and how seeds are dispersed to other locales.

In southern New England, the main action called for is intensive management of the one extant population. This management will involve removal of invasive species, exclusion of rabbits, which are eating the plants, and stabilization of a bank. Searches for historic populations and consideration of establishment of a new population are also important actions for southern New England. Sites need to be secured in order to provide for long term conservation of the species.

PREFACE

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

NEPCoP is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

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

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

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection. If you require additional information on the distribution of this rare plant species in your town, please contact your state's Natural Heritage Program.

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I. BACKGROUND

INTRODUCTION

Taenidia integerrima (L.) Drude (yellow pimpernel), a member of the Apiaceae (carrot family), is a long-lived perennial herbaceous plant that prefers dry, open or partially wooded sites. It is one of only two members of the genus *Taenidia* and is a distinct taxon. It is secure throughout most of its North American range. In New England, however, it is regionally rare with 10 extant and 23 historic populations found in Vermont, Connecticut and Rhode Island. Nine of the extant populations are in Vermont, while one is in Connecticut.

This species has a strong preference for sites where the herb and shrub layers are not dense and the canopy is open. In New England, it finds these conditions on banks, bluffs, and slopes adjacent to large water bodies and rivers. It flowers and fruits prolifically in most environments except when it gets shaded and where competition from herbaceous vegetation is intense. It also has a preference for calcareous soils but can tolerate (at least in the southern part of its range) non-calcareous soils.

Many historic populations of *Taenidia integerrima*, especially in southern New England, are in areas where intensive development has taken place, and this activity has most likely caused the extirpation of the species at these sites. A dense herb and shrub layer threatens one extant population (VT.007 [Ferrisburgh]). The only extant population in southern New England (CT.004 [Guilford]) is threatened by the invasive species *Cynanchum louiseae*, by rabbit herbivory, and by an eroding bank.

The purpose of this report is to present a detailed synopsis of what is known about *Taenidia integerrima* and to develop conservation goals and actions for this taxon in New England. This was achieved by gathering information from Natural Heritage programs, scientific literature, herbaria, and personal observations. Implementation, by private and public conservation organizations, of the actions laid out in this report is anticipated to lead to the conservation of this species in New England.

The conservation goals for the species in New England include the continued persistence of nine populations in Vermont and the presence of two in southern New England. All of these populations should have a minimum of 50 to 100 ramets, and a minimum of 50% of the ramets should produce umbels annually.

In Vermont, there are currently nine extant populations. Conservation actions for these populations include ongoing monitoring, opening the canopy, clearing the herbaceous layer, and scarification of the soil. Research should quantify the species reactions to opening the canopy, clearing the herbaceous layer, and scarification of the soil. Additional research should be conducted to better understand the seed bank and

means of dispersal. Searches for historic populations are recommended, as habitat for this species may still be present at these sites. Searches for new population should also be conducted. Securing sites is also recommended to allow for the conservation of this species into the future.

In southern New England, the main action called for is management to prevent extirpation of the one extant site. This management includes removal of invasive species, exclusion of rabbits (which are eating the plants), and stabilization of an eroding bank. Additional actions include searches for historic populations, securing sites, and the consideration of the establishment of a new population.

DESCRIPTION

Taenidia integerrima is a distinctive, glabrous, perennial, herbaceous plant. Each individual has one to a few stems that are 4-8 dm. in height. Small and non-reproductive individuals consist of only a basal rosette. Both basal and cauline leaves are once- to thrice-ternate or divided. The leaflets are entire and discrete, although some may be confluent with each other and therefore appear to have one to two lobes. The leaflets often have a mucronate tip. The inflorescence consists of one to a few umbels, which are terminal and lateral. The outer umbellets have marginal fertile flowers and inner staminate flowers. The inner umbellets are composed +/- entirely of staminate flowers. About one half of the total number of rays of an umbellet bear flowers which are fertile. The petals are yellow. The fruit is mostly 4-5 mm long by 3-4 mm wide. It is slightly compressed laterally and the ribs are distinct and low. The roots are tuberous-thickened and mostly vertical (Guthrie 1968, Gleason and Cronquist 1991). An occasional root will proliferate horizontally and produce a new clone (David Werier, personal observation).

In New England, *Taenidia integerrima* is easy to distinguish in the field. The entire leaflets separate it from other similar-looking plants in the Apiaceae. Other plants that look similar include *Caulophyllum* sp. and *Thalictrum* sp. These plants have consistently lobed leaves, whereas *Taenidia integerrima* has most if not all leaflets without lobes. The bruised foliage of *Taenidia integerrima* also has a celery-like odor that helps to distinguish it in the field.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

The genus *Taenidia* (Torrey & A. Gray) Drude is a member of the Apiaceae with two species, both occurring in eastern North America. *Taenidia montana* (Mackenzie) Cronq., which is closely related to *Taenidia integerrima* (L.) Drude, occurs primarily on shale barrens of Maryland, southern Pennsylvania, Virginia, and West Virginia. These two species are virtually indistinguishable morphologically except for the morphology of their fruits. *Taenidia integerrima* has wingless and laterally compressed fruits compared with the winged and dorsally compressed fruits of *T. montana* (Guthrie 1968). The two species also differ in the odor of the crushed foliage. The crushed foliage of *T.*

integerrima has a "light, pleasant, celery-like odor" while *T. montana* has a "heavy, rather unpleasant, somewhat anise-like odor" (Cronquist 1982). There is no evidence of hybridization between these two species. Since characteristics of the fruit have long been used in distinguishing different tribes in the Apiaceae, these two species had originally been placed in very disparate tribes (Guthrie 1968).

The type specimen of *Taenidia integerrima* was originally collected by John Clayton in Virginia (Clayton 549 (NHM)). Gronovious (1739) in *Flora Virginica* was the first to publish a description. *Taenidia integerrima* (L.) Drude (Drude 1898) was included in Carl Linnaeus' *Species Plantarum* in 1753 as *Smyrnium integerrimum*. Torrey and Gray (1840) placed *Taenidia integerrima* (as *Zizia integerrima*) in the section Taenidia. Drude (1989) elevated *Taenidia* to specific rank. Other synonyms, with citations from their original publication, include *Angelica integrifolia* (Walter 1788), *Sison integerrimus* (Sprengel 1825), *Zizia integerrima* (de Candolle 1829), *Pimpinella integerrima* (Bentham and Hooker 1867, Gray 1868), and *Pimpinella integrifolia* (Wood 1870).

Although *Taenidia integerrima* has been placed in several different genera, it has no obvious close allies except for *Taenidia montana* (Cronquist 1982). Currently, there is no widely accepted modern classification of the Apiaceae family. The classification of the family created by Drude (1898) — although most universally used in part due to the lack of acceptable alternatives — is highly criticized and believed to be artificial (Downie et al. 2000).

Contemporary taxonomists have been working on a new classification of the family and so far have come up with some tentative taxonomy (Plunkett et al. 1999, Downie et al. 2000). *Taenidia integerrima* falls into the subfamily Apioideae. This subfamily was recognized in Drude's (1898) monograph and is supported by recent investigations (Downie et al. 1998). The genus *Taenidia* is tentatively placed in a grouping (clade) called the "Rocky Mountain" umbellifers (with the realization that many of the species in this group extend beyond this range). Other eastern genera in this grouping include *Thaspium* and *Zizia* (Downie et al. 2000).

SPECIES BIOLOGY

Phenology of Flowering and Fruiting, and Seed Maturation

In New England, *Taenidia integerrima* flowers from late May until mid-June and is in fruit from July through early September. Most, if not all, fertile flowers go on to produce fruit. Seed set can be quite high. In an examination of herbarium specimens from outside of New England, an average of 77 seeds were produced per umbel. This number is consistent with casual observations of plants in New England even when only a few flowering plants are present (Werier, personal observation).

The floral and inflorescence characters within the Apiaceae appear to be specialized to favor outcrossing even though there is almost full self-compatibility (Lindsey 1982, Lindsey and Bell 1985). One such character in *Taenidia integerrima* is the occurrence of protogyny (the stigmas become receptive before the stamens mature). This condition is rare in Apiaceae, with most species being protandrous (the stamens mature before the stigmas become receptive). Protogyny is also present in spring-flowering species of *Lomatium*, *Polytaenia*, *Thaspium*, and *Zizia* of the Apioideae (Lindsey and Bell 1981).

The outer umbellets of *Taenidia integerrima* have hermaphroditic flowers on the margins and staminate flowers in the center. The inner umbellets are composed of fully staminate flowers (Mathias and Constance 1944, Gleason and Cronquist 1991). In *Thaspium* and *Zizia*, two genera closely related to *Taenidia*, the hermaphroditic flowers of an umbel all bloom simultaneously (with the stigmas becoming receptive before the stamens mature). After both the stigmas of the hermaphroditic flowers lose their receptivity and the anthers of the hermaphroditic flowers are no longer dehiscing, the staminate flowers develop. The primary umbel blooms first within a single flowering stalk; after it is fully done blooming, the secondary umbels on the stalk develop simultaneously. Separate stalks of a single plant are not completely synchronized so that selfing is possible among flowers of different stalks of the same plant (Lindsey 1982).

Lindsey (1982) showed that some fruit set occurred in mechanical self-pollination of some species in *Thaspium* and *Zizia*. There is the potential for inbreeding depression in *Thaspium barbinode* due to a reduction in fruit set following self-pollination of flowers on different stalks of a single plant. This has also been documented in *Daucus* (Lindsey 1982).

Pollination Biology

In the past, species of Apiaceae were considered to have "promiscuous pollination." That is, they can be pollinated by a large and diverse number of pollinators (Bell 1971, Lindsey 1984). This was considered the case by Robertson (1928), who observed 113 different species of insects "sucking nectar legitimately and effecting pollination" of the flowers of *Taenidia integerrima*. Lindsey (1984) proved that although many insects visit flowers of species of Apiaceae, there is a high degree of specialization in the pollination system and only a limited number of these insects are efficient and important pollinators.

