New England Plant Conservation Program for

Heart-leaved Twayblade (Listera cordata)

USDA Forest Service, Eastern Region

Joann Hoy
Auburn, New Hampshire
conserve@newfs.org www.newfs.org

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service – Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203

Table Of Contents

SUMMARY

A conservation plan for *Listera cordata* (Linnaeus) R. Brown (heart-leaved twayblade) was set in motion by the White Mountain National Forest because the twayblade has been given sensitive-species status. That status prescribes a site-specific conservation plan for each occurrence and investigation of potential sites before initiating ground-disturbing activities. This plan is for U.S. Forest Service Region 9, which extends from the East Coast through Minnesota and down to Missouri, Illinois, Indiana, Ohio, West Virginia, and Maryland.

Listera cordata has a global rank of G5 (widespread and secure). It is the most widespread twayblade, found throughout the northern hemisphere in cool northern areas and mountains, and inhabits a fairly broad range of habitat. Typical habitat for *L. cordata* is peat-moss hummocks in forested swamps, specially northern white cedar and spruce. It also frequents mossy moist areas in forests of conifers or mixed conifers and hardwoods. Hemlock groves in ravines may harbor it as well. *Listera cordata* grows on acid to subacid soil, and has been found from sea level up to 3,500 meters.

Colonies of *L. cordata* can include hundreds of plants, but the orchid is more often found in small groups. It is not clear whether populations remain in the same site or shift from place to place in an area. Some populations appear to expand and contract considerably. Timber harvesting, road and trail building, and other human disturbance to habitat and hydrology are probably the biggest threats to *L. cordata* persistence.

The conservation objectives for *L. cordata* in Region 9 are to buffer habitats that harbor *L. cordata* from logging and recreational use, to discover what it prefers in its habitat, and to search for extant populations in likely habitat, and perhaps in historical sites. The goal is to protect wetlands where *L. cordata* is known to be, to preserve the five sizable populations (25+ plants) in New England and the four sizable populations in Monongahela National Forest, and to search for and protect five or six more good-quality populations in New Hampshire and Massachusetts. The population size is based on Natural Heritage rankings and reports of stable populations in provinces and states where the orchid is not rare. The number of populations is an estimate of what it will take to maintain the orchid's presence in this part of its range, based on the number of historical and present occurrences.

ACKNOWLEDGMENTS

For their help in working out this plan, I would like to thank the staff of the White Mountain National Forest, especially Leighlan Prout and Kori Marchowsky; Marjory Brzeskiewicz of the Chequamegon-Nicolet National Forest; George Argus for making the manuscript of the *Listera* chapter of *Flora of North America* available; Everett Marshall of the Vermont Nongame and Natural Heritage Program; the New Hampshire Natural Heritage Inventory; the Massachusetts Natural Heritage and Endangered Species Program; the Nongame Wildlife and Natural Heritage Program of West Virginia; the New Jersey Natural Heritage Program; the Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry; and the Rhode Island Natural Heritage.

Suggestions that helped me improve the plan considerably came from reviewers Frankie Brackley Tolman and Doug Bechtel. Thanks to the Lake of the Clouds hut crew for promising to come find me if I didn't get back for dinner. And a special thank you to Bill Nichols of the New Hampshire Natural Heritage Inventory for comments and advice on this report.

INTRODUCTION

Listera cordata is a resident of cool parts of the northern hemisphere, with a global rank of G5 (widespread and secure). Because it prefers cool, moist forests and bogs, it spreads in a northern band across North America, dipping south along the western mountains and the Appalachians. There are two varieties of *L. cordata*; only var. *cordata* has been found east of the Great Plains, and it is the subject of this plan.

Recently the U.S. Forest Service in Region 9 added *L. auriculata, L. cordata,* and *L. convallarioides* to its list of sensitive species. Although these twayblades are not listed under the Endangered Species Act, they are locally rare, and the National Forests will use this plan and those for *L. auriculata* and *L. convallarioides* (Hoy 2001, 2002) to develop management strategies to protect and enhance populations and habitat.

The conservation objectives for *L. cordata* in U.S. Forest Service Region 9 are to preserve potential genetic diversity at the southeastern fringe of the orchid's range and to maintain its range across eastern North America.

DESCRIPTION

The following description is for *Listera cordata* var. *cordata,* based on Coleman and Magrath (in preparation) and Case (1987).

Listera cordata is a terrestrial orchid with slender, fibrous roots and a green to reddish-purple stem. It is between 5 and 33 cm tall. Its two sessile, subopposite leaves are glabrous, ovate-cordate or sometimes deltate, mucronate, 9–20 mm long, and 7–20 mm wide. It occasionally has an extra leaf, or bract, between the leaves and the flowers (Reddoch and Reddoch 1997). It has an open to dense terminal raceme, 20–100 mm long, with inconspicuous floral bracts that are ovate and 1–1.5 mm long by 1 mm wide. Below the leaves the stem is glabrous; the peduncle and rachis are slightly glandular-puberulent or glabrate. The bracts, pedicels, and ovaries are glabrous. A plant may have 5–25 flowers that are yellow-green, green, or reddish-purple. The sepals and petals are slightly falcate. The dorsal sepal is ovate-oblong to oblong-elliptic and 2–3 mm by 1 mm, and the lateral sepals are ovate-oblong to oblong-elliptic, obtuse, slightly falcate, and 2–3 mm by 0.5–1.5 mm. The petals are elliptic to oblong-linear, obtuse, and 1.5–2.5 mm by 0.5–1 mm. The lip is linear-oblong and is cleft approximately two-thirds of its length, forming two linear-lanceolate lobes. The base of the lip has a conspicuous pair of spreading, linear, acute lobes. The inconspicuous column is 0.5 mm by 0.5 mm. Seed capsules are subglobose, 5 mm by 4 mm, and semierect.

