

New England Plant Conservation Program

Amerorchis rotundifolia (Banks ex Pursh) Hultén
Small Round-leaved Orchis

Conservation and Research Plan
for New England

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SUMMARY

Small round-leaved orchis (Banks ex Pursh) Hultén (*Amerorchis rotundifolia*) is endemic to North America and Greenland. It is globally secure (G5), but rare throughout its distribution in the United States. In New England, *Amerorchis rotundifolia* only grows in cold northern white-cedar swamps and seepage forests of northern Maine (where it is ranked S1), though there are historic records from New Hampshire and Vermont (as well as New York). There are seven extant sites for *Amerorchis rotundifolia* in Maine; five are currently tracked, and two sites were discovered in the 2001 field season and have not yet been entered in the database for tracking. *Amerorchis rotundifolia* is at the edge of its range in northern New England, and likely has always been rather rare in our area.

Much of the biology of *Amerorchis rotundifolia* is unknown. It generally flowers in June, but information regarding pollinators, potential herbivores, preferred microhabitats, and mycorrhizal associations is lacking. Unlike some other orchid species, *Amerorchis rotundifolia* does not respond well to major disturbances such as power line cuts. Primary threats are timber harvest, general habitat destruction, and hydrologic changes. The first two threats are not an issue at the two largest sites as these sites are under conservation ownership, but hydrologic changes may be a potential threat there.

The primary conservation objective for *Amerorchis rotundifolia* in New England is to maintain plant populations at no fewer than the current number of known stations. Other conservation objectives are to continue protection of the plant on the two sites under conservation ownership, to reduce threats and increase population numbers on private lands through conservation easement or management, and to utilize the larger populations for demographic studies and possibly experiments to determine best management practices. Low-priority objectives are seed banking, *in situ* and *in vitro* germination, and outplanting into appropriate historic habitat.

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.

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I. BACKGROUND

INTRODUCTION

Small round-leaved orchis, *Amerorchis rotundifolia* (Banks ex Pursh) Hultén, is a member of the Orchid Family (Orchidaceae). *Amerorchis* is a monotypic genus, though it was previously considered in the genus *Orchis*, which in North America included *O. spectabilis* (= *Galearis spectabilis*) and *O. aristata* (= *Dactylorchis aristata*) (Luer 1975). *Amerorchis rotundifolia* is endemic to North America and is distributed from the west coast of Greenland, across Canada to Alaska, and south to a few northern states in the United States (Correll 1950, Luer 1975). In the most northern areas of its distribution, *Amerorchis rotundifolia* grows in tundra and limestone barrens (Luer 1975), but in its more southern areas of distribution, it is a plant of cold northern white-cedar swamps (Gibson 1905, Fernald 1919, Morris and Eames 1929, Correll 1950, Case 1964, Cameron 1976, Crow 1982, Brown 1997, Chapman 1997, Hinds 2000).

Amerorchis is rare throughout its distribution in the continental United States (NatureServe 2001). In New England, *Amerorchis* is extant only in Maine and has a state rank of S1. There are currently seven extant populations in Maine, including two previously unknown populations discovered by Andy Cutko and Mike Auger (of Maine Natural Areas Program, MNAP, personal communications) in 2001 and one population that is likely extirpated though is still tracked. There are five historical sites for *Amerorchis* in Vermont, where its state rank is SH. *Amerorchis* has been added to the tracking list in New Hampshire with the state rank of SH (October 2001) due to information discovered in the course of writing this plan (Sara Cairns, New Hampshire Natural Heritage Inventory, personal communication; see General Status and Distribution for more information). *Amerorchis* is not tracked in Connecticut, but based on information gathered while researching this plan, it should be ranked SR in that state. *Amerorchis* is considered extirpated from New York, where there are two historical records from the 1870's (Steve Young, New York Natural Heritage Program, personal communication), though Brown (1997) lists 4 historic sites for *Amerorchis* in New York. NatureServe (2001) lists it as SR in New Jersey.

New England Plant Conservation Program (NEPCoP) lists *Amerorchis rotundifolia* as a Division 2 plant, meaning it is a regionally rare taxa with fewer than 20 occurrences in New England (Brumback and Mehrhoff et al. 1996).

This conservation plan summarizes available information on ecology, taxonomy, and conservation biology of *Amerorchis rotundifolia*. Also presented are its current status, potential threats, and recommended actions for conservation of this species in New England.

DESCRIPTION

The following plant description is derived from Morris and Eames (1929), Correll (1950), Case (1964), Luer (1975), Gleason and Cronquist (1991), and Chapman (1997). *Amerorchis rotundifolia* is a perennial herb with a slender, glabrous, solitary scape 10-35 cm tall. The single leaf is dull green, subbasal, sessile, elliptic to broadly oval to round with an obtuse to rounded apex, 3-11 cm long, 2.3-7 cm wide. The basal portion of the leaf sheaths the stem. The inflorescence is a narrow, loosely flowered terminal raceme with 1-16 flowers, arranged more or less one-sided on the stem. Floral bracts are lanceolate, acuminate, 7-15 mm long, 3-5 mm wide at the base. Ovaries are stout-pedicillate, 8-12 mm long, about 1.5 mm wide. There are 3 sepals; they are white to pale pink mauve, ovate-elliptic, usually minutely cucullate at the apex, 3-5 nerved, 6-10 mm long, 3-4 mm wide. Lateral sepals are lance-ovate, oblique, spreading. The dorsal sepal is shorter, erect, wide-ovate, forms hood with lateral petals. Petals are white to pale pink to mauve, 5-6 mm long, 2-3 mm wide at the base (narrower and smaller than the sepals), lanceolate, connivent with the dorsal sepal, forming a hood over the column. The lip is 8-10 mm long, white, typically spotted with mauve to deep purple, three-lobed at the base. Lateral lobes are short-ovate to elliptic to oblong-lanceolate, about 2 mm long. The middle lobe is irregularly oblong spatulate, dilated and notched or bilobed at the apex, 3-6 mm wide. The spur is slender, shorter than the lip, slightly curved, 5-6.5 mm long, 1 mm wide. The column is short, stout, 3-4 mm long, 2 mm wide, anther cells contiguous. The capsule is ellipsoid, ascending, about 1.5 cm long, 0.5 cm wide.

Amerorchis rotundifolia has a slender branching rhizome with slender fibrous roots (versus rounded tuberoids as in most *Orchis* species or palmately lobed tuberoids as in *Dactylorhiza*) (Luer 1975). The flower color and lobed lip, with the solitary basal leaf present at flowering time are diagnostic for *Amerorchis*. Other orchids with lobed, pink and white flowers have leafy stems (Mitchell and Sheviak 1981). The Showy Orchis (*Galearis spectabilis*) has a leafless stem with flowers colored similarly to *Amerorchis rotundifolia*, but the lip on *Galearis* is not lobed or notched, and there are two leaves present at flowering time (Mitchell and Sheviak 1981, Gleason and Cronquist 1991). Some *Platanthera* species may have one leaf at flowering time, but the flowers of these species are greenish or whitish and inconspicuous (Chapman 1997). *Platanthera* species with one or two more or less basal leaves present at flowering time have white to greenish or yellowish petals, and the lateral petals are not connivent with any sepal(s). Other species of *Platanthera* have cauline leaves (Gleason and Cronquist 1991).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Amerorchis is a monotypic genus first proposed by Eric Hultén in 1968 (Luer 1975). The most common synonym and original genus for *Amerorchis* is *Orchis* (Baldwin 1884, Gibson 1905, Nylander 1918, Morris and Eames 1929, Correll 1950, Luer 1975, Gleason and Cronquist 1991, Haines and Vining 1998), though it has been considered as a *Habenaria* or *Platanthera* (Luer 1975). It is a member of the family Orchidaceae, subfamily Orchidoideae, tribe Orchideae, subtribe Orchidinae (Luer 1975).

Linnaeus first used the name *Orchis* to describe terrestrial orchids with two large ovoid fleshy tubers resembling testicles in 1753 (Luer 1975, Keenan 1983). Baldwin (1884) and Chapman (1997) comment on the derivation of the name *Orchis*, but Berliocchi (2000) offers the best version of the myth, summarized as follows: Orchis was the son of a nymph and a satyr who attempted to rape a priestess while attending a feast for Bacchus. As punishment he was torn limb from limb by wild beasts. The gods intervened and his mutilated body was metamorphosed into a modest and slender plant bearing paired round tubers similar to the organs of his own undoing (Berliocchi 2000).

Except where noted, the following is from Luer's (1975) excellent history of the genus *Orchis* in North America. In 1790, De Necker proposed that about half of the species in the genus *Orchis* be separated into the genus *Dactylorhiza* based on their root structure, fleshy roots in a palmate cluster versus paired fleshy tubers. His proposal was not widely accepted. In 1805, Willdenow established and removed the genus *Habenaria*. In 1813, Robert Brown established the genus *Gymnadenia* separate from *Orchis* based on differences in the column. In 1818, L. C. Richard established the genus *Platanthera* separate from *Orchis* based on differences in anther cell divergence or contiguity.