Some species of *Thaspium* and *Zizia* (two genera closely related to *Taenidia*) are almost entirely pollinated by a few insects, even though they are frequented by many insect visitors to the flowers. A study completed in North Carolina and Virginia, showed that the effective pollinators of these species were solitary bees (Andrenidae: *Andrena miranda*, *Andrena crataegii*, *Andrena nasonii*, and *Andrena ziziae*; Apidae: *Apis mellifera*; Colletidae: *Hyleus modestus*; and Halictidae: *Augochlorella striata*, *Dialictus* nr. *laevissimus*, and *Evylaeus macoupinensis*) and flies (Syrphidae: *Meliscaeva cinctella*)

(Lindsey 1984). Solitary bees have also been shown to be the most effective pollinators of another closely related genus *Lomatium* (Schlessman 1982).

An oligolectic relationship (the exclusive collection of pollen by the female bees from one plant species or a group of closely related species) exists between *Andrena ziziae* and the "zizioid" umbels (which include species of *Thaspium* and *Zizia*). When *Andrena ziziae* is present and abundant with some species of *Thaspium* and *Zizia,* it will be the dominant pollinator. At the same time, oligolecty appears to be a one-way specialization. Although the bee is specialized, the plant is not, and therefore in the absence of the bee other dominant pollinators fulfill the pollination role (Robertson 1899, Lindsey 1984). This information is relevant in regards to *Taenidia integerrima* because *Thaspium* and *Zizia* are closely related, and *Andrena ziziae* has been reported as an abundant insect found sucking nectar and collecting pollen on *T. integerrima* (Robertson 1928).

Dispersal

Taenidia integerrima dispersal methods are unknown. The fruits are about 4-5 mm long and 3-4 mm wide. As with all Apiaceae species, the fruits (schizocarps) split at maturity into two one-seeded carpels (mericarps). They have no burs, spines, or other means of attaching to animals. They appear to simply fall to the ground after maturation. Since the roots of *Taenidia integerrima* are tuberous-thickened, dispersal may also occur via root fragments.

The fact that *Taenidia integerrima* is found on shores of rivers and large bodies of water suggests that one mechanism of dispersal is via water. Both seeds and/or root fragments may be able to disperse via water. Along the shore of Lake Champlain, this dispersal method could have left populations stranded above the current lake level because lake levels have lowered since the time of the last glaciation when Glacial Lake Vermont covered most of the present day Champlain Valley (Thompson and Sorenson 2000). This dispersal method would also explain the populations that are on islands in Vermont (VT.001 [Ferrisburgh] and VT.003 [Shelburne]).

Populations of *Taenidia integerrima* occur most often in discrete patches. This is most evident in small populations (CT.004 [Guilford], VT.002 [Colchester], and VT.005 [Orwell]), where individuals are clumped together and are not spread out over a larger area, even when there is ample apparent habitat nearby. This may be due to poor dispersal ability.

Poor dispersal has been linked to increased genetic variation between populations. In a study on three sympatric forest herbs in the Apiaceae family, it was show that the predominant factor affecting gene flow in these ecologically and taxonomically similar species was their dispersal ability. Species that had less of an ability to disperse showed greater genetic variation between populations (Williams and Guries 1994).

Life Cycle

Taenidia integerrima has a deep-rooted, thickened rootstock. Most often, each root produces one crown from which arise one to a few stalks. Occasionally, more than one crown is produced. On exceptional individuals, the roots can proliferate horizontally and produce additional crowns at some distance (5-10 cm) (Werier, personal observation).

Field observations and root structure both suggest that individual plants are long lived (Werier, personal observation). At the same time, it is unknown how long seeds are viable in the seed bank. Clearly, disturbances are needed to maintain an open canopy and herbaceous layer, both requirements of *Taenidia integerrima* (see Habitat and Ecology section, below). After the disturbance event, either the germination of seeds from the seed bank or the ability of depauperate populations to become robust again would allow populations to survive.

Use by Native Americans

Taenidia integerrima is suspected of being introduced by Native Americans at a few sites near Montreal (Jacques Labrecque, Centre de Données sur le Patrimoine Naturel du Québec, personal communication). The plant is also known to grow on a clam-shell midden in southern Connecticut (CT.004 [Guilford]) that was created by Native Americans. A few references in the literature mention the use of this plant by Native Americans. The Menomini used *T. integerrima* roots as a seasoner to make female remedies taste good, root tea in the treatment of pulmonary troubles, and roots steeped and chewed for bronchial affections (Smith 1923). The Meskwaki also used the roots as a seasoner (Smith 1928). Ojibwe hunters smoked *T. integerrima* seeds in a pipe to bring luck when they went hunting (Smith 1932).

HABITAT/ECOLOGY

Taenidia integerrima is found throughout its range in dry, rocky or gravelly forests or thickets, on shaly slopes, in open forests, and in open areas where there is little competition from other vegetation. The open areas with little competition from other vegetation include: shale barrens; clearings in forests where the vegetation remains sparse; rocky bluffs and banks; sandy beaches of rivers and lakes; and poor soil of artificially created open areas such as highway and railroad cuts. Its inability to endure competition from other vegetation is demonstrated by its absence from true grassland communities (Guthrie 1968).

Taenidia integerrima prefers an open canopy where competition from other plants is low (Guthrie 1968). Dense canopy cover often results in the growth/production of fewer flowering stalks. This is quite apparent at VT.002 (Colchester) subpopulation one. There are two subpopulations at this site. At subpopulation one the canopy cover has

been quite dense for at least twenty years and the percentage of plants with flowering stalks compared to plants without flowering stalks has dropped from 70% in 1983 to about 10% in 2001. At the same time, it appears that *Taenidia integerrima* can produce ample fruits despite moderate canopy closure. An example of this is VT. 005 (Orwell), which is a woodland where there is some canopy closure. The proportion of plants with flowering stalks is about 67% (Werier, personal observation).

In populations where the herbaceous layer is dense, there seems to be fewer individuals, even if the individuals present are robust. An example of this is VT.007 (Ferrisburgh), where the canopy is open, yet the herbaceous layer is dense. There are only five individuals present at this site, but each individual is robust with many umbels and fruits per plant (Werier, personal observation).

Taenidia integerrima can grow in xeric conditions. In xeric shale barren areas, it appears that the rock mantle limits germination. However, once plants are rooted, there is sufficient moisture and nutrients for robust growth (Guthrie 1968).

According to Guthrie (1968), there is no association of *Taenidia integerrima* with any specific rock formation; it grows where the underlying or exposed bedrock is sandstone, limestone, or shale. On the shale barrens of the mid-Appalachians, where *Taenidia integerrima* is abundant, the pH of the soils ranges from 4.0-5.8 (Platt 1951, Guthrie 1968). *Taenidia integerrima* also grows where limestone is the underlying bedrock and this bedrock is close to the surface, showing that it can tolerate high pH soils. In Vermont, *Taenidia integerrima* is only known from sites with relatively high pH soils. In fact, it is unclear whether it can tolerate relatively lower pH soils in the northern part of its range.

Most New England populations grow adjacent to a large water body (Lake Champlain, Long Island Sound, and the Housatonic and Mianus rivers). All of the Vermont populations and the population in inland Connecticut (CT.002 [New Milford]) are in areas with high pH soils and limestone or other calcareous rocks (Dowhan and Craig 1976, Thompson and Sorenson 2000). Exact locations of many historic sites in Connecticut are unknown and therefore so is knowledge of the chemistry of the associated soils and bedrock. At the same time, all of the coastal populations (CT.001 [Branford], CT.004 [Guilford], CT Historic [Branford I], CT Historic [Branford II], CT Historic [Greenwich], CT Historic [Milford I], CT Historic [New Haven II], and CT Historic [West Haven]) are in areas where the soils are predominately acidic (Dowhan and Craig 1976). One site in coastal Connecticut (CT.004 [Guilford]) is growing on a clam-shell midden over exposed granitic bedrock. This shows that although populations may be in landscapes where the general bedrock and soils are acidic, the local growing site can have high pH and/or nutrient enrichment.

Many of the southern New England occurrences were or are growing adjacent to Long Island Sound (CT.001 [Branford], CT.004 [Guilford], CT Historic [Branford I], CT Historic [Branford II], CT Historic [Greenwich], CT Historic [Milford I], CT Historic [New Haven II], and CT Historic [West Haven]) and were or are receiving some minerals

from marine waters. All of these populations except CT.004 (Guilford) are historic and specific locality information is unknown. Therefore, except for CT.004 (Guilford), it is unknown how close these historic populations were or are to Long Island Sound and whether they were or are receiving some minerals for marine waters. The CT.004 (Guilford) population is approximately 10 meters from Long Island Sound and most likely, the ocean only occasionally sprays this population. The population does not seem particularly different from other known sites. It is interesting to note that Lake Champlain was a marine ecosystem from approximately 13,500 to 11,000 years before the present (Thompson and Sorenson 2000).

Taenidia integerrima may have come into New England, as did many other taxa, during a warm and dry period known as the Hypsithermal period which occurred between 8,500 to 5,000 years ago (Mehrhoff 1997; Les Mehrhoff, University of Connecticut, personal communication). Conditions during that time were probably more favorable for *T. integerrima.* If this hypothesis is correct, it is likely that populations in New England have been in decline since that time.

THREATS TO *TAENIDIA INTEGERRIMA*

Loss of Habitat

Intensive development has most likely caused the extirpation of many populations in southern New England (RI Historic [Smithfield], CT.001 [Branford], CT Historic [Milford I], CT Historic [Branford II], CT Historic [Greenwich], CT Historic [Milford II], CT Historic [Stratford], and CT Historic [West Haven]) and around Burlington, Vermont (VT.012 [Burlington]). It should be mentioned that at least one population (VT.015 [Ferrisburgh]) is growing in an area that has been heavily developed with "camps." It is possible that "camp" development actually benefited the species by creating more open sites and conditions. At the same time, further construction or landscaping "improvements" could harm these populations (Marc Lapin, Ecosystem Science and Consulting, personal communication). Since many of the populations in New England are growing adjacent to Lake Champlain and Long Island Sound (areas heavily used for "second home" development), there is also the potential that further development in these areas will damage existing populations.