A second variety of *L. cordata,* var. *nephrophylla,* is found in western North America. Its range overlaps in the west with var. *cordata,* and the debate over whether it is a good variety is unresolved. It has broader leaves and a longer lip (5–6 mm) than var. *cordata,* and produces only green flowers (Hultén 1941, Coleman and Magrath in preparation). Calder and Taylor (1968) say that difference in flower color is not indicative of varietal differences, and that only leaf morphology varies in a dependable way. The two varieties grow side by side, however. Some authors say the varieties have no intermediate characteristics; others say they do have intermediate characteristics (Coleman 1995). *Listera cordata* varies considerably in North America, and not all its variations fit the description of either variety (Voss 1972, Coleman and Magrath in preparation).

There are eight North American species in the genus *Listera; L. cordata* may overlap in habitat and distribution with all of the other seven. *Listera australis* (southern twayblade), *L. auriculata* (auricled twayblade), *L. convallarioides* (broad-leaved twayblade), *L. ovata* (common twayblade), and *L. smallii* (Appalachian twayblade) all are found in U.S. Forest Service Region 9. *Listera cordata* has pointed tips on a deeply cleft lip, and pointed basal auricles that project out like horns. These distinctive floral features separate it from other North American twayblades (see the key in Appendix 2). Nonflowering plants are probably *L. cordata* if their leaves are heart-shaped and mucronate.

The only known hybrid in North American twayblades is *L.* × *veltmanii,* with intermediate characteristics between its parents, *L. auriculata* and *L. convallarioides* (Catling 1976). It is known from New Brunswick, Newfoundland, Quebec, Ontario, Michigan, Wisconsin, and New Hampshire (Cody and Munro 1980, Coleman and Magrath in preparation).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Listera cordata was first described by Carolus Linnaeus in 1753, as *Ophrys cordata.* In 1813, Robert Brown identified *O. cordata* and *O. ovata* as members of a separate genus, *Listera. Distomaea cordata* (Linnaeus) Spenner was superseded by *Bifolium cordatum* (Linnaeus) Nieuwland, but *Listera* has since been conserved as the genus name (Gleason and Cronquist 1991). Other published synonyms are *Pollinirhiza cordata* (Linnaeus) Dulac, an illegitimate name for whose creation I have found no explanation; *Diphryllum cordatum* (Linnaeus) Kuntze, never clearly connected to *Listera* Brown; and possibly *Listera cordata* (Linnaeus) R. Brown var. *chlorantha* Beauverd. *Listera* is part of the Neottieae tribe (Dressler 1993), which has several genera, including one other North American genus, *Epipactis.*

Species Biology

The biology of *Listera cordata* has received scattered attention, and results from studies of other members of the genus may also be applicable. Rasmussen (1995) reviews the research done on *L. cordata* and *L. ovata,* a widespread, weedy European species,

including seed storage and culture. Details from that review that may be pertinent to *L. cordata* are mentioned below.

Colonies of *L. cordata* can include hundreds of plants, but are more often found in small groups. In Minnesota, established colonies may fluctuate considerably and unpredictably from year to year (Smith 1993). From the sketchy data for New Hampshire occurrences, it is not clear whether populations are always in the same site or shift from place to place in an area. Some populations appear to expand and contract considerably, although none are large (unpublished data from New Hampshire Natural Heritage field forms).

Listera cordata flowers from late May to August (Coleman and Magrath in preparation). The capsules start to release seeds while the upper flowers are still "apparently functional" (Stoutamire 1964). Flowers remain fresh-looking while the ovary ripens (personal observation, and Luer 1975). It is not known how long it takes *L. cordata* to mature. Smith (1993) says that the plants seem to live for only a few years. Estimates for how old *L. ovata* is before producing flowers are 7 to 15 years (Rasmussen 1995).

Twayblades have a small nectary that attracts nonspecific small flying insects, and all have a common pollination mechanism. Ackerman and Mesler (1979) describe pollination in *L. cordata*. A nectary runs down the middle of the lip, and another lies at the base of the column. An insect that visits the flower touches trigger hairs on the column. A dab of glue squirts on the insect, and the pollinia are immediately dropped on the glue. The insect then leaves a chunk of the pollinia at the next flower it visits. The stigma is covered for about a day after losing its pollinia, and then is exposed for pollination. This mechanism helps prevent self-pollination.

Because twayblade nectaries and columns are quite accessible, pollination requires no specific insect body shape (Ackerman and Mesler 1979). *Listera cordata* visitors in California were often fungus gnats (Mycetophilidae and Sciaridae) and occasionally other Diptera and some Hymenoptera (Ackerman and Mesler 1979). Fungus gnats are particularly abundant in early spring. Hapeman (2000) reports seeing fungus gnats pollinating *L. cordata* in Door County, Wisconsin. European twayblades are pollinated by ichneumon wasps, beetles, and small flies (Summerhayes 1951).