In 1833, Rafinesque proposed the monotypic genus *Galearis* for *Orchis spectabilis* based on the bilobed bursicle above the stigma, two basal leaves, and absence of tubers associated with the roots. His proposal was not widely accepted, but the name *Galearis* has been in recent use by taxonomists (also Mitchell 1986, Haines and Vining 1998). In 1898, Joannes Klinge divided the genus *Orchis* into two subgenera, *Orchis* and *Dactylorchis*. *Dactylorchis* is now accepted as *Dactylorhiza*, and in North America, this affects the previously named *Orchis aristata* complex, which grows in the Aleutian Islands and also an isolated colony of *Dactylorhiza maculata* in Ontario. In 1968, Eric Hultén separated *Amerorchis* from *Orchis*. There are now no occurrences of any *Orchis* species in North America; our formerly named *Orchis* species belong to the genera *Amerorchis*, *Dactylorhiza*, and *Galearis* (Luer 1975).

Amerorchis rotundifolia forma *lineata* was first reported at Elkwater Lake, Alberta, in damp mossy woods (Mousley 1941). This form has broad, longitudinal purple stripes on the lip versus the typical spots and has also been found at Sibley Park Ontario, on the north shore of Lake Superior, in a similar habitat (Elliot 1960, DeVitt 1961). Whiting and Catling (1986) visited the Frontenac site in Ontario and found 150 *A. rotundifolia* forma *lineata* and 700 typical plants, growing in similar small bog openings, but associated in separate groups. A white-lipped color form with lilac dorsal sepals and petals was found at the Sibley Peninsula, Ontario *A. rotundifolia* f. *lineata* colony (Johnson 1995). A single plant was found in 1993, and one year later, five plants of this new form were found near the original plant. Johnson (1995) indicates that variable lip color patterns with this species are not uncommon.

Amerorchis rotundifolia forma *beckettii* (also noted as forma *beckettiae*) was found in Churchill, Manitoba in 1954. This form has all white flowers, with white upper

petals and sepals, and an off-white lip (Boivin 1960 in Johnson 1995), but it is not found in the northeastern United States (Brown 1997).

List of synonyms:

Amerorchis rotundifolia (Banks) Hultén. Ark. Bot. II. 7:34. 1968. (Luer 1975, Mitchell and Sheviak 1981)

Amerorchis rotundifolia (Banks ex Pursh) Hultén. (Mitchell 1986, Haines and Vining 1998, MNAP rare plant fact sheet).

Amerorchis rotundifolia (Banks) Hultén f. *beckettii* (Boivin) Hultén. Ark. Bot. II 7:34. 1968. The white flowered form. (Luer 1975).

Amerorchis rotundifolia (Pursh) f. *immaculatae* Mazurski and Laur. P. Johnson, *forma nov.* (Johnson 1995)

Amerorchis rotundifolia (Banks) Hultén f. *lineata* (Mousley) Hultén. Ark. Bot. II 7:34. 1968. The purple-lined flowered form. (Luer 1975).

Orchis rotundifolia Banks f. *lineata* (Mousley) E. G. Voss, *comb.nov.* Rhodora 68:462. 1966.

Orchis rotundifolia Banks f. *beckettii* Boivin. Nat. Canad. 87:42. 1960. (Luer 1975).

Orchis rotundifolia Banks var. *lineata* Mousley. Can. Field-Nat. 55:65. 1941. (Luer 1975).

Platanthera rotundifolia (Banks) Lindley. Gen. Sp. Orchid. 292. 1835. (Luer 1975).

Habenaria rotundifolia (Banks) Richardson in Franklin. Journey 750. 1823. (Luer 1975).

Orchis rotundifolia Pursh. (Voss 1972).

Orchis rotundifolia Banks (Nylander 1918; Gleason and Cronquist 1991).

Orchis rotundifolia Banks ex Pursh. Fl. Am. Sept. 2:588. 1814. (Correll 1950, Luer 1975).

The common name in Greenlandic is Isigammassaaq, and in Danish is Rundbladet Rhizomg geurt (Danish Polar Center 2001)

SPECIES BIOLOGY

The diploid number for *Amerorchis rotundifolia* is 42 (Angelo and Boufford 2000).

Dormancy

Dormancy is common to terrestrial orchids (Hutchings 1987, Vitt 1991) and is a feature of *Amerorchis rotundifolia* (Gawler 1983). This aspect of the orchid life cycle is not well understood and may be a response to herbivory (Vitt 1991). Dormancy is difficult to distinguish from mortality, especially in short-term studies (Menges 1991).

The maximum dormancy of most orchids, excluding *Isotria medeoloides* which has a prolonged dormancy (Brumback and Fyler 1996), is usually less than three years,

with longer periods of dormancy infrequent (Hutchings 1987, Mehrhoff 1989, Tamm 1991). Hutchings (1987) notes that absence after a year does not indicate mortality, nor does presence of a new plant within three years indicate recruitment. Dormancy duration is not specifically indicated in the literature for *Amerorchis rotundifolia*.

Pollination

The specific pollinators for *Amerorchis rotundifolia* are unknown. Only 2 *Orchis* species are nectariferous (Dafni 1987). Van der Cingel (2001) reports that *Amerorchis rotundifolia* flowers are nectar-free and scentless, and that the species mostly reproduces vegetatively. In her study of *Goodyera* in northern Michigan, Kallunki (1981) noted that one species has no odor perceptible to humans, but commented that the odor may be perceptible to pollinators and that insects have a more sensitive sense of smell than humans. Perhaps the same would be true for *Amerorchis*.

A general background on orchid pollination, especially for orchids similar in habitat and taxonomy to *Amerorchis*, is presented, in the hopes that it will set the stage for further research. Almost all orchids are pollinated by one or a few species of insects (Gawler 1983). Some orchid species use sexual deceit by pseudocopulation with protandrous bees (male bees emerge before females), and there are examples where male bees and wasps will prefer the orchid flower over the female insect (Dafni 1987, Berliocchi 2000). Optical cues also can provide food deceit by inexperienced bees, such as bumblebees in spring. Sexual or food deceit was not specified for *Amerorchis*.

Most orchids are pollinated by bees and wasps, and floral structure in many orchid species evolved related to bees (Christensen 1994). Dipterans are the next most important insect pollinator group (Christensen 1994), though they are generally poor pollinators (Christensen 1994, Dick Dearborn, Maine Forest Service Entomology Laboratory, personal communication). They fly back and forth haphazardly, visit unspecialized flowers, and forage for their own metabolic needs. Flies are more important pollinators with tropical than terrestrial orchids (Christensen 1994). In the subtribe Orchidinae, bees, wasps, moths, butterflies are the important pollinators; flies are frequent visitors, though less important in pollination (Christensen 1994). The following orchid genera are known to be visited by the following fly families (Christensen 1994): *Orchis*, Tachinidae; *Platanthera*, Culicidae, Empididae; *Epipactis*, Syrphidae, Coelopidae, Sarcophagidae; *Listera*, Tipulidae, Mycetophilidae, Sciaridae, Empididae, Syrphidae, Tachinidae; *Liparis*, Sarcophagidae; *Malaxis*, Mycetophilidae; and *Corallorhiza*, Empididae, Syrphidae. Many of these orchid genera and fly families are found in or near areas where *Amerorchis* occurs (personal observation, MNAP field forms). Pollinators of *Platanthera obtusata*, a species of cool coniferous forests and northern white-cedar swamps, are several species of nectar-feeding female mosquito in the genus *Aedis*, and moths (Raup 1930, Gorham 1976, Brackley 1985). Pollinia are cemented to the eyes of the insect when it inserts its proboscis into the flower spur for the nectar reward (Gorham 1976, Christensen 1994, Van der Cingel 2001).

An *Orchis* species with flowers similar in appearance to *Amerorchis rotundifolia* (*Orchis ustulata* L., found in the Austrian Alps) is pollinated primarily by *Echinomyia magnicornis* (Tachinidae) (Christensen 1994). This is an Old World fly genus present in North America, but no details are provided regarding distribution or habitat (Nearctica 2001). However, between 1909 and 1959, about 4500 *Echinomyia magnicornis* Zetterstedt (= *Tachina vernalis* Robineau-Desvoidy) adults were released into New England as part of an attempt to find suitable parasites for the gypsy moth (Dick Dearborn, personal communication). This species has not been recovered in sampling efforts, possibly because it has not established here, it has been missed in sampling (likely if the fly established on a host other than the gypsy moth), and/or because these are a difficult group to work with and they have been undersurveyed (Dick Dearborn, personal communication). Another *Orchis* species, *Orchis maculata* (= *Dactylorhiza maculata*) is pollinated by *Empis livida* (Empididae) (Darwin 1877 in Christensen 1994). Almost 90 species of *Empis* flies are present in North America, but no details are provided regarding distribution or habitat (Nearctica 2001).