Invasive Species

Invasive species pose both a current and a potential threat to populations of *Taenidia integerrima* in New England. At the one extant Connecticut site (CT.004 [Guilford]), the population of *T. integerrima* is completely overgrown with *Cynanchum louiseae*. At this site, *C. louiseae* is outcompeting the *T. integerrima*. At all extant sites in Vermont, except perhaps VT.001 (Ferrisburgh), there is the potential that weedy non-native *Lonicera* shrubs, *Rhamnus cathartica*, and/or *Berberis vulgaris* could shade out *T. integerrima* populations. Although this does not appear to be happening in Vermont,

these invasive species are present at most sites. *Taenidia integerrima* would seem to be very susceptible to being out-competed by invasive species because it does not do well under dense shrub/canopy conditions and appears to disperse very slowly.

Severe Erosion

Erosion has caused the loss of a bank where part of a *Taenidia integerrima* population is growing (CT.004 [Guilford]). At this site, a storm caused a bank where the population of *T. integerrima* was growing to erode into the nearby Long Island Sound. New recruitment occurred adjacent to where the bank eroded away soon after the erosional event. Careful monitoring of this site was not done and it is unclear whether the new plants found were truly new recruitment or actually part of the original population. Another population of *T. integerrima* (VT.017 [Addison]) is growing on a bank subject to intense erosion. This population is apparently quite large and healthy although no seedlings were found during surveys of the site. Other populations (VT.002 [Colchester] and VT.003 [Shelburne]) are growing on top of bluffs and cliffs, which also undergo severe erosion. Most likely, *T. integerrima* grows in areas where high erosion is taking place because this erosion helps keep the habitat somewhat open both in the herbaceous and canopy layer. With some small populations, one large erosion event could potentially wipe out part of a population or the entire population. Therefore, severe erosion is both a potential threat that needs to be monitored and a needed element for population success. More information is needed to fully understand how disturbance impacts *T. integerrima* populations.

Herbivory

Herbivory at one site (CT .004 [Guilford]), likely by rabbits, has been quite extensive, and in one year prevented the production of any seed. Herbivory has not been noted for any of the other extant populations in New England. With large deer populations, there is the potential for herbivory to become a significant issue with other *Taenidia integerrima* populations, but the palatability of *Taenidia integerrima* to deer is unknown. As with erosion, herbivory can be both helpful and harmful since *Taenidia integerrima* needs areas with little competition from other plants. Past grazing by cattle has apparently opened up one site (VT.016 [West Haven]) to the point where *T. integerrima* is thriving. With small populations, herbivory could be detrimental if the *T. integerrima* is preferentially selected, as at CT.004 (Guilford).

Succession

Taenidia integerrima grows in sites that are often kept open by thin and droughty soils and/or steep slopes that are disturbed regularly by erosional forces. Fire may have also played a role in keeping these dry habitats open over time, particularly during the Hypsithermal period. Thus, vegetative succession may lead to conditions that are no

longer suitable for *Taenidia integerrima*. This may be occurring at VT.002 (Colchester) subpopulation one, where the canopy is very dense, and at VT.007 (Ferrisburgh), where the herbaceous layer is dense.

Succession and subsequent population declines followed by a disturbance and population increases may be a normal part of *T. integerrima* cycles. With fire suppression occurring in parts of Vermont (Thompson and Sorenson 2000), the disturbance needed to set back succession may be delayed or suppressed. Due to the small size of many *T. integerrima* populations, absence or delay of disturbance could mean the loss of this species. Therefore, it is important to manage, including potentially with fire, for early successional habitat.

Severe Natural Disturbances

Since many of the New England populations are relatively small in size (CT.004 [Guilford], VT.001 [Ferrisburgh], VT.003 [Shelburne], and VT.007 [Ferrisburgh]), a single disturbance event could wipe them out. The most likely event would be a storm, especially at coastal site CT.004 (Guilford). However, *Taenidia integerrima* is adapted to conditions that are often created by natural disturbance events. Also, the seemingly deep-rooted, strong, and tough roots of the species should be able to withstand disturbances. Overall, severe natural disturbances do not appear to be a significant threat, and may even be integral to the existence of *Taenidia integerrima*, at least compared to such threats as habitat loss and succession.

DISTRIBUTION AND STATUS

General Status

Taenidia integerrima is considered secure on a global level, with a rank of G5. It is also considered secure in the United States, with a national rank of N5. Its national rank in Canada is N?, meaning that the status in Canada has not yet been assessed. However, *T. integerrima* currently occurs in only two provinces in Canada: Quebec, with a provincial rank of S1, and one extant and five historic populations; and Ontario, with a provincial rank of S4 indicating it is apparently secure (Association for Biodiversity Information 2001). The *Flora Conservanda* (Brumback and Mehrhoff et al. 1996) lists the taxon as Division 2, "Regionally Rare." Table 1 and Figure 1 summarize the distribution and status of *Taenidia integerrima.*

Table 1. Occurrence and status of *Taenidia integerrima* in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS & LISTED AS (S1, S2, OR T &E)	**OCCURS & NOT LISTED AS (S1, S2, OR T & E)**	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
Connecticut (S1, E): 1 extant, 11 historic	Alabama (S?)	Arkansas (SR): occurs in 23 counties (USDA, NRCS 2001)	Rhode Island (SH): 1 historic occurrences
Delaware (S1.1)	District of Columbia (S?)	Georgia (SR): occurs in 8 counties (USDA, NRCS 2001)	South Dakota (SH)
Louisiana (S2)	Illinois (S?)	Indiana (SR): occurs in 36 counties (Deam 1940)	
Mississippi (S1)	Iowa (S3)	Kansas (SR): occurs in 11 counties (USDA, NRCS 2001)	
Quebec (S1): 1 extant and 5 historic occurrences	Kentucky (S?)	Maryland (SR)	
Texas (S1)	Michigan (S?)	Missouri (SR): occurs in 87 counties (USDA, NRCS 2001)	
Vermont (S2): 9 extant and 11 historic occurrences	Minnesota (SU)	Ohio (SR): 56 counties (Cooperrider 1995)	
	New Jersey (S3S4)	Oklahoma (SR)	
	New York (S?)	South Carolina (SR): occurs in 9 counties (USDA, NRCS 2001)	
	North Carolina (S3)	Tennessee (SR): 32 counties (Austin Peay State University et al. 2001)	

Table 1. Occurrence and status of *Taenidia integerrima* in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS & LISTED AS (S1, S2, OR T &E)	**OCCURS & NOT LISTED AS (S1, S2, OR T & E)**	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
	Ontario (S4)	Virginia (SR): occurs in 53 counties (USDA, NRCS 2001)	
	Pennsylvania (S?)	Wisconsin (SR): occurs in 30 counties (Wisconsin State Herbarium 2001)	
	West Virginia (S?)		

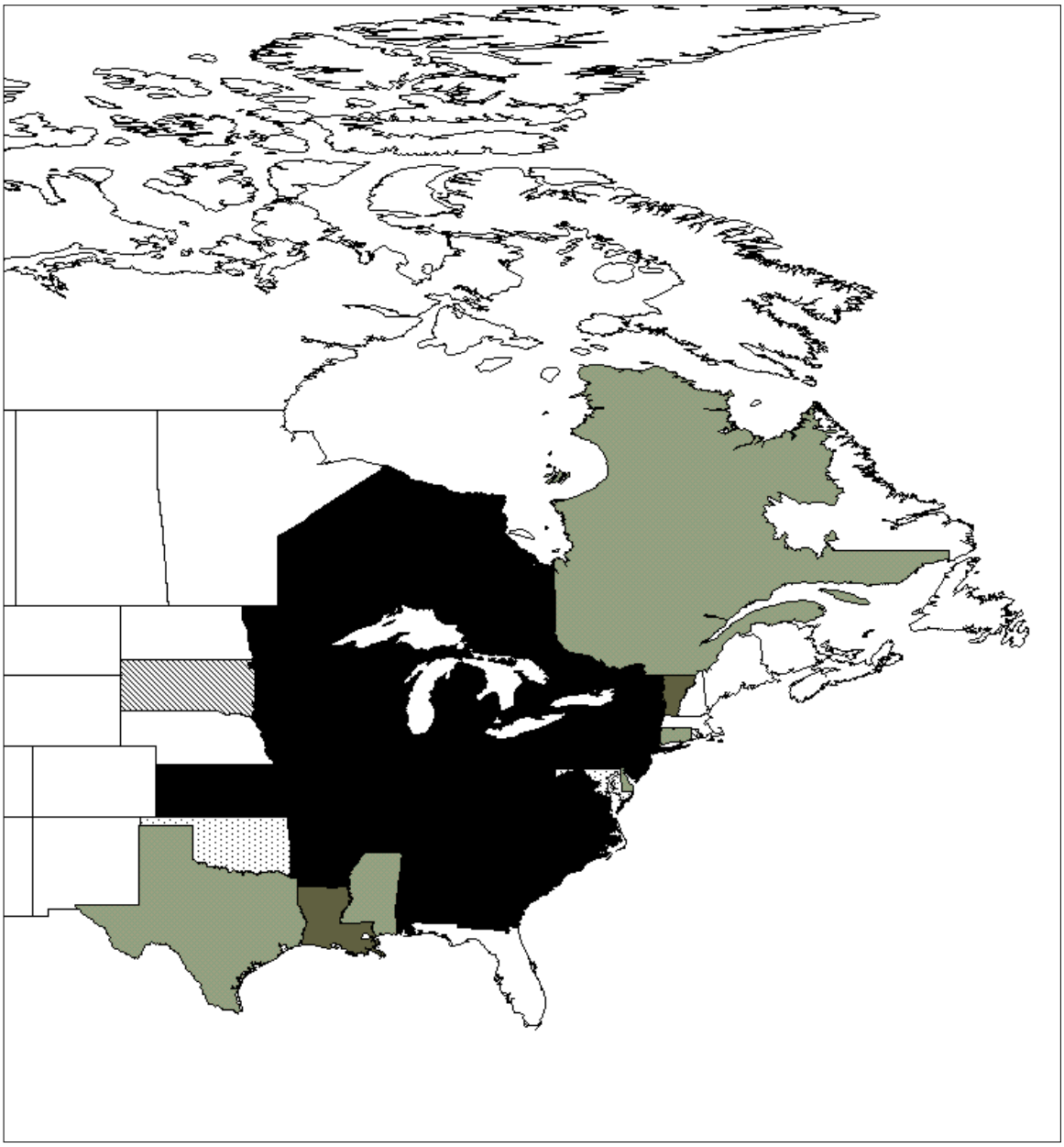

Figure 1. Occurrences of *Taenidia integerrima* in North America. Lightly-shaded states and provinces have a rank of S1 and darkly-shaded states have a rank of S2. States and provinces where *Taenidia integerrima* occurs but is not ranked as S1 or S2 are black. States with diagonal hatching are designated "historic." Stippling indicates states where *Taenidia integerrima* is ranked "SR" ("Status Reported;" see Appendix for explanation of biodiversity ranks).