Many species of *Listera* have fetid-smelling nectar (Brackley 1985), including *L. cordata*. Often foul odors are part of sapromyophily (pollination by flies that oviposit on feces, decaying fungi, or cadavers), and the plants provide no food. *Listera cordata* does not seem to fit this pattern: during observation in California, its pollinators never appeared to be trying to oviposit or to do anything but eat the nectar the flowers produce. Both male and female insects visited, and no eggs or larvae were found on the flowers. *Listera cordata*'s method of attracting its nonspecific group of pollinators is unknown. Although lack of specific pollinators is sometimes inefficient, the number of *L. cordata* flowers that produce fruitful capsules is high, 61–78% (Ackerman and Mesler 1979). Most of the terrestrial orchids mentioned in Mesler et al. (1980) have fruit set of less than 50%.

Hand pollination produces seeds that contain embryos, while autogamy produces no capsules. In *L. ovata,* when pollinia dry out, some pollen may contact the stigma and fertilize the plant. This may also happen in *L. cordata* (Ackerman and Mesler 1979).

The dust-sized seeds are produced early in the summer and most likely disperse by wind. It is not known whether they germinate the same year or are dormant for a time. Vinogradova (1996) reports the first green leaf appears after 2–3 years of development underground. Artificially germinated *L. cordata* are still tiny protocorms at 15 months, with no chlorophyll (Stoutamire 1964). *Listera cordata* adults overwinter by a shoot at the base of the current year's stem, hidden in moss. Reddoch and Reddoch (1997) report that the new shoot is present when the plant is flowering and grows 1–1.5 cm high. Vinogradova (1996) found that shoot development starts when the main part of the parent plant dies.

Listera cordata's long roots act like runners, and the apical meristem becomes a shoot (Rasmussen 1986). Nieuwdorp (1972) reports long rhizomes with several stems. The many herbarium specimens I examined had rhizomes, and one plant had three stems (two in bloom) on one root system. However, *L. cordata* did not reproduce vegetatively in California populations studied by Ackerman and Mesler (1979) in redwood forests. Disconnected roots contain some starch and can produce shoots. The root-tip meristem transforms directly into a shoot meristem. It sheds the root cap after a shoot meristem with leaf primordia forms beneath. New roots arise at nodes of the shoot (Rasmussen 1995).

Nieuwdorp (1972) reports that the fungal genus *Rhizoctonia* associates with *L. cordata*. Its sprouts and adults have fungal "infections." Its long, hairy roots harbor fungi, but its rhizomes do not (Rasmussen 1995). Chodat and Lendner (1896) located the pelotons (coiled, penetrating hyphae) of mycorrhizae in *L. cordata* in cortical cells in root tips, 1–1.5 cm from the apex. Nieuwdorp (1972) also found fungus in limited areas of the adults. The cortical cells do not die when infected; the plasmalemma surrounds the hyphae.

Habitat/Ecology

Typical habitat for *Listera cordata* is peat-moss hummocks in forested swamps, especially northern white cedar and spruce swamps. It also frequents mossy moist areas in forests of conifers or mixed conifers and hardwoods (Lakela 1965, Cody and Munro 1980, Case 1987, Hapeman 2000). Case (1987) describes ideal habitat for the Great Lakes region as shady bogs with open floors in pure stands of peat moss, where there are "large colonies" of 25–40 plants. At times the two leaves are just at the surface of the sphagnum, so that they appear to be basal (Frankie Brackley Tolman, personal communication). *Listera cordata* grows in jack pine woods near Lake Superior (Chadde 1996). In Michigan, it is found in tamarack, spruce, cedar, or fir swamps (Voss 1972). Hemlock groves in ravines may harbor it as well. Soils are acid to subacid, and *L. cordata* has been found at elevations from sea level to 3,500 meters (Correll 1950, Coleman and Magrath in preparation).

Although the field forms that I have seen describe populations in shaded moss, in California, dry conifer duff is the most common habitat (Coleman 1995). Smith (1993) also reports *L. cordata* growing in Minnesota upland forests in humus or needle duff. Perhaps habitat differences are reflected in varieties *cordata* and *nephrophylla,* with the latter favoring well-drained rich humus in forest shade (Coleman and Magrath in preparation).

Typical associates of *L. cordata* in the Northeast are northern white cedar *(Thuja occidentalis),* balsam fir *(Abies balsamea),* peat mosses (*Sphagnum* spp.), goldthread *(Coptis trifolia),* Labrador-tea *(Ledum groenlandicum),* twinflower *(Linnaea borealis),* white pine *(Pinus strobus),* black spruce *(Picea mariana),* red maple *(Acer rubrum),* speckled alder *(Alnus incana),* wood-fern (*Dryopteris* spp.), bunchberry *(Cornus canadensis),* dwarf enchanter's nightshade *(Circaea alpina),* bedstraw (*Galium* spp.), northern wood-sorrel *(Oxalis montana),* moss (*Polytrichum* spp.), blue-bead lily *(Clintonia borealis),* rein-orchid (*Platanthera* spp.), and sedges (*Carex* spp.). The southernmost populations in the east are in West Virginia at elevations between 700 and 900 meters. There, *L. cordata* is found in forests made up of red spruce *(Picea rubens),* eastern hemlock *(Tsuga canadensis),* American beech *(Fagus grandifolia),* and birches (*Betula* spp.).

THREATS TO THE TAXON

Harvesting the canopy over a seepy depression or in a forested swamp could affect *Listera cordata* habitat in several ways. Increased light might encourage other plants to outcompete *L. cordata,* dry out the habitat, or make it too warm. Driving logging equipment through a soft moist spot or swamp may seriously alter water flow and drainage by creating microdams and channels and compacting the substrate (Thompson and Sorenson 2000, Prenger and Crisman 2001). Although logging of northern white cedar *(Thuja occidentalis)* continues in the region, affecting habitat for *L. cordata,* it is presently not an issue at most sites tracked in this plan.