Though ants are unlikely pollen vectors worldwide due to antibiotic secretions on their body surface, relatively more ant pollination may be expected with orchids because their pollinia could be attached by stigmatic secretions or viscidium, and thus avoid the ant's antibiotic secretions (Peakall 1994). However, ants are unlikely pollinators where plants are widely spaced, and ant-orchid interactions are known in only 3 of 6 subfamilies including Epidendroideae, Vandoidea, Orchidoideae (the subfamily to which *Amerorchis* belongs) (Peakall 1994). Patches of *Amerorchis* were found at the two large Maine populations in northern white-cedar swamps, and though plants within the patches were fairly close to each other, many patches were quite widely spaced (personal observation). It is unclear how this would affect the possibility of ant pollination with this species.

Reproduction

Amerorchis rotundifolia typically blooms from late June to mid July through most of its range (Gibson 1905, Morris and Eames 1929, Case 1964, Cameron 1976, Whiting and Catling 1986, Chapman 1997), though Correll (1950) notes that it blooms as early as March in Alberta. The age of reproduction for *Amerorchis rotundifolia* is not indicated in the literature, though Stuckey (1967) notes that many native orchid species must be 12-16 years old before they can produce seed. Van der Cingel (2001) reports that *Amerorchis rotundifolia* mostly reproduces vegetatively. This should be investigated for New England occurrences.

Orchid seeds are dustlike and are produced in large numbers (Case 1964). Darwin (1888 in Arditti 1967) counted 6200 seeds/capsule of *Orchis maculata*. Orchid seeds are light and buoyant (Arditti 1967), highly mobile (Sheviak 1990), and can travel long distances by air (Case 1964, Summerhays 1951 in Arditti 1967) and water currents (Case 1964, Ames 1948 in Arditti 1967). Ants or birds can transport some orchid seeds (Anonymous 1915 b and 1923b in Arditti 1967). Rasmussen and Whigham (1998a) state that orchid seeds are "so small practically nothing is known about their fate in the soil."

Their small size minimizes the requirement for maternal investment (McKendrick et al. 2000a).

The movement of seeds upon reaching the ground may be influenced by surface roughness of the ground and distribution of wind speeds (Johnson and Fryer 1992). My impression from bogs I visited was that *Amerorchis* occurs in fairly level areas (versus distinct hummocks or deep hollows), with *Hylocomium splendens* and other mosses (field forms list *Drepanocladus vernicosus* as dominant in one plot), and fine-leaved sedges (field forms list *Carex disperma* and *C. trisperma*), thus fine-scaled microtopographical roughness exists in areas where *Amerorchis* grows. Perhaps this fine-scaled microtopography acts to trap orchid seeds via actual physical roughness or reduced wind speeds. Generally I would expect wind speeds in interior areas of northern white-cedar swamps to be low, except during high wind events (personal observation). Even so, the small size and light weight of orchid seeds would likely allow them to utilize even the lightest winds for dispersal.

Germination/Regeneration

An important factor in regeneration of any species is the concept of safe regeneration sites and the germination niche, as per Grubb (1977). Menges (1991) indicates that the safe site/regeneration niche microsite number and distribution may be more important to plants than the total habitat area.

The texture of bryophytes may provide safe germination sites for tree seeds in northern white-cedar swamps (Johnson and Fryer 1992, Ohlson and Zackrisson 1992, St. Hilaire and Leopold 1995); perhaps the same would be true for orchid seeds in similar habitats, allowing that other factors needed for germination (such as mycorrhizal symbionts and photosynthetically active radiation) are also present. Bryophytes may affect orchid germination and establishment, potentially due to: depth and growth form of the bryophyte (Harmon 1989, Harmon and Franklin 1989); moisture relations (Keizer et al. 1985); nutrient interruption/transfer (Tamm 1964, Oechel and Sveinbjörnsson 1978, Richardson 1981, Chapin et al. 1987, Bates and Farmer 1990, Carleton and Read 1991, Longton 1988, 1992); fungal associations (Pocock and Duckett 1985, Carleton and Read 1991); and release of growth regulatory compounds (Cox and Westing 1963, Arditti 1967, Huneck and Schreiber 1972, Huneck and Meinunger 1990). For tree seedlings in a northern white-cedar swamp, it has been suggested that bryophyte structure and moisture relations may enhance seed germination, though other factors such as nutrient leaching may negatively affect subsequent survival (St. Hilaire and Leopold 1995). Some mosses (e.g., *Sphagnum* species) can overgrow tree seedlings and inhibit their survival (Ohlson and Zackrisson 1992); perhaps the same would be true for orchid seedlings in moss microhabitats. Stuckey (1967) indicated that newly germinated seedlings of *Cypripedium reginae* died under a thick mat of *Sphagnum* because of increased acidity. Overgrowth, as indicated by Ohlson and Zackrisson (1992), may also have been a factor. Overgrowth would affect any seedling, and acidity is likely to be a detrimental factor for *Amerorchis*,

which typically grows in calcareous northern white-cedar swamps. Arditti (1967) suggests that algae may be a source of a growth-stimulating factor for orchids.

Orchid seedlings associated with mosses include *Cypripedium calceolus* (Rasmussen and Whigham 1998a), *Platanthera blephariglottis*, and *Dactylorhiza fuchsii* (Case 1964, Leeson et al. 1991 in Rasmussen and Whigham 1998a). *Orchis ustulata*, *Epipogium aphyllum*, and *Corallorhiza trifida* seedlings have been recorded in humus and decomposing litter (Rasmussen and Whigham 1998a and references therein). Rasmussen and Whigham (1998a) looked at the germination of *Tipularia discolor* on wood and showed that seed germination was enhanced by the presence of decomposing wood. They believe this and other organic debris matter should be investigated as a requirement for germination, and that this could be important for restoration efforts. *Amerorchis rotundifolia* plants at the two large populations in Maine were primarily associated with mosses, and also with sedges, in small glades in northern white-cedar swamps (personal observation). The role of bryophytes and woody debris in *Amerorchis* ecology is an area for further research. The fungal symbiont may depend on woody debris, and woody debris itself may start a fungal succession leading to a symbiont on which *Amerorchis* depends.

For tree and herb seedlings, favorable germination sites are not necessarily sites most favorable for survival (Harmon and Franklin 1989, Collins 1990, Kellman and Kading 1992, Ohlson and Zackrisson 1992, Smith and Capelle 1992, St. Hilaire and Leopold 1995). For *Amerorchis*, this is an area needing further research.

Orchid shoot buds are formed the year prior to growth (Mehrhoff 1989, Sheviak 1990, Light 1998), and even up to two years prior to growth (Light 1998). If the shoot growth is destroyed (*e.g.*, from late frost, foraging animals, disease, accident, or poor management practices), an orchid cannot replace lost tissues until the following year. The root system remains, and a new bud may form, or a dormant bud may enlarge, but the dormant buds will not initiate growth (Sheviak 1990). In *Cypripedium*, plants that lose growth prior to midsummer commonly appear the next season, but do not flower (Whitlow 1983 in Sheviak 1990). In several species of *Platanthera*, the usual result of shoot loss before or during bloom is plant mortality (Sheviak 1990), though *P. leucophaea* and *P. praeclara* may survive (Bowles 1983 in Sheviak 1990). Bud development at flower time in the two latter *Platanthera* species is more advanced than in related species; this may contribute to its survivability after shock (Sheviak 1990). The status of *Amerorchis* bud development is unknown. It will be important to determine this in *Amerorchis*, especially if a management experiment is to be conducted.

A surgeon named John Harris was the first to note that orchid seeds will germinate if scattered at the base of the mother plant (Anon 1893 in Arditti 1967). This knowledge was used commercially, especially prior to Knudson's work on non-symbiotic germination of orchid seeds (see references in appendix 1). It should be noted that new plants appearing close to an existing plant may not necessarily be recruited from seed; they may represent vegetative reproduction. Hutchings (1987) could not determine if

new rosettes of the early spider orchid appearing close to existing rosettes were recruited from seed or vegetatively since destructive sampling was prohibited.

Seeds of many orchid species germinate in spring after a period of dormancy in the soil over the winter (Rasmussen and Whigham 1993). Abscisic acid is a factor in the dormancy of other plants, and it has been suggested that this hormone may have a similar effect in orchids (Van der Kinderen 1987 in Arditti et al. 1990). The effects of temperature on the germination of orchid seeds are mixed (Arditti et al. 1990). Available evidence suggests that seed coats are not a factor in dormancy, though they have been so implicated (Arditti et al. 1990 and references therein). Arditti et al. (1990) did not find good evidence for dormancy of orchid seeds and indicated that dormancy as a factor in germination had been proposed based purely on speculation. However, light may inhibit the germination of some temperate orchids, though specific genera were not indicated (Arditti et al. 1990).