Taenidia integerrima ranges from southwestern Quebec south to Connecticut, (one undocumented record from Massachusetts and no extant populations in Rhode Island), and central Georgia, west to Ontario, Minnesota, (no extant populations in South Dakota), Iowa, eastern Kansas, Oklahoma, and Texas (Guthrie 1968, Association for Biodiversity Information 2001). All the extant and historic populations in Quebec are around old Native American sites so it is suspected that these sites are of aboriginal introduction (Jacques Labrecque, personal communication). Massachusetts is not listed in Table 1 because the one report of its occurrence in the state is unverified.

Status of All New England Occurrences — Current and Historical

There are 10 extant and 23 historic occurrences of *Taenidia integerrima* in New England. These occurrences are from Vermont, Rhode Island, and Connecticut. Nine extant occurrences are from Vermont and there is one extant occurrence in Connecticut. There is one historic occurrence from Rhode Island, which is believed extirpated. Some of these occurrences are based on herbarium records with vague location information. As a result, some of these occurrences might actually be from the same sites. See Figure 2 for extant occurrences and Figure 3 for historic occurrences of *Taenidia integerrima* in New England. In Vermont, *T. integerrima* has the legal protection of state-threatened; in Connecticut it has the legal protection of state-endangered. For more information, see the specific information for each occurrence listed below.

There are also a few unconfirmed reports of *Taenidia integerrima* in New England. For example, there is a report of *T. integerrima* growing in Massachusetts (Cobb 1887, Stone 1913), but a search of numerous herbaria has turned up no specimens (see Appendix 1). These reports are listed below but are not assumed accurate until a voucher is found.

The New England occurrences are from two areas that are spatially disparate: the Lake Champlain Valley of Vermont and southern New England (Connecticut and Rhode Island). See Table 2 for a concise listing of all New England occurrences. See Table 3 for a listing of all endangered, threatened, rare, and uncommon species found at each occurrence.

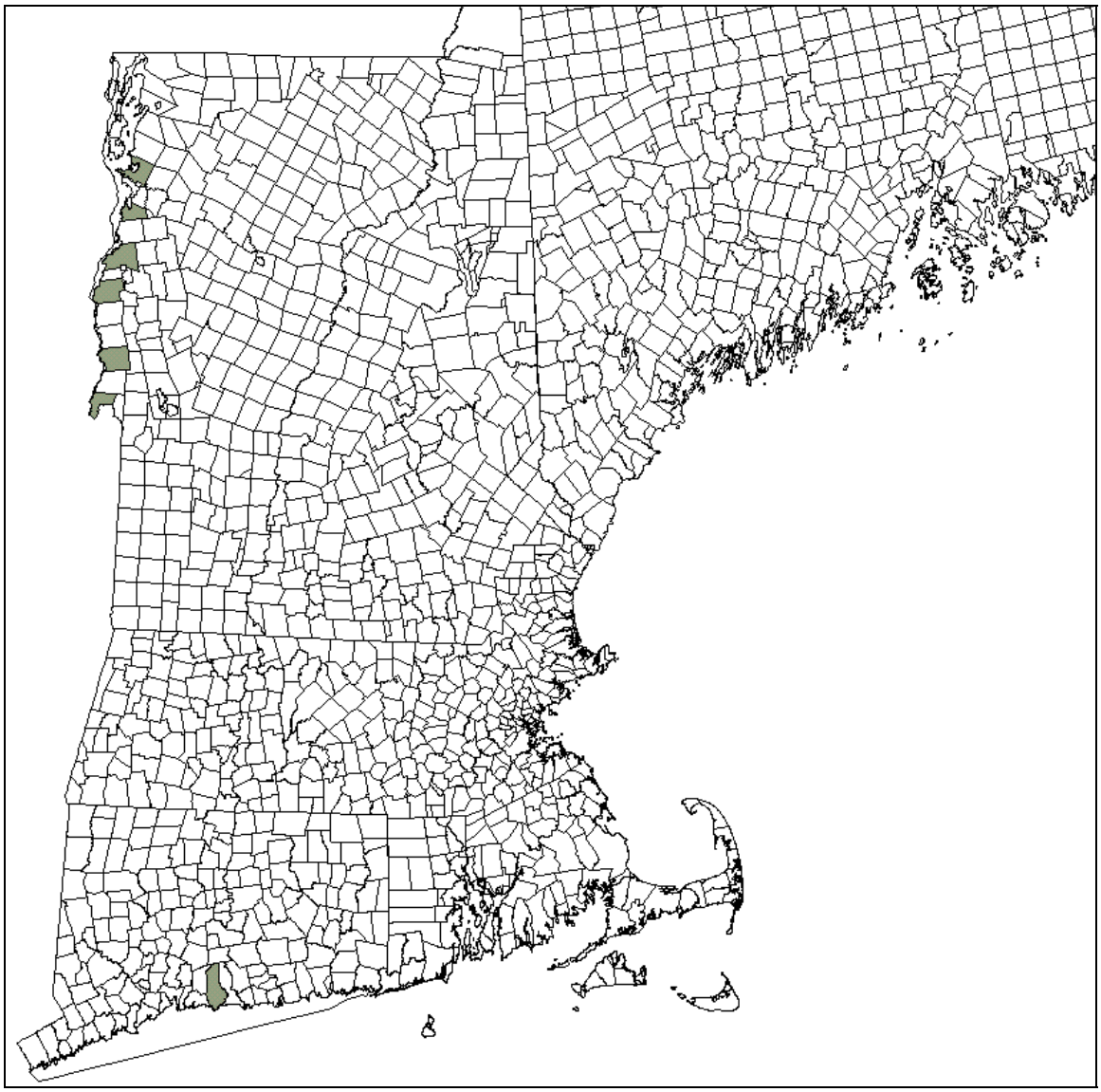

Figure 2. Extant occurrences of *Taenidia integerrima* in New England. Town boundaries for New England states are shown. Shaded towns have one to five confirmed, current occurrences.

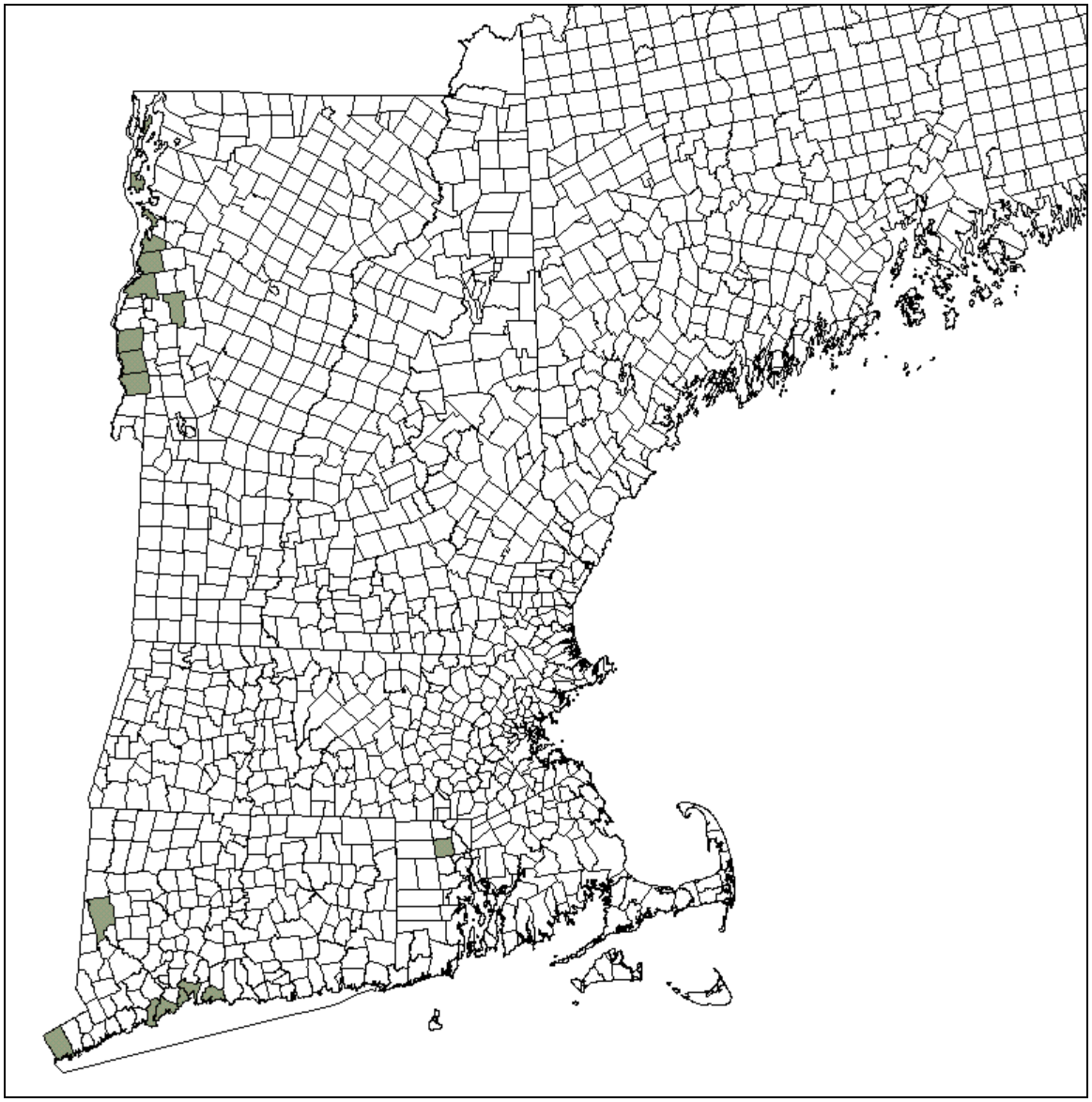

Figure 3. Historic occurrences of *Taenidia integerrima* in New England. Shaded towns have one to five historic records of *Taenidia integerrima*.