In the ravine and stream-bank settings that some *L. cordata* inhabits in the White Mountain National Forest, hikers, bicyclists, ATV users, and trail maintainers can trample the plants or affect drainage by causing erosion or by digging water bars. Some Monongahela National Forest populations are also close to hiking trails. *Listera cordata* is not adapted for disturbance, but for continuity. It returns to a forest slowly when disturbed by clear-cutting or fire (Delin 1992).

Hydrological changes in the forested swamps that *L. cordata* often inhabits could eliminate the plant. Roads can obstruct water flow. Road salt and artificial impoundments also affect the habitat: northern white cedar is salt-sensitive and cannot stand long impoundment (Thompson and Sorenson 2000, Johnston 1990). Beavers also alter hydrology. Any major activity up-slope from a seep or swamp is likely to affect water quality and quantity. Groundwater that feeds the swamps can also be altered, primarily by humans using it. Overuse of groundwater may thwart efforts to protect wetland habitat. For example, Massachusetts has strict state laws about preserving

wetlands and Endangered species (as *L. cordata* is in the state). If groundwater drawdown continues to increase with new development, however, it may eventually affect forested wetlands (Pat Swain, Massachusetts Natural Heritage and Endangered Species Program, personal communication).

Global climate change is ongoing and is likely to affect temperature, precipitation, and storm severity and frequency in Region 9 (Dale et al. 2001, Hansen et al. 2001). These changes will affect different plants in different ways, leading to changes in range and in community species composition (Halpin 1997, McCarty 2001). Climate change is likely to affect *L. cordata* through the arrival of new competitors, loss of northern white cedar habitat (or its movement north), warming of groundwater and thus microclimate, change in size of the subalpine area (it is not yet clear whether that will increase, decrease, or stay about the same [Halpin 1997]), and changes in number and type of pollinators and herbivores. Because of land use that leads to forest fragmentation, *L. cordata* at the edges of its range may not be able to migrate to accommodate these changes. Hunter (1993), who gives reasons for preserving fringe populations of even common species, points out that plants and animals adapted to conditions at the edge of their range may be well-adapted to a climate change. Because *L. cordata* tolerates dryer habitat in the western part of its range, it might be able to adapt to higher temperature and precipitation change there. The other effects caused by climate change would still exist, however.

Disruption of pollinators by changes in habitat may not be an issue, since *L. cordata* apparently has a variety of pollinators. Invasive plants are not a problem in the reports I have seen or sites I have visited, but could be introduced by logging equipment, recreational vehicles, railways, and hikers. McCarty (2001) suggests that invasive plants in general could become a greater problem as the climate changes. Another influence on community structure of forested swamps, especially northern white cedar, is excessive deer browse, which can prevent regeneration and change the character of the forest (Johnston 1990). Deer are also known to eat orchids.

DISTRIBUTION AND STATUS

General Status in Region 9

Listera cordata has a global rank of G5 (widespread and secure; NatureServe 2001). It is the most widespread twayblade, found throughout the northern hemisphere in cool northern areas and mountains, and inhabits a fairly broad range of habitat. At the edges of its range, however, it is locally rare.

States in U.S. Forest Service Region 9 that list *L. cordata* as Endangered or Threatened are Massachusetts, New Jersey, New Hampshire, Pennsylvania, and West Virginia. Massachusetts has one extant site, New Jersey has three, and Pennsylvania has two. West Virginia has four extant sites, all in Monongahela National Forest. In New Hampshire, the White Mountain National Forest holds seven of the ten extant sites.

In other Region 9 states, *L. cordata* is not tracked, because it is not rare. In Vermont, *L. cordata* is uncommon but widespread. It is found in almost every part of the state, most often in northern white cedar swamps, but also in red maple–northern white cedar swamps and spruce–fir–tamarack swamps, communities that are uncommon but not rare in the state (Everett Marshall, Vermont Nongame and Natural Heritage Program, personal communication, Thompson and Sorenson 2000). In Maine, *L. cordata* appears in most counties, except for the southern coast, in northern white cedar swamps and moist forests (Josselyn Botanical Society 1995, herbarium labels from the herbarium at University of Maine, Orono). In Wisconsin, it is distributed in a band from Lake Superior to Lake Michigan (Fuller 1933, Case 1987); about 50 sites occur in the Chequamegon-Nicolet National Forest. The orchid is frequently found in northeast Minnesota (including the Chippewa National Forest) in northern white cedar swamps and black spruce swamps and bogs (Minnesota Department of Natural Resources 1993, Smith 1993). Other Region 9 National Forests that probably have populations are Hiawatha and Huron, since it is frequent in northern Michigan and the Upper Peninsula (Voss 1972, Case 1987).

Table 1. Summarizes the distribution and status of *Listera cordata* in North America.