Most orchid germination information comes from *in vitro* studies (Arditti et al. 1990; Rasmussen and Whigham 1993; Marilyn Light, University of Ottawa, personal communication). *Amerorchis rotundifolia* seeds (from Alberta) germinated to an advanced stage (leaf becoming green after 21-27 weeks) on Fast's synthetic medium, a substrate used for asymbiotic germination tests (Smreciu and Currah 1989). Embryos developed to the point that they were swollen and had a cracked testa after 18-27 weeks on Warcup's cellulose agar (WCA), utilized as a control. The WCA substrate was inoculated with various fungi. *Sistrotrema* sp. (obtained from orchid mycorrhizae) and *Ceratobasidium cereale* (from a pathogenic source) inhibited embryo swelling, with no seed development after 27 weeks. Protocorm development occurred on plates inoculated with *Rhizoctonia solani* and *Thanatephorus pennatus* (both from orchid mycorrhizae); seedlings developed to the point where the embryo was 2-3 times enlarged and had apparent rhizoids after 5-11 weeks. Neither *Rhizoctonia solani* (from pathogenic source) nor *Ceratobasidium obscuro* (isolated from *Amerorchis rotundifolia*) had any effect on germination; seeds developed to the same stage as on controls (Smreciu and Currah 1989). Seed viability was not tested in this study. The authors noted that only a small number of seeds germinated, and it was unknown if this was due to dormancy or low viability.

In a field germination experiment, Rasmussen and Whigham (1993) noted that *Galearis spectabilis* had a germination rate of 7.4% (+/- 2.2% [SE]) to 10.2% (+/- 2.5%) in the absence of a compatible fungus. The seeds in the study had a split testa but no fungal infection, and there was no further growth 62 weeks after sowing. Their methods (utilizing retrievable seed packets constructed of plastic photographic slide mounts and plankton netting) could be used to study field germination and seedling development of *Amerorchis rotundifolia*.

Mycorrhizal Associations

Fungi have long been noticed with orchid roots, but it was not until 1899 that it was realized that fungi play a role in germination (Arditti 1967). Mycorrhizal fungi initiate germination of orchid seed (Arditti et al. 1990, Clements 1988) and supply early developmental stages with an exogenous source of carbon (McKendrick et al. 2000a), though the seeds themselves do not carry endophytic fungi (Warcup 1981b in Clements 1988).

In the early 1920's, Knudson was the first to germinate orchid seed asymbiotically in the lab (Arditti 1967, original references in Appendix 1). It has been suggested that the fungus provides an exudate with vitamins, hormones, specific sugars, amino acids, and/or other small molecules (Knudson 1925 in Clements 1988). This has not been supported by experimental evidence, which indicates that the physical presence of the live fungus is necessary for germination (Clements 1988, Arditti et al. 1990). This suggests the possibility that temperate orchids may require cellular contact, cell-surface signaling, an elicitor-type molecule, or a plasmid (Arditti et al. 1990).

Orchid species differ in germination strategy, and site and orchid/fungus specificity play a role in seedling establishment (Rasmussen and Whigham 1993). Orchid/fungus system specificity, known mostly for Australian species, can be extreme in temperate terrestrial orchids and may also be a reason for non-germination (Arditti et al. 1990 and references therein).

Not all fungi isolated from orchid roots can support germination (Smreciu and Currah 1989, Arditti et al. 1990 and references therein, Rasmussen and Whigham 1993 and references therein, Marilyn Light, personal communication). For terrestrial Australian orchids, the less vigorous fungal isolate best supports germination, and the same may be true for other temperate terrestrial orchids (Clements 1981 and 1982 in Arditti et al. 1990). *Ceratobasidium obscurum* has been isolated from *Amerorchis rotundifolia* roots, but it does not affect germination (Currah et al. 1987, Smreciu and Currah 1989).

Terrestrial orchid protocorms can live as parasites on fungi, living underground for weeks, months, and even years after germination (Rasmussen and Whigham 1993). The usual time between seed dispersal and production of the first foliage leaf is 2-4 years, but estimates vary considerably (Rasmussen and Whigham 1998b and references therein) and can range up to 15 years (Whigham and Willems in press). The length of the underground phase is unknown in *Amerorchis*.

In an *in vivo* experiment with *Dactylorhiza maculata*, Van der Kinderen (1995) noted that seeds almost immediately produced epidermal hairs, suggesting that these structures are important for establishment of symbiotic fungi. Although seeds germinated readily after 3.5 months incubation in soil, many of these were dead or parasitized after 15 months. *In vitro* studies have shown that vigorous mycelia may destroy orchid seeds (Arditti et al. 1990). Because mycorrhizal fungi are potential pathogens of other plants, it

is necessary for the orchid to control the infecting hyphae (Clements 1988). Without such control, the invading fungus could destroy the orchid. The mechanism for such control has yet to be determined, but it has been suggested that it may be similar to the control mechanisms between legumes and *Rhizobium* bacteria that use mRNA (Clements 1988).

Mycorrhizal fungi known to be associated with *Amerorchis rotundifolia* from Alberta are *Ceratobasidium obscurum* Rogers and *Phialocephala fortinii* Wang and Wilcox (Currah et al. 1987, Smreciu and Currah 1989). Other mycorrhizal species reported from orchids include *Rhizoctonia repens* Bernard “a ubiquitous orchid endophyte” (Currah et al. 1987, McKendrick et al. 2000a), *Leptodontidium orchidicola* Sigler and Currah “found in a wide range of terrestrial orchids” (Currah et al. 1990), *Ceratorhiza* spp., and *Epulorhiza* spp. (Zelmer 1994).

For most orchids, the myco-heterotrophic juvenile phase is followed by an autotrophic adult phase, but associations with early fungal symbionts are retained (McKendrick et al. 2000a, 2000b). *Corallorhiza trifida* is an achlorophyllous species that is myco-heterotrophic as an adult. There is evidence that *Corallorhiza* species obtain carbon from surrounding photosynthetic plants via shared ectomycorrhizal fungi (Bruns et al. 2000). The proximal host is a fungus mutualistically associated with trees, the ultimate carbon source (Bruns et al. 2000). A short term ^{14}C tracer established direct transport of carbon from *Salix repens* and *Betula pendula* (but not from *Pinus sylvestris*) to *C. trifida* in a Scottish study (McKendrick et al. 2000b). Campbell (1970 in Homoya 1993) showed a mycorrhizal connection between the rhizome of *Corallorhiza trifida* and the roots of *Thuja* and *Picea*. Nutrients were transferred from the tree to the orchid via the mycorrhizae. In boreal sites in Alberta, Canada, an as yet unidentified endomycorrhizal symbiont of *C. trifida* formed in vitro ectomycorrhizae with *Pinus contorta* (Zelmer 1994; Zelmer and Currah 1994).

Hyphal transfer of carbon between plants interconnected by a common mycorrhizal mycelium may be especially important in supplementing carbon requirements of shaded understory plants (McKendrick et al. 2000b). This occurs between some autotrophic species; one study showed that shaded *Pseutotsuga menziesii* received about 6% of its carbon from unshaded *Betula papyrifera* (Simard et al. 1997 in McKendrick et al. 2000b).

This is of interest because *Corallorhiza trifida*, *Thuja occidentalis*, and *Picea mariana* all occur in the same habitat as *Amerorchis rotundifolia*. Perhaps autotrophic orchids depend on fungal connections with surrounding trees at the protocorm stage, or even as fully autotrophic adults. *Phialocephala fortinii* (found with *Amerorchis rotundifolia* in Alberta) was originally described from pseudomycorrhiza of *Pinus resinosa* and *P. sylvestris* in Finland, and is a member of a group of fungi that are typically found with conifers (Currah et al. 1987, June Wang, State University of New York College of Environmental Science and Forestry, personal communication). It has also been isolated from conifer roots and soil in New York (Pack Forest, Warrensburg and Whiteface Mountain in the High Peaks of the Adirondacks), New Hampshire

(Hubbard Brook), Maine (Kussuthe), Germany, and Switzerland; it is likely worldwide in distribution. This fungus is pathogenic in conifers, but environmental conditions may moderate this pathogenicity. It was not pathogenic in orchids in Alberta, nor in lupines in Oregon (June Wang, personal communication). It should be determined if this fungus is mycorrhizal with *Amerorchis rotundifolia* in New England, if it is also mycorrhizal with surrounding trees, and if hyphal transfer of carbon or other nutrients occurs between the trees and *Amerorchis* at the protocorm or adult stage.

The expansion or decline of orchid populations may be greatly influenced by processes that determine germination and survival of seedlings, and to date, great spatial and temporal variability in seedling establishment appears to be the rule in terrestrial orchids (Rasmussen and Whigham 1998a). Fungal switching during the lifetime of an orchid has not been documented, but it has been suggested that the symbionts that play an important role in orchid seedling development are replaced by others in adults (Zelmer et al. 1996 in Rasmussen and Whigham 1998a). Marilyn Light (personal communication) notes that there are a variety of fungal associates with orchid roots, many of which will not support germination, but may be useful for water and phosphate uptake.