Table 2. New England Occurrence Records for *Taenidia integerrima.* Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
VT	**.001**	**Addison**	**Ferrisburgh**
VT	**.002**	**Chittenden**	**Colchester**
VT	**.003**	**Chittenden**	**Shelburne**
VT	.004	Addison	Orwell
VT	**.005**	**Addison**	**Orwell**
VT	**.006**	**Addison**	**Ferrisburgh**
VT	**.007**	**Addison**	**Ferrisburgh**
VT	.008	Addison	Shoreham
VT	.009	Chittenden	Shelburne
VT	.010	Addison	Ferrisburgh
VT	.011	Addison	Bristol
VT	.012	Chittenden	Burlington
VT	.013	Grande Isle	North Hero
VT	.014	Grande Isle	South Hero
VT	**.015**	**Addison**	**Ferrisburgh**
VT	**.016**	**Rutland**	**West Haven**
VT	**.017**	**Addison**	**Addison**
VT	Historic	Addison	Bridport
VT	Historic	Chittenden	Charlotte
VT	Historic	Chittenden	Shelburne
MA	Report		
RI	Historic	Providence	Smithfield
CT	.001	New Haven	Branford
CT	.002	Litchfield	New Milford
CT	.003	Litchfield	New Milford
CT	**.004**	**New Haven**	**Guilford**
CT	Historic	New Haven	Branford I
CT	Historic	New Haven	Branford II
CT	Historic	Fairfield	Greenwich
CT	Historic	New Haven	Milford I
CT	Historic	New Haven	Milford II
CT	Historic	New Haven	New Haven I
CT	Historic	New Haven	New Haven II
CT	Historic	Fairfield	Stratford
CT	Historic	New Haven	West Haven
CT	Report	Hartford	Berlin
CT	Report	Middlesex	Haddam
CT	Report	New Haven	Orange
CT	Report	Fairfield	Wilton

Table 3. Endangered, Threatened, Rare, and Uncommon Plants Found at Occurrences of *Taenidia integerrima*.

Element Occurrence	Rarities at site
VT.001 (Ferrisburgh)	*Agropyron trachycaulum* (S3-uncommon); *Astragalus canadensis* (S2-state-threatened); *Draba arabisans* (S2S3-rare); *Physostegia virginiana* (S2-state-threatened); *Quercus muhlenbergii* (S3-uncommon); and *Triosteum aurantiacum* (S3-uncommon)
VT.003 (Shelburne)	*Lathyrus ochroleucus* (S2-rare); *Shepherdia canadensis* (S3-uncommon); and *Symphoricarpos albus* (S3S4-uncommon)
VT.005 (Orwell)	*Adlumia fungosa* (S3-uncommon); *Asclepias quadrifolia* (S3S4-uncommon); *Carex formosa* (S3-uncommon); *Carex hitchcockiana* (S3-uncommon); *Eupatorium purpureum* (S2-rare); *Hedyotis cf. longifolia* (S2S3-rare); *Polygala senega* (S2S3-rare); *Quercus muhlenbergii* (S3-uncommon); *Rhus aromatica* (S3-uncommon); and *Symphoricarpos albus* (S3S4-uncommon)
VT.006 (Ferrisburgh)	*Polygala senega* (S2S3-rare)
VT.007 (Ferrisburgh)	*Symphoricarpos albus* (S3S4-uncommon)
VT.015 (Ferrisburgh)	*Corydalis aurea* (S2-state-threatened); and *Rhus aromatica* (S3-uncommon)
VT.016 (West Haven)	*Asclepias quadrifolia* (S3S4-uncommon); *Desmodium paniculatum* (S3-uncommon); *Eupatorium sessilifolium* (S1-state-endangered); and *Quercus muhlenbergii* (S3-uncommon)
VT.017 (Addison)	*Carex molesta* (S1); *Polygala senega* (S2S3-rare); *Rhus aromatica* (S3-uncommon); *Shepherdia canadensis* (S3-uncommon)
CT.004 (Guilford)	*Potentilla arguta* (special concern); *Solidago rigida* (S1-state-endangered); and *Sporobolus asper* (special concern)

CURRENT CONSERVATION MEASURES IN NEW ENGLAND

The New England Wild Flower Society (NEWFS) has done some *ex situ* work with *Taenidia integerrima*. One trial was done with 150 seeds sown in pots outside in April 1992. The seeds came from the Shaw Arboretum in Missouri. None of these seeds germinated in 1992, but five seeds germinated in May 1993. The seedlings were grown in pots till 1994, when they were planted out to three different locations in the botanical garden. One of these plantings was weeded out in 1997. Another one of the plantings was observed to be growing in 1999. In 2001, this same planting was considered dead. The third planting was not tracked. In another trial, seeds were sown in flats in February 1998. These seeds also came from the Shaw Arboretum in Missouri. The flats contained a mix of one part metro-mix (a general seed starting mix) and one part horticultural sand. The flats were covered with plastic and refrigerated for 90 days. In May 1998, a total of seven out of 27 seeds sown germinated. These plants were planted out in 1999. All the plants survived and were flowering in 2000 and 2001.

In September 2000, 37 seeds were collected from VT.002 (Colchester). The seeds were sent to the NEWFS. Thirty of the seeds were banked. In February 2001, the other seven were sown in two flats. The mix used in these flats was one part metro-mix, one part horticultural sand, and one part rice stone. The flats were placed on light tables

and then moved outside in the spring of 2001. No seeds germinated in 2001. The flats were left outside over the winter of 2002 and covered with micro-foam and plastic (Chris Mattrick, NEWFS, personal communication; records of the New England Plant Conservation Program).

One population, VT.016 (West Haven), is in a preserve owned by The Nature Conservancy (TNC). Use of this preserve is limited to recreation and hunting is allowed with permission. The preserve gets limited use. The area of the preserve where the *Taenidia integerrima* occurs is not actively managed (Droege, personal communication).

Another population, VT.017 (Addison), is in a Vermont State Park. Park officials are not aware of the presence of *Taenidia integerrima* at the park. Management plans for the park do not seem to interfere with the population at this site (Lincoln, personal communication).

Some private landowners where populations occur are sympathetic to preservation of these populations (VT.002 [Colchester] subpopulation one, VT.006 [Ferrisburgh], VT.007 [Ferrisburgh], and CT.004 [Guilford]) (Lapin, personal communication, Werier, personal observation). However, some of these landowners do not know where the exact populations are and do not know how to manage or monitor them.

Lauren Brown has been voluntarily monitoring and managing the population at CT.004 (Guilford). Black plastic netting has been placed over the population to prevent further herbivory by rabbits although, for unknown reasons, the netting has not been staying in place. Brown has also been clipping the invasive *Cynanchum louiseae*.

In Connecticut, where *Taenidia integerrima* is listed as state-endangered, it is protected by the Connecticut Endangered Species Act. The purpose of the Act is "to conserve, protect, restore, and enhance any Endangered or Threatened species or habitat." "Any action authorized, funded, or performed" by state agencies, shall "not threaten the continued existence of any Endangered or Threatened species or result in the destruction or adverse modification of habitat designated as essential to such species." The Act prohibits the taking of "an Endangered or Threatened species for the purpose of selling, offering for sale, transporting for commercial gain, or exporting." However, the Act does not prohibit "a person from performing any legal activities on his own land that may result in the incidental taking of Endangered or Threatened animal and plant species" (Connecticut General Statutes: Chapter 495: Section 26-303 to Section 26-315).

In Vermont, where *Taenidia integerrima* is listed as state-threatened, it is protected by the Vermont Endangered Species Law. The Law states that a person shall not "take, possess, or transport" a Threatened species (Vermont Statutes: Title 10: Part 4: Chapter 12: § 5401- § 5410).

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

In dealing with objectives for *Taenidia integerrima* in New England, it makes sense to break up the populations into two areas (the Champlain Valley of Vermont and southern New England (southern and western Connecticut and Rhode Island)) and to look at each of these areas separately. These two areas are separated by a large distance (approximately 135 miles), and the Vermont populations are all associated with similar habitat that is different from the habitat of the southern New England populations.

Champlain Valley of Vermont

The conservation objective for *Taenidia integerrima* in Vermont is to maintain nine populations (which is equal to the number of extant populations) at a population size of 50 to 100 ramets with at least 50% of these ramets flowering annually.

Taenidia integerrima is at or near the northeastern limit of its range in Vermont. The five historic and one extant population around Montreal and the St. Lawrence River are believed to be introduced by Native Americans in past times (Labrecque, personal communication). If the latter is true, the Vermont populations are truly at the edge of the species current range. As such, these populations probably contain different genetic information than the species in more central parts of the range; such genetic diversity could be helpful in the long-term survival and evolutionary potential of the species overall. Also, a loss of this species at the edge of its range will contract the overall species range.

It is clear from herbarium records, Vermont floras, and current Vermont Nongame and Natural Heritage Element Occurrence records that *Taenidia integerrima* has existed along the western edge of Vermont, adjacent to Lake Champlain along most of its length, for at least the past 100 years. It is not completely clear whether *T. integerrima* has increased or decreased over this period of time due to the uncertainty of whether or not many of the eleven historic populations are still extant, and the fact that since 1983 seven populations have been documented for the first time. Comparisons between the number of documented populations, within a 25-year period, at different times, shows that this number has not changed significantly. For example: in 1902 the number was eight; in 1927 the number was six; in 1952 the number was one; in 1977 the number was zero; and in 2002 the number was 10. This comparison is not a good reflection of whether the number of populations in Vermont have decreased over time — it is a better reflection of the amount of survey work done at any particular time — but it does help to illustrate the difficulty in assessing the change. At the same time, it can be assumed, that since there are at least nine historic populations that have, most likely, not

been relocated and that there has been intensive botanical surveys of the Champlain Valley in the 1980's and 1990's, that *T. integerrima* has declined in the past century. See below for further analysis on this question.