Table 1. Occurrence and status of *Listera cordata* 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[1]	HISTORICAL (LIKELY EXTIRPATED)
Massachusetts: S1	California: S3	Alaska: SR	Maryland: SH
New Hampshire: S2	Alberta: S3	Colorado: SR	North Carolina: SH
New Jersey: S1	Manitoba: S4?	Connecticut: SR	Ohio: SH
Pennsylvania: S1	Nova Scotia: S4	Idaho: SR	Rhode Island: SH
Utah: S1	Ontario: S5?	Maine: SR	
West Virginia: S2		Michigan: SR	
Wyoming: S2		Minnesota: SR	
Prince Edward Island: S1		Montana: SR	
Saskatchewan: S2		Nevada: SR	
		New Brunswick: SR	
		New Mexico: SR	
		New York: SR	
		Oregon: SR	
		Vermont: SR	
		Washington: SR	
		Wisconsin: SR	
		British Columbia: SR	
		Newfoundland: SR	

Table 1. Occurrence and status of *Listera cordata* 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[1]**	**HISTORICAL (LIKELY EXTIRPATED)**
		Northwest Territories: SR	
		Nunavut: SR	
		Quebec: SR	
		Yukon Territory: SR	

[1]*SR* means "status reported." For *L. cordata* in many cases (e.g., Maine, Alaska, Wisconsin, Michigan, Minnesota), *SR* indicates that the orchid is occasional and widespread.

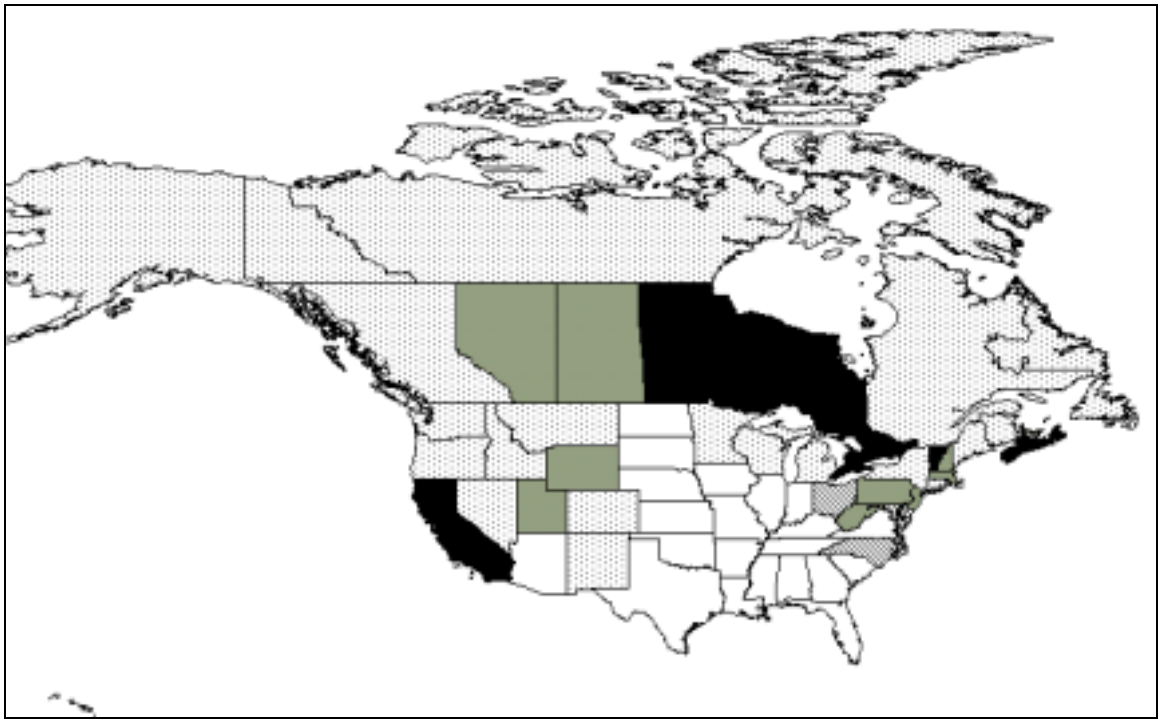

Figure 1. Distribution of *Listera cordata* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon, while states shaded in black have more than five occurrences. Stippling indicates areas where the taxon is ranked SR ("status reported") with no further information. See Appendix 3 for an explanation of NatureServe ranks. Diagonal hatching indicates states where the taxon is considered historical.

Figure 2. States in Region 9 from which *Listera cordata* has been recorded. Shading indicates that the taxon is extant. Black polygons indicate National Forest boundaries.

Listera cordata is not tracked in six of the eleven states in which it occurs in Region 9: Connecticut, Maine, Michigan, Minnesota, Vermont, and Wisconsin. In New Hampshire and West Virginia, it has been reported in 18 National Forest sites. Seven of those occurrences have not been seen for more than 20 years. One new site for the White Mountain National Forest was located in 2001. Table 2 shows occurrences for Region 9 National Forests and New England states where *L. cordata* is tracked.

Element occurrence (EO) quality ranks are based on the size, condition, and landscape context of a rare species population. They range from A (excellent) to D (poor). The rank E applies to element occurrences that are extant but unranked because of a lack of information. The rank H applies to sites for which no observations have been made for more than 20 years and are considered historical. The rank X applies to sites that are known to be extirpated. See Appendix 3 for more details.

For *L. cordata,* EO ranks have been published in Chase 2001, which is quoted here.

> A = 50+ genets with evidence of reproduction in excellent habitats of large size and high natural integrity . . .
>
> B = 25–49 genets in habitat of good to excellent condition and landscape context and with minimal threats to viability . . .
>
> C = 12–24 genets in habitat of fair to excellent condition and landscape context . . .
>
> D = 1–11 genets in habitat of poor to excellent condition and landscape context.