Clements (1988) experimentally demonstrated that the fungus chances upon orchid seeds, rather than there being a specific mechanism to attract one organism to the other. He suggests that a similar mechanism probably operates in the wild, and that seeds landing in the general vicinity of the “correct” mycorrhizal fungus have a good chance of eventually being infected and germinating. His experiments support species-specific relationships between orchids and fungi, and he and others suggest that the distribution of adult orchids is based on the distribution of the fungi that initiate symbiotic germination (Clements 1988, McKendrick et al. 2000a). This may at least be true for the establishment phase, provided other factors are suitable, especially for long-lived orchids (Marilyn Light, personal communication). Experiments have suggested that fungal partners can vary considerably across the range of a given orchid species (Marilyn Light, personal communication).

Determination of the fungal partners of adult *Amerorchis rotundifolia* in New England, and those necessary for germination, would be a huge contribution to the population biology of this species. Positive identification of the fungal symbionts is crucial. *Phialocephala fortinii* is difficult to identify, and it has frequently been called a *Cenococcum* (June Wang, personal communication). Van der Kinderen (1995) believes that knowledge of mycorrhizal associates is especially useful for cultivating endangered species, and that collected plant material could be used to start additional controlled cultures of protocorms or mycorrhizal fungi. Detailed knowledge of reproductive and competitive strategies used by terrestrial orchids is also vital to efficient conservation and management programs (Currah et al. 1990).

Herbivory

The small black weevil, *Stethobaris ovata*, is known to feed on a variety of orchids and other plants (Marilyn Light, personal communication). The weevil's first generation emerges in spring and feeds on orchid flowers, including *Galearis spectabilis* and *Cypripedium pubescens*, and also on *Maianthemum canadense*. Oviposition occurs on the flower scapes and ovaries of *Galearis* and *Cypripedium*. The second generation emerges late July to mid August, feeds on *Epipactis helleborine* flowers, and oviposits in stems and fruits of *Epipactis* and *Cypripedium pubescens*. This weevil is considered a pest and can considerably reduce seed yield (75% of fruits affected in *C. pubescens* in 2000, an as yet unpublished study). The small black weevil has not been observed on *Amerorchis*, but if other species that it uses are present, a weevil population could also be present (Marilyn Light, personal communication). This deserves a closer look with our New England populations, as *Cypripedium pubescens* occurs at the sites where *Amerorchis* is present. *Epipactis helleborine* is also likely to occur at these sites, and if it does not presently occur at these sites, it may soon as it is colonizing many areas of Maine (Jill Weber, Consulting Botanist, personal communication).

Deer have been observed foraging on *Cypripedium acaule* and *Habenaria psycoides*, and in an experimental deer enclosure, rabbits ate *Habenaria blephariglottis* and *Cypripedium acaule* (Stuckey 1967). This same author notes that orchids do not provide a major portion of these herbivore's diets because there is usually abundant forage among other plant species in June and July, and by August when forage is scarce, most orchids have set seed and disappeared (Stuckey 1967). A small population of *Cypripedium reginae* in a northern white-cedar swamp in central New York showed evidence of deer herbivory (personal observation; the deer ate all the flower buds). Deer have browsed *Cypripedium reginae* in at least one of the extant *Amerorchis rotundifolia* sites in Maine (Jill Weber, personal communication). Herbivory of other species may decrease competition with other plants and increase light and moisture availability (Case 1964, Stuckey 1967). The cyclical nature of the deer herd population affects orchids in places such as northern white-cedar swamps. Case (1964) notes an example where over-browsing created open glades which had large numbers of *Cypripedium reginae*. As the herd decreased through overpopulation, starvation, and subsequent reduction by hunting, the orchid population declined and mostly disappeared within 10 years.

HABITAT/ECOLOGY

The habitat of *Amerorchis rotundifolia* has been variously described (see Appendix 2). The habitat for the five current occurrences in Maine, and one of the new occurrences, is northern white-cedar swamp. This is also the title of the natural community in the new community classification for Maine (Gawler 2001). The National Vegetation Classification for this community is *Thuja occidentalis/Mitella nuda/Hylocomium splendens* Saturated Forest (Gawler 2001, NatureServe 2001). This community occurs in Maine (ranked S4), New Hampshire (titled "boreal acidic northern white-cedar swamp", ranked S1), Vermont (ranked S3), Connecticut, and New York

(NatureServe 2001, and individual state heritage programs). The habitat for the other new occurrence in Maine is northern white-cedar seepage forest, which is now called cedar-spruce seepage forest (Gawler 2001). The National Vegetation Classification for this community is *Thuja occidentalis-Equisetum* spp. Saturated Seepage Forest (Gawler 2001, NatureServe 2001). This community occurs in Maine (ranked S3), New Hampshire (titled “seasonally saturated northern white-cedar seepage forest”, ranked S3), Vermont, and New York (NatureServe 2001). Vermont Nongame and Natural Heritage lists “northern white-cedar sloping seepage forest” as a variant of northern white cedar swamp, but does not give the National Vegetation Classification or a rank for this variant.

In Maine, the northern white-cedar swamp is represented by a closed-canopy forest of *Thuja occidentalis*, often with *Picea mariana* or *Acer rubrum* (Gawler 2001). There is a well-developed herb layer, with small cedar trees and an array of boreal herbs. Hummock-hollow topography carpeted by a lush bryophyte layer is characteristic. This community is typically found in poorly drained basins along streams or small ponds. The substrate is usually shallow peat over mineral soil, with a somewhat acidic to circumneutral pH (Gawler 2001). The cedar-spruce seepage forest community in Maine is characterized by a closed-canopy forest of *Thuja occidentalis*, alone or with other conifers; maple and birch are rarely present. There are extensive herb and moss layers, with feather mosses typically more abundant than *Sphagnum* mosses. These communities are found on gentle slopes, or at the base of slopes and are groundwater-fed, have mineral soils, and perhaps a shallow peat layer (Gawler 2001).

The most important habitat feature cited for *Amerorchis* is cold soil, and other features such as light and moisture can vary (Case 1964). In our region (Region 1), *Amerorchis rotundifolia* is classified as an Obligate Wetland species, meaning that it almost always occurs in wetlands (estimated probability 99%) (USDA, NRCS 2001). Nationally, it is classified as a Facultative Wetland/Obligate Wetland species, indicating that it is occasionally found in non-wetlands.

Northern white-cedar swamps are generally found in minerotrophic situations, versus other forested peatlands, which tend to be in ombrotrophic situations (Christensen et al. 1959, Sjörs 1959, Heinselman 1970, Veery 1975, Collins et al. 1979, Schwintzer 1981, Seischab 1984, Malmer 1986, Wilcox et al. 1986, Kenkel 1987, Crum 1988). Water and nutrients in minerotrophic peatlands are received from ground water, surface runoff, and precipitation (Heinselman 1970, Moore and Bellamy 1974, Mitch and Gosselink 1986, Crum 1988, Siegal 1988, Boeye and Verheyen 1992). Hydrology plays a major role and influences vegetation by influencing groundwater nutrient conditions, pH, and specific conductivity (St. Hilaire 1994). Fens (including forested northern white-cedar swamps) occur in groundwater discharge areas, where the ground water moves upward, though recharge and discharge volumes are small versus inputs and losses from precipitation, runoff, and evapotranspiration (meaning chemical quality is more important than water quantity) (Siegal 1988). Humified peat can cause significant interactions between groundwater and surficial waters (Chason and Siegal 1986). Vascular plants, especially sedges, contribute to the peat formed in northern white-cedar swamps where

groundwater is rich in calcium, magnesium, iron, and carbonate (Verhoeven and Arts 1987)

Natural processes such as windthrow, flooding, fire, drainage, drought, and cutting/heavy browse can affect the northern white-cedar swamp community and can cause community changes (St. Hilaire 1994). Windthrow of a few trees does not change community structure (Curtis 1946, 1959) and may benefit *Amerorchis* by increasing microsite variability within the swamp and by providing somewhat more light, provided light levels are not excessive. Windthrow of many trees may cause a change in community structure to a rich sedge fen (St. Hilaire 1994). Flooding may also change community structure and result in a rich shrub fen, rich sedge fen (Schwintzer and Williams 1974, Jeglum 1975), or marsh (Catenhusen 1950, Kenkel 1987). Beavers, roads, railroads, ditches, pipelines, and dams can cause flooding upstream of a peatland or drainage downstream (Catenhusen 1950, Stoeckeler 1967, Boelter and Close 1974, Jeglum 1975, Schwintzer and Williams 1974, Rowell 1986, Johnston 1990, Klinger et al. 1990, Jacobson et al. 1991). Drainage and drought can lead to the invasion of pines, balsam fir, and hardwoods, and also to an increased fire frequency (Catenhusen 1950, Christensen et al. 1959, Curtis 1959, Crum 1988). Superficial fires do not affect community structure, but medium and repeat fires may result in community changes and lead to a rich shrub fen or marsh; deep fires may lead to a quaking aspen community (Catenhusen 1950). Cutting/heavy brows, and also fire, may lead to a black ash/red maple swamp forest (Gates 1942, Johnston 1990). These community changes are not beneficial to *Amerorchis*.