In the 1900's, many plant species with southern distributions increased or expanded their ranges in the Champlain Valley (Zika et al. 1983, Zika 1988, Zika and Marshall 1991). With current predictions of rapid climate change, there will be further, and perhaps relatively rapid, changes in plant distributions. In particular, species that grow in warmer local microhabitats will most likely be resilient to warming regional temperatures and may even become more abundant at such sites (Kutner and Morse 1996). At the same time, the species with southern distributions that have increased or expanded their range in the Champlain Valley are species that are good dispersers such as southern weeds and wind-dispersed species (Zika, personal communication). *Taenidia integerrima* is apparently a poor disperser and therefore may not benefit much from the trend of southern species increasing their range north.

Seven out of 20 populations (historic and extant) of *Taenidia integerrima* in Vermont appear to have been found in the last twenty years (or at least have been documented for the first time). A close inspection of historic herbarium specimens indicates that four (VT.002 [Colchester], VT.005 [Orwell], VT.006 [Ferrisburgh], and VT.015 [Ferrisburgh]) of these seven "newly found" populations might actually be rediscoveries of historic populations. It is hard to determine if this is truly the case, because many of the historic specimens have vague location data.

Eleven out of the 20 populations (historic and extant) of *Taenidia integerrima* in Vermont are historic. Seven of these historic populations have not been seen in at least a century. Most of these eleven historic populations are known only from historical collections, which have vague location data and have not been specifically searched for in recent times, but there has been a rather intensive effort at botanical inventory in the Champlain Valley of Vermont in the 1980's and 1990's. Even though there has been this general, intensive effort in the Champlain Valley, due to the lack of specific searches to find known historic populations, many populations may have been overlooked. One example that helps to illustrate this point regards VT.007 (Ferrisburgh). This site is relatively close to three other sites (VT.001 [Ferrisburgh], VT.006 [Ferrisburgh], and VT.015 [Ferrisburgh]) that have been documented in the recent past. VT.007 (Ferrisburgh) had not been seen since 1902 until the author specifically made an effort to find the population in 2001. The point being made is that until populations are deemed extirpated from a site, either by specific searches or observations of significant land conversion, their status should be considered historic but not necessarily extirpated.

The Champlain Valley was studied well in the late 1800's (Zika et al. 1983) and the literature that reflects this study shows that *Taenidia integerrima* was never considered rare in Vermont. Perkins (1888) in *Catalogue of the Flora of Vermont* described *T. integerrima* as being "common." This statement is not backed up by historical specimens, but it at least shows that *T. integerrima* was not truly rare. Later Vermont floras (Vermont Botanical Club 1900 and 1915, Dole 1937) all list *T.*

integerrima as occasional in the Champlain valley, which is the frequency category used just above rare. Flynn's (1935) *Flora of Burlington and Vicinity* also lists *T. integerrima* as occasional. In this publication, the term "rare" is used for plants that "occur in but few stations and there but sparingly" and "local" is used for plants that occur at few stations and are "abundant at such stations." These literature reports are not fully backed by voucher specimens, and the frequency categories are not precise; however, *T. integerrima* clearly was not very rare in the past 100+ years.

Although it is unclear if *Taenidia integerrima* has expanded or declined in Vermont, it is assumed it has declined due to the information presented above. In any case, the fact that there are only nine extant populations does indicate that it is not thriving in Vermont. Continued monitoring and searches (outlined in conservation actions below) are needed to better determine the trend of *T. integerrima*.

Determination of what a minimum viable population (MVP) should be is difficult due to the lack of understanding of *Taenidia integerrima* species biology. According to Pavlik (1996), a MVP (the minimum number of individuals needed to have a 95% chance that the population will survive 100 years) for a particular species ranges from 50 to 2500 individuals depending on specifics of the species biology and habitat needs. Table 4 presents information on the number of individuals and the percent in flower at each extant site in Vermont. There are five populations with over 100 individuals (one having as many as several hundred). It is also evident that there is not a wholesale reduction in population sizes over time. In central New York, where *Taenidia integerrima* is not rare, population sizes are often less than 150 individuals (Werier, personal observation). It is, therefore, assumed that the average population size of 50-100 is the size of a MVP in Vermont until further information indicates otherwise.

Table 4. Number of individuals and percent in flower for extant populations of *Taenidia integerrima* in Vermont

Element Occurrence	Number of individuals	Percent of plants that flowered
VT.001 (Ferrisburgh)	12+	unknown
VT.002 (Colchester)	48/150*	10%/unknown*
VT.003 (Shelburne)	2	100%
VT.005 (Orwell)	75	67%
VT.006 (Ferrisburgh)	100's	unknown
VT.007 (Ferrisburgh)	5	100%
VT.015 (Ferrisburgh)	150+	unknown
VT.016 (West Haven)	170	71%
VT.017 (Addison)	265	99%

*two well separated subpopulations

To determine the percentage of plants that should be in flower in each population, data was examined for Vermont populations (see Table 4). Casual observation of

numerous populations of *Taenidia integerrima* in New York indicate that most populations have a high percentage (at least 50%) of individuals that flower (Werier, personal observation). One subpopulation, in Vermont, with a low percentage of flowering individuals, VT.002 (Colchester) subpopulation one, is in decline and has lost vigor over the past twenty years. In 1987, when the surveyor considered this subpopulation healthy, at least 50% of the plants flowered. Therefore, it seems reasonable to suggest that to be considered healthy, populations in Vermont should have a minimum of 50% of individuals that produce umbels annually. Seedling recruitment should also be assured.

Southern New England

The conservation objectives in southern New England are to have at least two populations. Conserving at least two populations will help to prevent one catastrophic event from simultaneously destroying all populations in southern New England. Each of the populations should have a minimum of 50 to 100 ramets with at least 50% of the ramets producing umbels annually (see conservation objectives for Vermont). These objectives are quite conservative, but will allow for this species to remain extant in southern New England. As new research data become available, these objectives should be amended.

Taenidia integerrima appears to have undergone a large reduction in populations in southern New England in the past century (from at least twelve populations to one extant population). Herbivory, invasive plants, and erosion currently threaten the one extant population.

III. LITERATURE CITED

Austin Peay State University Center for Field Biology and the University of Tennessee Herbarium. 2001. Atlas of Tennessee Vascular Plants: Online Version. The University of Tennessee Herbarium, Knoxville, Tennessee, USA and The Austin Peay State University, Clarksville, Tennessee, USA. Available at: http://www.bio.utk.edu/botany/herbarium/vascular/atlas.html

Association for Biodiversity Information. 2001. NatureServe: An Online Encyclopedia of Life [web application]. Version 1.5. Arlington, Virginia, USA. Available at: http://www.natureserve.org/.

Bell, C. R. 1971. Breeding systems and floral biology of the Umbelliferae or evidence for specialization in unspecialized flowers. Pages 93- 107 in V. H. Heywood (Editor), *The Biology and Chemistry of the Umbelliferae*. Supplement 1 to the Botanical Journal of the Linnaean Society. Volume 64. Academic Press, New York, New York, USA.

Bentham, G. and J. D. Hooker. 1867. *Genera Plantarum.* Volume 1. Reeve and Co., Williams and Norgate, London, UK.

Berzelius Society. 1878. *A Catalogue of the Flowering Plants and Higher Cryptogams Growing Without Cultivation Within Thirty Miles of Yale College.* Yale University, New Haven, Connecticut, USA.

Bishop, J. N. 1896. *A Catalogue of All Phaenogamous and Vascular Cryptogamous Plants At Present Known To Grow Without Cultivation in The State of Connecticut*. Case, Lockwood and Brainard Co., Hartford, Connecticut, 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.

Chambers, J. C. and J. A. MacMahon. 1994. A day in the life of a seed: movements and fates of seeds and their implication for natural managed systems. *Annual Review of Ecology and Systematics* 25: 263-292.

Cobb, N. A. 1887. *A List of Plants Found Growing Wild Within Thirty Miles of Amherst.* S. E. Bridgman and Co., Northampton, Massachusetts, USA.

Cooperrider, T. S. 1995. *The Dicotyledoneae of Ohio. Part 2. Linaceae through Campanulaceae*. Ohio State University Press, Columbus, Ohio, USA.

Cronquist, A. 1982. Reduction of *Pseudotaenidia* to *Taenidia* (Apiaceae). *Brittonia* 34: 365-367.

Deam, C. C. 1940. *Flora of Indiana.* Department of Conservation, Division of Forestry, Indianapolis, Indiana, USA.

de Candolle, A. P. 1829. Troisième notice sur les plantes rares: qui ont fleuri dans le jardin botanique de Genève. *Mémoires de La Société de Physique et D'Histoire Naturelle de Genève* 4: 493.

Dole, E. J. (Editor). 1937. *The Flora of Vermont*. Third Revised Edition, Compiled by a Committee of the Vermont Botanical Club.. Free Press Printing Company, Burlington, Vermont, USA

Dowhan, J. J. and R. J. Craig. 1976. *Rare and Endangered Species of Connecticut and Their Habitats.* State Geological and Natural History Survey of Connecticut, Natural Resources Center. Department of Environmental Protection, Report of Investigations No. 6, Hartford, Connecticut, USA.

Downie, S. R., D. S. Katz-Downie, and M. F. Watson. 2000. Phylogeny of the flowering plant family Apiaceae based on chloroplast DNA rpl16 and rpoC1 intron sequences: toward a suprageneric classification of subfamily Apioideae. *American Journal of Botany* 87: 273-292.