CURRENT CONSERVATION MEASURES IN REGION 9

Massachusetts has one extant site, in an Atlantic white cedar swamp on public land. Timber harvest would affect the canopy and perhaps make the area too sunny for *Listera cordata;* however, commercial harvesting should receive a review by the Natural Heritage and Endangered Species Program. Massachusetts law protects wetlands and endangered state plants, so this population would seem to be secure. Increasing drawdown of groundwater for household use could affect the hydrology of the site (Pat Swain, personal communication).

Of New Hampshire's nine extant sites, six in the White Mountain National Forest seem secure from human interference. Another is in a Nature Conservancy preserve. Two sites are on private land that is logged, and are not protected.

In New Jersey, *L. cordata* is not legally protected. Its three sites are on state lands and Nature Conservancy land.

The two small populations in Pennsylvania are on state lands, with no specific conservation protection. They may be close enough to each other to be considered one population.

West Virginia has five extant sites, one in a nature preserve. One is on private logging land. This site should be secure as long as prescribed logging practices are followed (i.e., buffered riparian areas and wetlands). Some sites are vulnerable to trampling or collecting.

CONSERVATION OBJECTIVES FOR *LISTERA CORDATA* IN REGION 9

In its entire range, *Listera cordata* is considered secure. At the limits of its range in U.S. Forest Service Region 9, however, pressure on *L. cordata* habitat threatens its persistence.

The conservation objectives for *L. cordata* in Region 9 are to buffer habitats that harbor *L. cordata* from logging and recreational use, to discover what it prefers in its habitat, and to search for extant populations in likely habitat, and perhaps in historical sites. The goal is to protect wetlands where *L. cordata* is known to be, to preserve the five sizable populations (25+ plants) in New England and the four sizable populations in Monongahela National Forest, and to search for and protect five or six more good-quality populations in New Hampshire and Massachusetts. The population size is based on Natural Heritage rankings (Chase 2001) and reports of stable populations in provinces and states where the orchid is not rare. The number of populations is an estimate of what it will take to maintain the orchid's presence in this part of its range, based on the number of historical and present occurrences.

GENERAL CONSERVATION ACTIONS FOR *LISTERA CORDATA*

1. Contact landowners and inform them of the species' status. Get permission to monitor sites and conduct research.

2. Ensure that trail maintainers and logging operators know to protect seepy habitat in harvest areas and along trails. Follow best practices for sensitive areas.

3. Study habitat preferences. This information would aid the search for new populations and focus on areas that would benefit from protection.

4. Search for historical populations and new populations in likely habitat. Collect detailed information, including population size, condition, associated species, landscape context, and threats.

5. Institute regular monitoring of extant sites to collect population data. This information can be used to head off possible threats to extant populations.

Landowner Communications

Contact landowners and ask for permission to monitor or search for *Listera cordata*. Let them know the habitat needs of the plant (so far as we know them) and encourage them not to interfere with hydrology while logging or clearing land. In many cases, reasonable protection may involve nothing more than formalizing good forestry practices that are already in use.

Sensitive Land Use

Preserving *L. cordata* requires logging and trail-maintenance practices that will be least damaging to the hydrology that supports its habitat. Sensitive-species status in the National Forests mandates individual site plans prior to ground-disturbing activity. Undisturbed forest floor, soil moisture, and canopy are essential to shade-loving plants, giving them an edge over competitors (Carlson 1999). The plans should minimize or avoid disturbances resulting from trail and road building or maintenance. A buffer of at least 30 meters around a seep that harbors a population is suggested (Chase et al. 1995). Even a large buffer may be inadequate for *L. cordata* persistence in the habitat, however, if the populations shift from patch to patch within a wetland (Ouborg 1993).

Describing Habitat Preferences

Searching for new populations presupposes an accurate description of *L. cordata* preferred habitat. In the Chequamegon-Nicolet Forest in Michigan, it can be "found in any high-quality northern white cedar *(Thuja occidentalis)* stand with an open understory and lots of sphagnum groundcover . . . in deep shade with moist but not wet soil" (Marjory Brzeskiewicz, personal communication). But outside of northern white cedar habitat, it is not clear what moisture, pH, soil, and light conditions encourage *L. cordata* to grow. Although it grows in dry duff in the west, in Region 9 it appears to prefer habitat that is at least seasonally moist. It might be easier to gather information on moisture regime (perennial or seasonal), pH of water and soil, and

light availability for populations where it is relatively common, for example Maine and Wisconsin.

Searching for New Occurrences

Searching for new populations in likely habitat should emphasize sites at a distance from trails and in wilderness areas. In the White Mountain National Forest, this means searching wooded swamps and forested seeps right up through subalpine areas, as there is little northern white cedar habitat in the forest (Sperduto and Engstrom 1998). In Monongahela National Forest, moist, forested elevations over 700 meters are where it has been found in the past. In Massachusetts, a search in good-quality Atlantic white cedar swamps might disclose new populations. At a new site, surveyors should collect detailed information, including population size, condition, associated species, landscape context, and threats.

Monitoring Populations

It may be possible to annually monitor population demography. Information on seed production and seedling establishment could be used to head off possible threats to extant populations. These data could tell us whether *L. cordata* migrates, stays put, or does not appear in some years, like many orchids (Rasmussen and Whigham 1998, Gillman and Dodd 1998). At many sites, however, monitoring should be limited to estimation or presence/absence, to protect the habitat from trampling (Elzinga et al. 1999).

LITERATURE CITED

Ackerman, J. D., and M. R. Mesler. 1979. Pollination biology of *Listera cordata* (Orchidaceae). *American Journal of Botany* 66: 820–824.