One of Maine's two large *Amerorchis* populations is at a site that has an old railroad bed to its west. West of the railroad bed is an alder swamp. Beaver activity has been noted along this railroad bed (9/98 correspondence between TNC Steward and MNAP office), but there was no indication if the beaver population has increased here. Beaver harvest rates continue to be low, and beaver pelt prices are fairly low (about \$20, IFW Web Page), so it is likely that if beaver are a problem, trapping pressure would be insufficient to control the population. The presence of the railroad bed at this site leads me to think that fire may have played a role here in the past. A railroad built in 1893 through another wetland in Maine (Crystal Fen) caused an increase in fire frequency due to sparks from steam locomotives (Jacobson et al. 1991). Fire frequency declined after steam locomotives switched to diesel in 1950. In Massachusetts, steam locomotives were responsible for 25% of forest fires between 1916 and 1929, versus only 1% of forest fires due to lightning (Averill and Frost 1933). The disturbance history of ME .001 (Perham) may be worth looking at, as it likely contributed to the formation of natural communities in the area. Also, the disturbance history of a site is helpful in creating management plans (Rowell 1986).

THREATS TO TAXON

Timber harvest (typically for cedar fence posts) and general habitat destruction are the major potential threats to *Amerorchis* (Eastman 1977, Gawler 1983, Brown 1997).

Pesticide application in adjacent uplands may also be a threat, at least for some populations (as for ME .006; Jim McGowan, Preserve Design File). Eastman (1977) notes any activity that impedes the lateral flow of groundwater such as filling, dredging, and peat mining is a threat. He recommends limiting access when *Amerorchis* is inconspicuous to avoid trampling.

Orchid populations are often ephemeral because many species are colonizers but poor competitors (Sheviak 1990). For example, *Liparis* will colonize a windthrow within a few years of disturbance, increase its population, then eventually decrease, and die out as the canopy closes (Sheviak 1990). Changing land use is a threat to orchids in general, especially so for orchids of more open areas when woody plants increase due to land management changes (Stuckey 1967; Tamm 1972 in Rasmussen and Whigham 1998a). Case (1964) noted an increase in populations of *Cypripedium reginae* and *Cypripedium calceolus* in power-line cuts versus adjacent areas of the orchid populations in shade. *Amerorchis rotundifolia*, however, did not respond well to this power-line cut, and after ten years had not reappeared in the opening, though it grew nearby in an undisturbed area (Case 1964). See also the discussion under ME .006 (Chapman), where it appears that logging has disturbed the area such that it will no longer support an *Amerorchis* population.

In Alaska, *Amerorchis* flowers are harvested for a small commercial enterprise. The Alaskan Flower Essence Project lists *Amerorchis rotundifolia* on their web site (Alaskan Essences 2001) and states that its essence is used as “support to live more deeply in our hearts and maintain that position in times of confusion and chaos; promotes equanimity, balance, and awareness of center; helps us get to and stay with the core of an issue without being distracted by all the energy at the periphery.” Healthy flowers are harvested at the peak of their bloom cycle, and their vibrational energies are captured and bottled for use. I rather doubt that harvest for medicinals is a threat in New England.

Collection of any orchid species for wild supplied horticultural collections is, however, a potential threat (Mitchell and Sheviak 1981). Propagators of rare North American terrestrial orchids, some of whom sell wild-collected plants, can be found on the Internet (Gardens of the Blue Ridge 2002, Native Sons Nursery 2002). These sites do not offer *Amerorchis*, though they do offer other rare orchids. Trampling of young, inconspicuous plants by photographers is also a potential threat for orchids (Light 1998).

DISTRIBUTION AND STATUS

General Status and Distribution

Amerorchis is apparently globally secure, with a ranking of G5. *Amerorchis* grows in North America from Greenland to Alaska, in all Canadian provinces, and southward into a few northern states (Figure 1, Correll 1950, Case 1964, Luer 1975, Chapman 1997). *Amerorchis* does not grow on other continents. In Newfoundland, *Amerorchis* only found between Cook’s Harbour and Burnt Island (Boland 2001a) on the

Great Northern Peninsula, where it is listed as rare (Boland 2001b). Fernald (1926) mentions collecting *Amerorchis* in the Big Brook area of Newfoundland. In New Brunswick, *Amerorchis* is listed as S1 and is primarily found in the northern areas of the province in calcareous bogs, fens, and cedar swamps (Hinds 2000, Sean Blainey, Atlantic Canada Conservation Data Centre, personal communication). *Amerorchis* is ranked S4S5 in Ontario (NatureServe 2001), where it is found mostly in northern Ontario in bogs, fens, and wet coniferous forests, though dwarf plants are also found in the tundra near Hudson Bay (Whiting and Catling 1986). The type specimen of *Amerorchis rotundifolia* was collected at Hudson Bay, in 1814 by Pursh. The purple striped form (*A. rotundifolia* f. *lineata*) has been found in Ontario on north shore Lake Superior (Elliot 1960, DeVitt 1961, Voss 1966, Whiting and Catling 1986). A white-lipped color form of *A. rotundifolia* f. *lineata* was also found here (Johnson 1995). The all-white form (*A. rotundifolia* f. *beckettii*) has been found in Manitoba (Boivin 1960 in Johnson 1995). *Amerorchis rotundifolia* is ranked S2 in Quebec; S5 in Alberta, Manitoba, and Saskatchewan; and SR in Newfoundland (Labrador and Island), Northwest Territories, Nunavut, and Yukon Territory (Table 1).

In the United States, except for New England, *Amerorchis rotundifolia* is ranked as follows: SX in New York; S1 in Michigan, Wisconsin, and Wyoming; S2/S3 in Montana; and SR in Alaska, Minnesota, and New Jersey (Table 1, NatureServe 2001). Case (1964) indicates distribution of *Amerorchis* in Montana, Wyoming, New York, Michigan, Wisconsin, and Minnesota, and that *Amerorchis* is more frequent in Minnesota than at other U. S. locations. *Amerorchis* is considered extirpated from New York, where there are two historical records from the 1870's (Steve Young, New York Natural Heritage Program, personal communication), though Brown (1997) lists 4 historic sites for *Amerorchis* in New York.

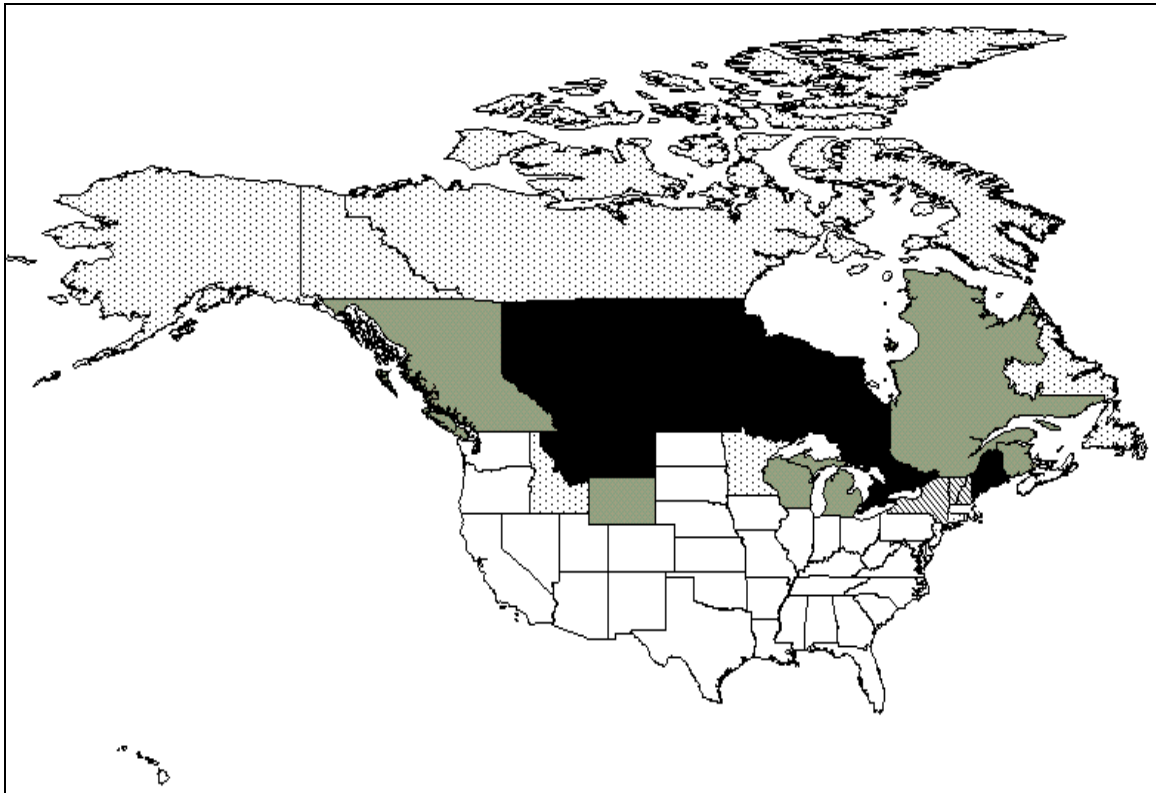


Figure 1. Occurrences of *Amerorchis rotundifolia* in North America. States and provinces shaded in gray have one to five current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix 3 for explanation of state ranks).