Downie, S. R., S. Ramanath, D. S. Katz-Downie, and E. Llanas. 1998. Molecular systematics of Apiaceae subfamily Apioideae: Phylogenetic analyses of nuclear ribosomal DNA internal transcribed spacer and plastid rpoC1 intron sequences. *American Journal of Botany* 85: 563-591.

Drayton, B. and R. B. Primack. 2000. Rates of success in the reintroduction by four methods of several perennial plant species in eastern Massachusetts. *Rhodora* 102: 299-331.

Drude, O. 1898. Umbelliferae. Page 195 in A. Engler and K. Prantl (Editors), *Die Natúrlichen Pflanzenfamilien* 3: 195.

Flynn, N. F. 1935. *Flora of Burlington and Vicinity: A List of The Fern and Seed Plants Growing Without Cultivation.* Second Edition. Free Press Print Company, Burlington, Vermont, USA.

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

Graves, C. B., E. H. Eames, C. H. Bissell, L. Andrews, E. B. Harger, and C. A. Weatherby. 1910. *Catalogue of the Flowering Plants and Ferns of Connecticut*

Growing Without Cultivation. Connecticut Geological and Natural History Survey, Hartford, Connecticut, USA.

Gray, A. 1868. Characters of new plants of California and elsewhere, principally of those collected by H. N. Bolander in the state geological survey. *Proceedings of the American Academy of Arts and Sciences* 7: 327-401.

Griggs, J. E. 1971. *Soil Survey of Addison County, Vermont.* US Soil Conservation Service, Washington, D.C., USA.

Gronovius, J. F. 1739. *Flora Virginica*. Cornelium Haak, Lugduni Batavorum, Netherlands.

Guthrie, R. L. 1968. *A Biosystematic Study of Taenidia and Pseudotaenidia (Umbelliferae).* Ph. D. Dissertation, West Virginia University, Morgan Town, West Virginia, USA.

Harger, E. B., C. B. Graves, E. H. Eames, C. H. Bissell, L. Andrews, C. A. Weatherby. 1917. Additions to the Flora of Connecticut. *Rhodora* 19: 245.

Harger, E. B., C. B. Graves, E. H. Eames, C. A. Weatherby, R. W. Woodward, and G. H. Bartlett. 1930. *Additions to the Flora of Connecticut.* State Geological and Natural History Survey, Hartford, Connecticut, USA.

Harvard University Herbarium. 2001. Index of Botanists: online version. Harvard University, Cambridge, Massachusetts, USA. Available at: http://www.huh.harvard.edu/databases/cms/botanist_index.html.

Holmgren, P. K. and N. H. Holmgren. 2001. *Index Herbariorum:* online version. New York Botanical Garden, Bronx, New York, USA. URL: http://www.nybg.org/bsci/ih/ih.html.

Hyatt, L. A. and B. B. Casper. 2001. Seed bank formation during early secondary succession in a temperate deciduous forest. *Journal of Ecology* 88: 516-527.

Kutner, L. S. and L. E. Morse. 1996. Reintroduction in a changing climate. Pages 127-155 in Falk, D., C. I. Millar, and M. Olwell (Editors), *Restoring Diversity: Strategies for Reintroduction of Endangered Plants*. Island Press, Washington, D.C., USA.

Lapin, M. 1997. Mount Independence State Historic Site. Rare and uncommon plants of Mount Independence. In Mount Independence State Historic Site, Trails Master Plan. Prepared by Open Space Management and The Office of Robert A. White. Available at Fort Ticonderoga Reference Collection, Ticonderoga, New York, USA.
Lapin, M. and B. Engstrom. 1995. Biological Natural Areas of Western Addison County. Unpublished report. Vermont Nongame and Natural Heritage Program, Waterbury, Vermont, USA.

Lawlor, T. 2002. Element Stewardship Abstract for *Vincetoxicum nigrum* (L.) Moench. and *Vincetoxicum rossicum* (Kleopov) Barbarich -- Swallow-wort. Prepared for The Nature Conservancy and available online. The Nature Conservancy, Arlington, Virginia, USA. Available at: http://tncweeds.ucdavis.edu/esadocs/documnts/vinc_sp.pdf.

Lindsey, A. H. 1982. Floral phenology patterns and breeding systems in *Thaspium* and *Zizia* (Apiaceae). *Systematic Botany* 7: 1-12.

Lindsey, A. H. 1984. Reproductive biology of Apiaceae: 1. Floral visitors to *Thaspium* and *Zizia* and their importance in pollination. *American Journal of Botany* 71: 375-387.

Lindsey, A. H. and C. R. Bell. 1981. Protogyny and associated reproductive characters in Apiaceae. Page 269 in G. E. Scudder and J. L. Reveal (Editors), *Evolution Today: Proceedings of the Second International Congress of Systematic and Evolutionary Biology*, Vancouver, B. C., Canada, July 17- 24, 1980. University of British Columbia, Vancouver, British Columbia, Canada.

Lindsey, A. H. and C. R. Bell. 1985. Reproductive biology in Apiaceae II. Cryptic specialization and floral evolution in *Thaspium* and *Zizia.* *American Journal of Botany* 72: 231-247.

Linnaeus, C. V. 1957. *Species Plantarum*. A facsimile of the 1st ed., 1753. Volume 1. Ray Society, London, UK.

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.

Mathias, M. E. and L. Constance. 1945. Umbelliferae. *North American Flora* 28b: 161-295.

Mehrhoff, L. J. 1997. Thoughts on the biogeography of grassland plants in New England. Pages 15-23 in P. D. Vickery and P. W. Dunwiddie (Editors), *Grasslands of Northeastern North America: Ecology and Conservation of Native and Agricultural Landscapes.* Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Nuzzo, V., W. McClain, and T. Strole. 1996. Fire impact on groundlayer flora in a sand forest 1990-1994. *The American Midland Naturalist* 136: 207-221.

Pavlik, B. M. 1996. Defining and measuring success. Pages 127-155 in D. Falk, C. I. Millar, and M. Olwell (Editors), *Restoring Diversity: Strategies for Reintroduction of Endangered Plants.* Island Press, Washington, D.C., USA.

Perkins, G. H. 1888. *Catalogue of The Flora of Vermont, Including Phaenogamous and Vascular Cryptogamous Plants Growing Without Cultivation.* Free Press Association, Burlington, Vermont, USA.

Platt, R. 1951. An ecological study of the mid-Appalachian shale barrens and of the plants endemic to them. *Ecological Monographs* 21: 269-300.

Plunkett, G. M. and S. R. Downie. 1999. Major lineages within Apiaceae subfamily Apioideae: A comparison of chloroplast restriction site and DNA sequence data. *American Journal of Botany* 86: 1014-1026.

Robertson, C. 1899. Flowers and insects. XIX. *Botanical Gazette* 28: 27-45.

Robertson, C. 1928. *Flowers and Insects: Lists of Visitors of Four Hundred and Fifty-three Flowers.* Charles Robertson, Carlinville, Illinois, USA.

Schlessman, M. A. 1982. Expression of andromonoecy and pollination of tuberous Lomatiums (Umbelliferae). *Systematic Botany* 7: 134-149.

Seymour, F. C. 1982. *The Flora of New England: A Manual For The Identification of All Vascular Plants, Including Ferns and Fern Allies Growing Without Cultivation in New England*. Second Edition. H. N. Moldenke and A. L. Moldenke, Plainfield, New Jersey, USA.

Smith, H. H. 1923. Ethnobotany of the Menomini Indians. *Bulletin of The Public Museum of The City of Milwaukee* 4: 1-174.

Smith, H. H. 1928. Ethnobotany of the Meskwaki Indians. *Bulletin of The Public Museum of The City of Milwaukee* 4: 175-326.

Smith, H. H. 1932. Ethnobotany of the Ojibwe Indians. *Bulletin of The Public Museum of The City of Milwaukee* 4: 327-525.

Sorrie, B. A. and P. Somers. 1999. *The Vascular Plants of Massachusetts: A County Checklist.* Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program, Westborough, Massachusetts, USA.

Sprengel, K. 1825. *Systema Vegetabilium*. Volume 1. Sumtibus Librariae Dieterichianae, Gottingae, Germany.

Stone, G. E. 1913. *A List of Plants Growing Without Cultivation in Franklin, Hampshire, and Hampden Counties Massachusetts*. Press of Carpenter and Morehouse, Amherst, Massachusetts, USA.

Thompson, E. H. and E. R. Sorenson. 2000. *Wetland, Woodland, Wildland: A Guide to The Natural Communities of Vermont.* Vermont Department of Fish and Wildlife and

The Nature Conservancy. University Press of New England, Hanover, New Hampshire, USA.

Torrey, J. and A. Gray. 1840. *A Flora of North America.* Volume 1. Wiley and Putnam, New York, New York, USA.

United States Department of Agriculture, Natural Resources Conservation Service. 2001. The PLANTS Database, Version 3.1. National Plant Data Center, Baton Rouge, LA, USA. Available at: http://plants.usda.gov/.

Vermont Botanical Club. 1900. *Flora of Vermont: A List of The Fern and Seed Plants Growing Without Cultivation.* Prepared by Ezra Brainerd, L. R. Jones, and W. W. Eggleston. Free Press Association, Burlington, Vermont, USA.

Vermont Botanical Club. 1915. *Flora of Vermont: List of Ferns and Seed Plants Growing Without Cultivation.* Vermont Agriculture Experiment Station. Bulletin Number 187. Free Press Printing Company, Burlington, Vermont, USA.

Vermont Statutes: Title 10 Conservation and Development: Part 4 Fish and Wildlife Conservation: Chapter 123. Protection of Endangered Species: § 5404. Protection of Endangered and Threatened Species.

Walter, T. 1788. *Flora Caroliniana.* Sumptibus J. Fraser, London, UK.

Williams, C. F. and R. P. Guries. 1994. Genetic consequences of seed dispersal in three sympatric forest herbs. I. Hierarchical population - genetic structure. *Evolution* 48: 791-805.

Wisconsin State Herbarium: University of Wisconsin - Madison. 2001. Wisconsin Vascular Plants: online version. Wisconsin State Herbarium, Madison, Wisconsin, USA. Available at: http://wiscinfo.doit.wisc.edu/herbarium/.