Brackley, F. E. 1985. The orchids of New Hampshire. *Rhodora* 87: 1–117.

Calder, J. A., and R. L. Taylor. 1968. *Flora of the Queen Charlotte Islands: Part 1, Systematics of the Vascular Plants.* Canada Department of Agriculture, Ottawa, Ontario, Canada.

Carlson, B. D. 1999. *Threatened and Endangered Species in Forests of Maine: A Guide to Assist with Forestry Activities.* Edited by J. M. Sweeney. Champion International. Distributed by UMCE State Communications Office, Orono, Maine, USA.

Case, F. W., Jr. 1987. *Listera.* Pages 130–143 in *Orchids of the Western Great Lakes Region,* rev. ed. Cranbrook Institute of Science, USA.

Catling, P. M. 1976. On the geographical distribution, ecology, and distinctive features of *Listera* × *veltmanii* Case. *Rhodora* 78: 261–269.

Chadde, S. W. 1996. *Plants of Pictured Rocks National Lakeshore.* PocketFlora Press, Lake Linden, Michigan, USA.

Chase, V. P. 2001. Ranking specifications for rare plant species that occur in areas impacted by the 1998 ice storm. In K. F. Crowley and B. D. Kimball, Evaluation of rare plant populations and exemplary natural communities in areas impacted by the 1998 ice storm in New Hampshire, final report. New Hampshire Natural Heritage Inventory, Department of Resources and Economic Development, Concord, New Hampshire, USA.

Chase, V. P., L. S. Deming, and F. Latawiec. 1995. Buffers for wetlands and surface waters: A guidebook for New Hampshire municipalities. Audubon Society of New Hampshire, Concord, New Hampshire, USA.

Chodat, R., and A. Lendner. 1896. Sur les mycorhizes du *Listera cordata. Bulletin de l'Herbier Boissier* 4: 265–272.

Cody, W. J., and D. Munro. 1980. The genus *Listera* (twayblades) in New Brunswick. *Canadian Field-Naturalist* 94: 443–446.

Coleman, R. A. 1995. *The Wild Orchids of California.* Cornell University Press, Ithaca, New York, USA.

Coleman, R. A., and L. K. Magrath. In preparation. *Listera* chapter for *Flora of North America: North of Mexico.* Unpublished manuscript.

Correll, D. S. 1950. *Native Orchids of North America: North of Mexico.* Chronica Botanica Company, Waltham, Massachusetts, USA.

Dale, V. H., L. A. Joyce, S. McNulty, R. P. Neilson, M. P. Ayres, M. D. Flannigan, P. J. Hanson, L. C. Irland, A. E. Lugo, C. J. Peterson, D. Simberloff, F. J. Swanson, B. J. Stocks, and B. M. Wotton. 2001. Climate change and forest disturbances. *BioScience* 51: 723–734.

Delin, A. 1992. Kärlväxter i taigan i Hälsingland: Deras anpassningar till kontinuitet eller störning. Summary in English. *Svensk Botanisk Tidskrift* 86: 161–176.

Dressler, R. L. 1993. *Phylogeny and Classification of the Orchid Family.* Dioscorides Press, Portland, Oregon, USA.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1999. *Measuring and Monitoring Plant Populations.* BLM Technical Reference 1730-1. Bureau of Land Management, Denver, Colorado, USA.

Gillman, M. P., and M. E. Dodd. 1998. The variability of orchid population size. Pages 65–71 in S. Waite, ed., *Orchid Population Biology, Conservation, and Challenges.* London, Linnaean Society, UK.

Gleason, H. A., 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.

Halpin, P. N. 1997. Global climate change and natural-area protection: Management responses and research directions. *Ecological Applications* 7: 828–843.

Hansen, A. J., R. P. Neilson, V. H. Dale, C. H. Flather, L. R. Iverson, D. J. Currie, S. Shafer, R. Cook, and P. J. Bartlein. 2001. Global change in forests: Responses of species, communities, and biomes. *BioScience* 51: 765–779.

Hapeman, J. R. 2000. *Listera cordata* (L.) R. Brown. In Orchids of Wisconsin: An interactive flora. Available at http://www.wisc.edu/botany/Orchids/Orchids_of_Wisconsin.html.

Hoy, J. M. 2001. *Listera auriculata* (auricled twayblade) conservation and research plan. New England Wild Flower Society, Framingham, Massachusetts, USA.

Hoy, J. M. 2002. *Listera convallarioides* (broad-leaved twayblade) conservation and research plan for U.S. Forest Service Region 9. New England Wild Flower Society, Framingham, Massachusetts, USA.

Hultén, E. 1941. *Flora of Alaska and Yukon.* Lund University, Lund, Sweden.

Hunter, M. L., Jr. 1993. Of puffins and parochialism: Why is it important to conserve species that are locally rare, but globally common? *Maine Naturalist* 1: 39–42.

Johnston, W. F. 1990. *Thuja occidentalis* L., northern white cedar. Pages 580–589 in R. M. Barnes and B. H. Honkala, *Silvics of North America.* Volume 1, *Conifers.* U.S. Government Printing Office, Washington, DC, USA.

Josselyn Botanical Society of Maine. 1995. The checklist of the vascular plants of Maine. Bulletin 844. Maine Agricultural and Forest Experiment Station, Orono, Maine, USA.

Lakela, O. 1965. *A Flora of Northeastern Minnesota.* University of Minnesota Press, Minneapolis, Minnesota, USA.

Luer, C. A. 1975. *The Native Orchids of the United States and Canada Excluding Florida.* New York Botanical Garden, Bronx, New York, USA.