Table 1. Occurrence and status of <i>Amerorchis rotundifolia</i> in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE UNVERIFIED OR REPORTED (SR and SRF)	HISTORIC (LIKELY EXTIRPATED) (SH and SX)
Maine (S1, T): 7 extant and 1 historic occurrences	Alberta (S5)	Connecticut (SR): 1 location (Baldwin 1884; Bronars, personal communication)	New Hampshire (SH): Baldwin (1884) lists 6 locations; 1 confirmed record (Angelo, personal communication)
Michigan (S1)	British Columbia (S?)	Alaska (SR)	Vermont (SH): 5 historic occurrences
Montana (S2/S3)	Manitoba (S5)	Minnesota (SR)	New York (SX): 4 historical areas (Brown 1997); 2 historic locations (Young, personal communication)
Wisconsin (S1)	Ontario (S4/S5)	Idaho (SR)	
Wyoming (S1)	Saskatchewan (S5)	New Jersey (SR)	
New Brunswick (S1)		Labrador (Newfoundland) (SR)	
Quebec (S2)		Newfoundland (SR)	
		Northwest Territories (SR)	
		Nunavut (SR)	
		Yukon Territory (SR)	

* If no information is given regarding number of occurrences, or if no citation is given, the information is from the Nature Serve web site (www.natureserve.org)

Status of All New England Occurrences -- Current and Historical

Flora Conservanda lists *Amerorchis rotundifolia* as Division 2, which indicates it is a regionally rare taxon with fewer than 20 occurrences in New England (Brumback and Mehrhoff et al. 1996). In Maine, *Amerorchis* is ranked S1 by Maine Natural Areas Program and is listed as Threatened. It is ranked SH in Vermont, though it is likely extirpated. Jerry Jenkins (personal communication) says that *Amerorchis* has been looked for and not found by L.A. Charette in the 1950's or 1960's, then by Peter Zika and himself in the 1980's, and perhaps since then by others. The New Hampshire Natural Heritage Inventory has newly listed *Amerorchis* as SH based on the herbarium specimen at Harvard (Sara Cairns, personal communication). NatureServe (2001) lists *Amerorchis* as SR in New Hampshire, and Angelo and Boufford (2000) show distribution to include northern New Hampshire. Angelo (personal communication) says there is a specimen at Harvard's Oakes Ames Herbarium by Cyrus G. Pringle (1838-1911) with no date from the "White Mts." in New Hampshire. NatureServe (2001) does not list *Amerorchis* in Connecticut, and Connecticut's heritage program does not track it. I believe it should be listed as SR for Connecticut. Baldwin (1884) and Williams (1902) make reference to a credible written record ("Bishop's List") of *Amerorchis* in Connecticut. Lori Bronars (Yale University's Kline Science Library, personal communication) determined that "Bishop's List" is most likely *A Catalogue of All Phaenogamous and Vascular Cryptogamous Plants at Present Known to Grow Without Cultivation in the State of Connecticut* by James Nathaniel Bishop, Hartford Press, third edition, 1901 (first edition 1895). On page 19, "*O. rotundifolia*, Pursh. Norfolk - Robbins" is listed.

Scientific and common names for vascular plants are from Haines and Vining (1998). Bryophyte common names are from Glime (1993); scientific names are from Allen (1999).

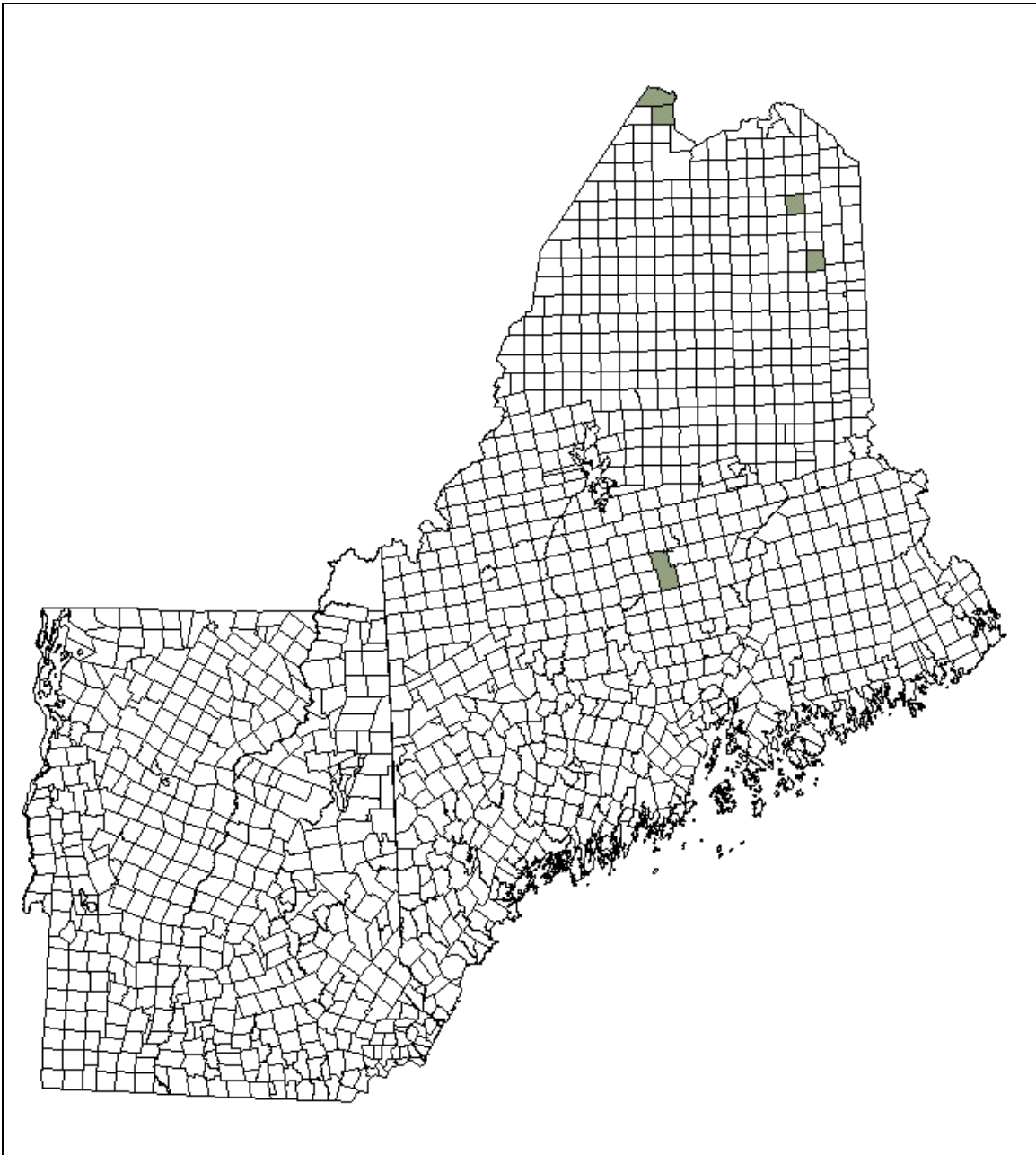


Figure 2. Extant occurrences of *Amerorchis rotundifolia* in New England. Town boundaries for Maine, New Hampshire, and Vermont are shown. Towns shaded in gray have one to five occurrences of the taxon.