Wood, A. 1870. *The American Botanist and Florist*. A. S. Barnes and Co., New York, New York, USA.

Zika, P. F. 1988. Contributions to the flora of the Lake Champlain Valley, New York and Vermont, II. *Bulletin of the Torrey Botanical Club* 115: 218-220.

Zika, P. F, R. J. Stern, and H. E. Ahles. 1983. Contributions to the flora of the Lake Champlain Valley, New York and Vermont. *Bulletin of the Torrey Botanical Club* 110: 366-369.

Zika, P. F. and E. J. Marshall. 1991. Contributions to the Flora of the Lake Champlain Valley, New York and Vermont, III. *Bulletin of the Torrey Botanical Club* 118: 58-61.

IV. APPENDICES

1. **Herbarium Documentation for *Taenidia integerrima***

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

1. Herbarium Documentation for *Taenidia integerrima*

The following herbaria were examined for specimens of *Taenidia integerrima* by the author unless otherwise noted: BH/CU (Bailey Hortorium, Cornell University, Ithaca, New York); CONN (George Safford Torrey Herbarium, University of Connecticut, Storrs, Connecticut); GH (Gray Herbarium, Harvard University, Cambridge, Massachusetts) examined by Arthur Haines, New England Wildflower Society (personal communication); HNH (Dartmouth College, Hanover, New Hampshire) information for Vermont from VT NNHP files; LSC (Lyndon State College, Lyndonville, Vermont) examined by David Conant, Lyndon State College (personal communication); MASS (University of Massachusetts, Amherst, Massachusetts) examined by Dr. Karen B. Searcy, University of Massachusetts (personal communication); MID (Middlebury College, Middlebury, Vermont) examined by Helen Young, Middlebury College (personal communication); NCBS (Connecticut Botanical Club, Yale University, New Haven, Connecticut); NEBC (New England Botanical Club, Harvard University, Cambridge, Massachusetts) examined by Arthur Haines (personal communication); NY (New York Botanical Garden, New York, New York); SJFM (Fairbanks Museum and Planetarium, St. Johnsbury, Vermont) information for Vermont from VT NNHP files; SPR (Springfield Science Museum, Springfield, Massachusetts) examined by David Stier, Springfield Science Museum (personal communication); VT (Pringle Herbarium, University of Vermont, Burlington, Vermont); YU (Yale University, New Haven, Connecticut).

VT.001 (Ferrisburgh)

Ferrisburgh, Gardiner's Island, 3 June 1882, E. Brainerd s.n. (SJFM);

Vermont, Ferrisburgh, Gardiner's Island, Lake Champlain, 8-11 July 1911, George L. Kirk and D. Lewis Dutton s.n. (VT);

Vermont, Addison County, Ferrisburgh, Gardiner's Island, Lake Champlain, open woods, 8 July 1981, P. F. Zika 4066 (VT).

VT.002 (Colchester)

Vermont, Colchester, no date, D. B. Griffen s.n. (VT). This record may not be from VT.002 (Colchester);

Vermont, Chittenden County, Town of Colchester, 29 June 1983, P. F. Zika 7305. Currently this specimen is still in Zika's collection (Peter Zika, personal communication).

VT.005 (Orwell)

Vermont, Orwell, 28 May 1936, G. H. Ross s.n. (VT). This record may not be from VT.005 (Orwell);

Vermont, Orwell, altitude 125 ft?, collected at Camp Singing Cedars, shale cliff, 28 May 1936, L. H. Potter s.n. (VT). This record may not be from VT.005 (Orwell).

VT.007 (Ferrisburgh)

Vermont, Ferrisburgh township, Fort Cassin, 10 Sept. 1878, E. Brainerd s.n. (VT);

Ferrisburgh, Fort Cassin, 4 July 1902, T. E. Hazen s.n. (SJFM).

VT.008 (Shoreham)
Vermont, Shoreham, 27 Aug. 1882, E. Brainerd s.n. (MID, SJFM, VT).

VT.009 (Shelburne)
Shelburne Bay, 29 Sept. 1855, William Boott s.n. (GH).

VT.010 (Ferrisburgh)
Vermont, Panton, Basin Harbor, 24 June 1882, E. Brainerd s.n. (VT). Basin Harbor is actually in the Town of Ferrisburgh and not the Town of Panton;
Ferrisburgh, Basin Harbor, 29 Aug. 1880, C. E. Faxon s.n. (GH).

VT.011 (Bristol)
Vermont, Bristol, rocky hills, 18 July 1879, C. G. Pringle s.n. (VT). The date should probably be 18 June 1879;
Vermont, Bristol, hills, 18 June 1879, C. G. Pringle s.n. (VT);
Vermont, Bristol, rocky hillsides, 18 June 1879, C. G. Pringle s.n. (VT);
Vermont, Bristol Pond, 18 June 1879, E. Brainerd s.n. (two sheets) (MID).

VT.012 (Burlington)
Vermont, Burlington, rocky ground, Holt's, 10 June 1901, N. F. Flynn s.n. (VT);
Vermont, Burlington, rocky hillside, 12 June 1896, N. F. Flynn s.n. (VT);
Vermont, Burlington, rocky hillside, 27 June 1899, N. F. Flynn s.n. (VT);
Abundant, 1842-1853, Joseph Torrey s.n. Note on sheet says, "possibly collected in Burlington VT or at least in Vermont. LAC!" (VT). LAC is the initials for Leopold A. Charette.

VT.013 (North Hero)
North Hero, 5 July 1905, no collector, herbarium of D. S. Carpenter (VT).

VT.014 (South Hero)
Vermont, South Hero, Miss Motte's Swamp, 1 June 1894, A. J. Grout s.n. (VT).

VT.015 (Ferrisburgh)
Ferrisburgh, Long Point, 27 May 1894, W. W. Eggleston s.n. (HNH, NEBC).

VT Historic (Bridport)
Addison County, Bridport, in dry, clayey soil on high banks of Lake Champlain, 30 August 1942, Weatherby 7202 (NEBC).

VT Historic (Charlotte)
Chittenden County, Charlotte, dry headland by lake, 28 May 1922, Knowlton s.n. (NEBC).

VT Historic (Shelburne)

Chittenden County, Shelburne, dry wooded shore, Shelburne Point, Utica shale, 28 May 1922, Knowlton s.n. (NEBC).

Additional Vermont specimens

Addison County, Ferrisburgh, dry open woods, 30 May 1920, Knowlton s.n. (NEBC);
Addison County, Ferrisburgh, N. Ferrisburgh, 30 May 1908, Kirk s.n. (NEBC).

CT.001 (Branford)

Connecticut, New Haven County, Branford, Hotchkiss shore woods, no date, A. W. Driggs s.n. (CONN).

CT.002 (New Milford)

New Milford, 18 June 1909, A. E. Blewitt 2599 (NCBS);
Connecticut, Litchfield County, New Milford, rocky bank of Housatonic River, 18 June 1909, C. H. Bissell s.n. (YU, NCBS);
Connecticut, New Milford, rocky bank of Housatonic River, 8 Sept. 1909, C. H. Bissell s.n. (NCBS);
Litchfield County, New Milford, dry stony ground near Housatonic River, 8 Sept. 1909, Weatherby s.n. (NEBC);
Kent, rocky bank of Housatonic River, 8 Sept. 1909, R. W. Woodard s.n. (NCBS, NEBC). This specimen is most likely from the New Milford site and therefore in New Milford township as opposed to Kent township. The NCBS specimen has two stems one with mature fruit and the other with immature fruit and greener leaves. Since it appears that several collections were made from this site both on 18 June and 8 Sept. it is believed that this specimen is actually two, one from 18 June and the other from 8 Sept. 1909.

CT Historic (Branford I)

Connecticut, Stony Creek, dry hillside, 7 June 1926, Mrs. E. P. Bullard Jr. s.n. (CONN).

CT Historic (Branford II)

Connecticut, New Haven County, Branford, Double Beach, 30 May 1926, E. B. Kelsey s.n. (YU, NEBC).

CT Historic (Greenwich)

Connecticut, Fairfield County, mouth of Myamus River, July 1869, M. Ruger s.n. (NY).

CT Historic (Milford I)

Connecticut, Milford, dry wooded bank along the Housatonic River near Milford Point, 27 May 1941, E. H. Eames s.n. (CONN);
Connecticut, Milford, dry woodland bank besides Housatonic River, colony, 27 May 1941, E. H. Eames s.n. (NCBS).

CT Historic (Milford II)

Milford, wooded dry bank along Housatonic River, 12 June 1907, E. H. Eames 5639 (CONN);

Milford, wooded bank of Housatonic River, 12 June 1907, E. H. Eames 5739 (NCBS);

Connecticut, Milford, wooded bank along the Housatonic River, 12 June 1907, E. H. Eames s.n. (NY);

Connecticut, New Haven County, Milford, shaded bank of Housatonic River, 13 July 1920, R. W. Evans s.n. (YU, NEBC).

CT Historic (New Haven I)

Connecticut, New Haven, East Rock, 1873, F. W. Hall s.n. (CONN);

Connecticut, New Haven, no date, no collector (VT);

Connecticut, New Haven, 1830-1833, no collector (YU).

CT Historic (New Haven II)

Connecticut, New Haven, near Oyster Point, 1859, A.B.E. s.n. (YU).

CT Historic (Stratford)

Stratford, sandy bank of Housatonic River, in shade of thin woods, 22 May 1898, E. H. Eames 7 (CONN);

Connecticut, Fairfield County, Stratford, thin shade of woods on dry bank of Housatonic River, 22 May 1898, E. H. Eames s.n. (NEBC);

Stratford, sandy bank of Housatonic River, in shade of thin woods, 22 July 1898, E. H. Eames 7 (CONN).

CT Historic (West Haven)

Connecticut, West Haven 9 June and 3 July 1879, J. A. Allen s.n. (YU).

New York sites adjacent to New England

New York, Skenes Mountain, Whitehall, 30 August 1900, Stewart H. Burnham s.n. (BH/CU).

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

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

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

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

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

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

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

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