McCarty, J. P. 2001. Ecological consequences of recent climate change. *Conservation Biology* 15: 320–331.

Mesler, M. R., J. D. Ackerman, and K. L. Lu. 1980. The effectiveness of fungus gnats as pollinators. *American Journal of Botany* 67: 564–567.

Minnesota Department of Natural Resources, Natural Heritage Program. 1993. Minnesota's native vegetation: A key to natural communities. Version 1.5. Minnesota Department of Natural Resources, St. Paul, Minnesota, USA.

NatureServe. 2001. *Listera cordata.* Association for Biodiversity Information, Arlington, Virginia, USA. Available at http://www.natureserve.org.

Nieuwdorp, P. J. 1972. Some observations with light and electron microscope on the endotrophic mycorrhiza of orchids. *Acta Botanica Neerlandica* 21: 128–144.

Ouborg, N. J. 1993. Isolation, population size, and extinction: The classical and metapopulation approaches applied to vascular plants along the Dutch Rhine-system. *Oikos* 66: 298–308.

Pease, A. S. 1964. *A Flora of Northern New Hampshire.* New England Botanical Club, Cambridge, Massachusetts, USA.

Prenger, J. P., and T. L. Crisman. 2001. Timber harvest in wetlands: Strategies and impact assessment. Pages 429–449 in R. B. Rader, D. P. Batzer, and S. A. Wissinger, eds., *Bioassessment and Management of North American Freshwater Wetlands.* John Wiley and Sons, New York, USA.

Rasmussen, H. N. 1986. The vegetative architecture of orchids. *Lindleyana* 1: 42–50.

Rasmussen, H. N. 1995. *Terrestrial Orchids: From Seed to Mycotrophic Plant.* Cambridge University Press, Cambridge, UK.

Rasmussen, H. N., and D. F. Whigham. 1998. The underground phase: A special challenge in studies of terrestrial orchid populations. Pages 49–64 in S. Waite, ed., *Orchid Population Biology, Conservation, and Challenges.* London, Linnaean Society, UK.

Reddoch, J. M., and A. H. Reddoch. 1997. The orchids in the Ottawa District: Floristics, phytogeography, population studies, and historical review. *Canadian Field-Naturalist* 111: 1–183.

Smith, W. R. 1993. *Orchids of Minnesota.* University of Minnesota Press, Minneapolis, Minnesota, USA.

Sperduto, D. D., and B. Engstrom. 1998. Northern white cedar swamps of New Hampshire. New Hampshire Natural Heritage Inventory and The Nature Conservancy, Eastern Region, Boston, Massachusetts, USA.

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

Stoutamire, W. P. 1964. Seeds and seedlings of native orchids. *Michigan Botanist* 3: 107–119.

Summerhayes, V. S. 1951. *Wild Orchids of Britain.* Collins, London, UK.

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, Hanover, New Hampshire, USA.

Vinogradova, T. N. 1996. The early stages of *Listera cordata* (L.) R. Br. development in natural conditions. *Moskovskoe obshchestvo i spyta telei prirody biulletin,* NS otd. 101: 83–92. Summary in English.

Voss, E. G. 1972. *Michigan Flora.* Volume 1. *Monocots and Gymnosperms.* Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, Michigan, USA.

APPENDICES

1. PERSONAL COMMUNICATION REFERENCES

Frankie Brackley Tolman
6 Nubanusit Road
Marlborough, New Hampshire 03455 USA

Marjory Brzeskiewicz
Chequamegon-Nicolet National Forest
1170 South 4th Avenue
Park Falls, Wisconsin 54552 USA

Frederick W. Case, Jr.
7275 Thornapple Lane
Saginaw, Michigan 48609 USA

Everett Marshall
Nongame and Natural Heritage Program
Vermont Department of Fish and Wildlife
103 South Main Street
Waterbury, Vermont 85671 USA

Patricia Swain
Natural Heritage and Endangered Species Program
Division of Fisheries and Wildlife
Route 135
Westborough, Massachusetts 01581 USA

2. KEY TO *LISTERA* SPECIES IN U.S. FOREST SERVICE REGION 9

Adapted from Coleman and Magrath (in preparation) and Case (1987). Habitats are for Region 9.

1. Lip deeply cleft into pointed, linear lobes .....2.

1. Lip expanded at apex, or, if cleft, with rounded lobes.....3.

   2. Lip with basal lobes (auricles) rounded and curved back, partly surrounding the column; moist woods, peatlands.....*L. australis*

   2. Lip with basal lobes pointed and projecting outward like horns, away from the column; wet woods, northern white cedar swamps .....*L. cordata*

3. Lip about as broad at the apex as at the base; banks of streams and rivers, shores of large lakes.....*L. auriculata*

3. Lip broader at the apex than at the base.....4.

   4. Lip with a short claw (lip appearing stalked).....5.

   4. Lip with no claw (lip sessile) .....6.

5. Base of lip with inconspicuous triangular tooth on each side; lip slightly notched; rich humus in open woods, forest seeps.....*L. convallarioides*

5. Base of lip with distinct lobe on each side; lip deeply notched.....*L.* × *veltmanii*

   6. Lip angled downward; base of lip without lobe; moist, rich areas, disturbed sites .....*L. ovata*

   6. Lip not angled downward; base of lip with two lobes; shady, moist Appalachian forests.....*L. smallii*

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 made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EOs have received such ranks in all states, and ranks are not necessarily consistent among states as yet.