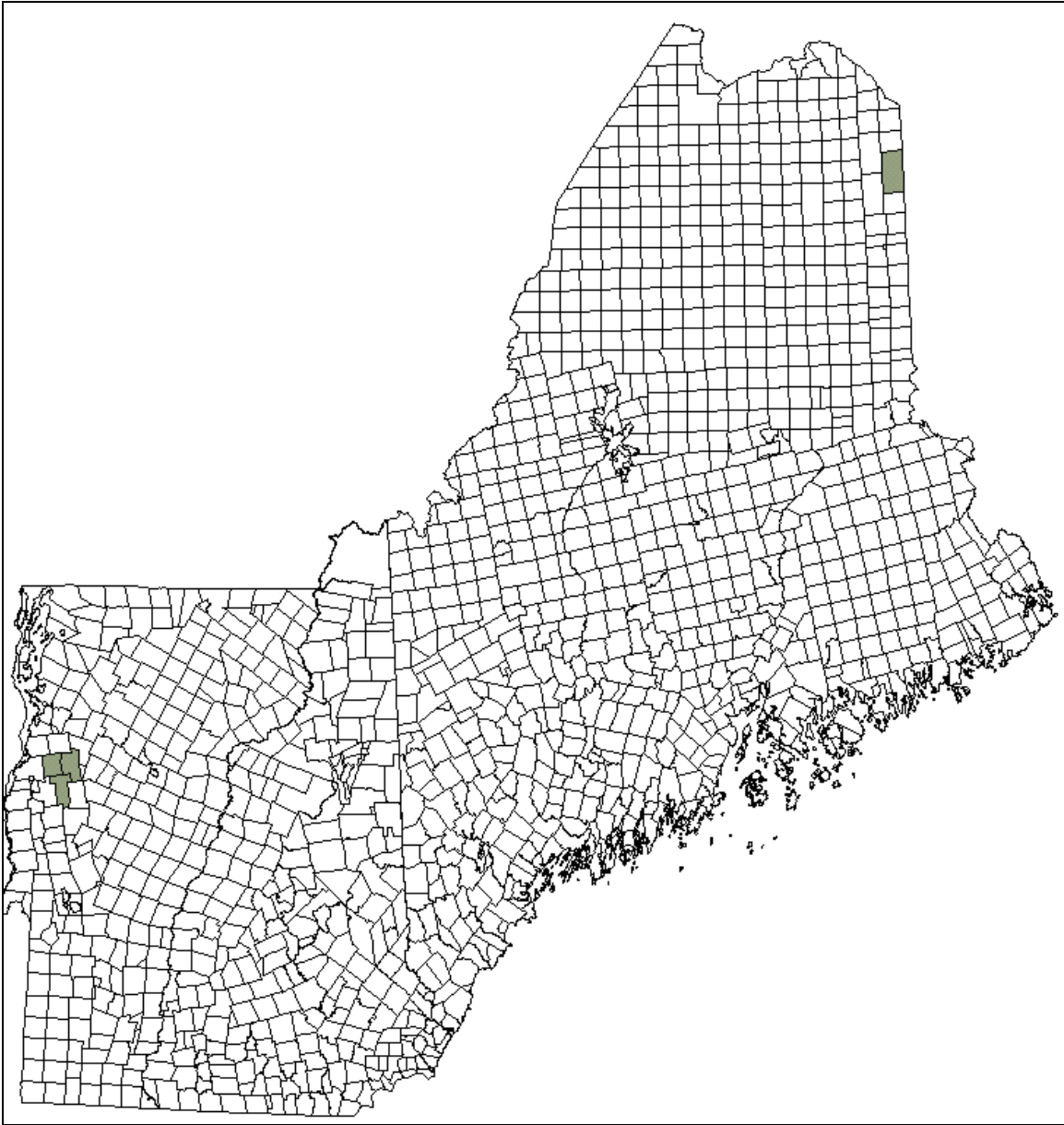


Figure 3. Historical occurrences of *Amerorchis rotundifolia* in New England. Towns shaded in gray have one to five historic records of the taxon. An additional occurrence has been noted from the "White Mountains" of New Hampshire, but no more specific locality is given.

Table 2. New England Occurrence Records for <i>Amerorchis rotundifolia</i>. Shaded occurrences are considered extant.			
State	EO #	County	Town
ME	.001	Aroostook	Perham
ME	.002	Aroostook	Woodland
ME	.003	Aroostook	Perham
ME	.006	Aroostook	Chapman
ME	.008	Piscataquis	Dover-Foxcroft
ME	.009	Aroostook	Fort Fairfield
ME	NEW	Aroostook	Big 20 Township
ME	NEW	Aroostook	T19 R11 WELS
NH	.I	?	White Mountains
VT	.001	Addison	Bristol
VT	.002	Addison	Monkton
VT	.003	Addison	Starks-boro
VT	.004	Addison	Bristol
VT	.005	Addison	Monkton

CURRENT CONSERVATION MEASURES IN NEW ENGLAND

The two largest known populations in New England are at sites owned by The Nature Conservancy, and a TNC steward monitors them annually. Maine Natural Areas Program has notified the landowner of the two newly discovered populations of the significance of these locations (Andy Cutko, personal communication). This owner has willingly set aside the areas where *Amerorchis* occurs and plans not to use these areas as a forestry resource.

Amerorchis is listed by the Convention on International Trade in Endangered Species Protection Status (CITES) as an Appendix II species. Export trade in species from this list is allowed provided that trade will not be detrimental to the survival of the species and if the appropriate permits and certificates are obtained; import permits are not necessary (CITES 2002).

II. CONSERVATION

CONSERVATION OBJECTIVES FOR TAXON IN NEW ENGLAND

General conservation objectives for *Amerorchis rotundifolia* in New England are to:

- **Secure existence** via conservation easement, site design, and habitat preservation
- **Maintain high population numbers** at the two large sites in Maine (approximately 400-500 individuals at ME .002 [Perham] and approximately 2000-3000 at ME .003 [Woodland])
- **Increase population numbers** at the smaller sites in Maine such that the numbers reflect a similar percentage of habitat occupied as at the larger sites, preferably in the range of several hundreds of individuals (this may be unrealistic)
- **Reintroduce populations** at appropriate historic sites in Vermont (a low priority objective)

Monotypic genera or families deserve highest conservation priority as they may play a unique evolutionary role or represent a distinct evolutionary line (Holsinger and Gottlieb 1991). Habitat conservation and management are important to maintaining biological diversity in general (Shaffer 1987), and this would be even more important when that habitat contains a taxonomically unique species. The habitat for the two largest populations of *Amerorchis* in New England is under conservation ownership, and the areas where *Amerorchis* occurs at the two new Maine populations has been set aside. Conserving viable plant populations in their natural habitat is the goal of conservation land managers (New England Wild Flower Society 1992) and should be the goal with *Amerorchis*. Site design, protection, and habitat management are the three steps used to conserve rare plants in their natural habitats (New England Wild Flower Society 1992). In general, these should be the goals at all *Amerorchis* sites in Maine, and in part have been implemented at the two largest populations and the two new populations. Site design and protection should be the conservation objective for populations on private property.

Programs that combine approaches of representative display in a botanical garden, establishment of a new population at a distant site, and off-site seed banking are most likely to succeed (Falk 1991). These approaches may be worth pursuing after the initial conservation objectives are met.

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IV. APPENDICES

- 1. Additional References**
- 2. Habitat Descriptions**
- 3. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

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2. Habitat Descriptions

Gibson 1905: cold and damp cedar woods and ferny places

Nylander 1918: cedar swamp (ME .002)

Fernald 1919: found with *Thuja occidentalis*, northern ME, New Brunswick, Gaspé

House 1923: damp mossy woods

Morris and Eames 1929: found in moist mossy hollows in bogs under cover of cedar, spruce, tamarack; in rich wet bog cover, in open areas at edge of thicket, and sparsely treed sedgy areas. Has a preference for neutral soil, tolerant of some acidity, also found in limestone areas of Ontario and Quebec.

Correll 1950: Found in places with cool summer climate, plenty of moisture with good drainage, and sufficient lime to keep the soil reaction neutral or essentially so. Found in cold moist or wet forests, common in calcareous regions, in cedar, spruce or tamarack swamps and bogs, in moss of spruce-covered mountain slopes, and in peaty open soil. In Newfoundland, it occurs on turfy limestone barrens.

Case 1964: The most important feature of habitat is COLD SOIL, other features vary: sun or shade (if cool soil and limited competition—both even at one location); wet or dry (bog wetness or in dry beds of spruce needles). In Michigan and Wisconsin, found almost exclusively in very cold balsam fir-black spruce-white cedar bogs, usually with a layer of marl underneath. *Amerorchis* characteristically grows in beds of mosses, or occasionally in cedar or spruce needles, usually in pockets or well-like depressions at the base of trees and avoids competition with larger herbs. In the far north, it is a plant of dry spruce woods and open tundra. “In general, orchids, like most plants, show greater tolerance for varied habitats in the heart of their geographic range, but become more selective and exacting near its periphery.”

Seymour 1969: bogs, swamps, boggy woods

Leur 1975: In the far north, *Amerorchis* grows dwarfed in full exposure of cold open tundra or limestone barrens. In the west, it grows in cold coniferous forests and at moderate elevations, and may thrive in the humus of dry spruce needles. Farther south plants are restricted to shaded bogs where cool moist beds of *Sphagnum* moss offer summer air-conditioning. Good drainage of a constant water supply over sufficient lime is essential for the frail roots, which can tolerate neither heat nor acid.

Cameron 1976: damp woods and cedar/tamarack swamps; neutral to slightly acid soil

Eastman 1977: cold, moist, wet conifer forest, often calcareous; tundra and limestone barrens in north. In Maine, *Amerorchis* is found under mature *Thuja* in cold ground, with partial sun/shade, and limited competition.

Mitchell and Sheviak 1981: cold, calcareous swamps (historic habitat in NY)

Crow 1982: cool wet northern white-cedar woods in Maine, extirpated in Vermont. Also in low arctic regions of northwest North America.

Gawler 1983: cold alkaline bogs

Keenan 1983: requires cold and limey soil

Whiting and Catling 1986: bogs, fens, wet coniferous forests (dwarf plants in tundra near Hudson Bay).

Brown 1997: northern cedar swamps and woodlands

Chapman 1997: cold, moist cedar woods to mossy spruce and tamarack bogs, often associated with limestone soils

Angelo and Boufford (2000): bogs, swamps, boggy woods in basic soil

Hinds 2000: calcareous bogs, fens, cedar swamps (New Brunswick)

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

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

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

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

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

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

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

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