

New England Plant Conservation Program

Listera australis Lindl.
Southern Twayblade

Conservation and Research Plan
for New England

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SUMMARY

The orchid *Listera australis* Lindley (southern twayblade) is widespread in the southern United States, with disjunct populations north of Tennessee and New Jersey. In New England, it has been found only at three sites in Vermont, and its continuing existence there is vulnerable to local changes in hydrology (beaver activity or human withdrawals) or land use.

Listera australis is a North American endemic, with a global rank of G4 (widespread and apparently secure). Its distribution forms a band along the Gulf of Mexico and on the coastal plain from Florida to New Jersey, with disjunct patches up to Nova Scotia. Disjunct patches have also been found in central Tennessee, among the Finger Lakes of New York, in the northern Green Mountains of Vermont, and near Lakes Ontario and Erie in Ontario and Pennsylvania. It seems to be uncommon but widespread in the Gulf states, and stretches north to Maryland, Delaware, and North Carolina in a patchy distribution. Vermont lists it as S1; other states and provinces that list it as S1 or S2 are Alabama, Georgia, Kentucky, New Brunswick, New Jersey, New York, Nova Scotia, Oklahoma, Ontario, Pennsylvania, Quebec, and Tennessee.

Listera australis flowers mostly in June in the northern part of its range. By most reports, the plant appears for just a few weeks above ground. Typical habitat for *L. australis* in the northern part of its range is open or sparsely wooded poor fens, on the side and base of hummocks.

Two sites in Vermont have been known for many years, one a kettle-hole bog complex, the other a poor fen. A new site in Vermont was found in 2002 in a forested peatland. There are no reports of populations that have disappeared. *Listera australis* may occur in New England more frequently than the three known occurrences, as the small plants are hard to see and disappear quickly after they set seed. Its peatland habitat occurs in other New England states, for example, peatlands in Maine and northern New Hampshire and red maple swamps in Massachusetts.

The conservation objectives in Vermont are to preserve the three known populations in Vermont and to search for and protect good-sized populations (25+ plants) in likely habitat elsewhere in New England. This population size is based on published population sizes for northern sites; a small population in one year may be large the next and should not automatically downgrade the occurrence. The goals for *L. australis* in New England are to protect peatlands that harbor populations and to search for new populations. The plant has a disjunct distribution, with populations in Ontario, New Brunswick, New York, and Pennsylvania; it is possible that it has been overlooked in the states between.

PREFACE

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

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

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

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

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection.

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I. BACKGROUND

INTRODUCTION

Listera australis (southern twayblade) is a North American endemic, with a global rank of G4 (widespread and apparently secure). Its distribution forms a band along the Gulf of Mexico and on the coastal plain from Florida to New Jersey, with disjunct patches up to Nova Scotia (Lamont 1996, Zinck 1998). Disjunct patches have also been found in Kentucky, central Tennessee, among the Finger Lakes of New York, in the northern Green Mountains of Vermont, and near Lakes Ontario and Erie in Ontario and Pennsylvania (Rowlee 1897, Whiting and Bobbette 1974, Henry et al. 1975, Webb 1978, Bates et al. 1985).

Listera australis flowers mostly in June in the northern part of its range (Case 1987, Reddoch and Reddoch 1997, Hinds 2000). By most reports, the plant appears for just a few weeks above ground. Typical habitat for *L. australis* in the northern part of its range is open or sparsely wooded poor fens, on the side and base of hummocks.

The conservation objectives for *L. australis* in New England are: to preserve the three known populations in Vermont; to search for and protect good-sized populations (25+ plants) in likely habitat elsewhere in New England; to protect peatlands that harbor populations; and to use our understanding of its microhabitat to search likely habitat for other populations in New England.

DESCRIPTION

This description of *Listera australis* is based on Coleman and Magrath (in preparation) and Case (1987). *Listera australis* is a terrestrial orchid with slender, fibrous roots and a purplish green stem. It is between 8 and 29 cm tall. Its two sessile, subopposite leaves are glabrous, ovate to ovate-oblong or sometimes elliptic, obtuse to apiculate, often subcordate at the base, 13–40 mm long, and 5–21 mm wide. It occasionally has an extra leaf, or bract (Wiegand 1899, Mousley 1940, Luer 1975, Reddoch and Reddoch 1997, personal observation). It has an open terminal raceme, 45–110 mm long, with inconspicuous floral bracts that are suborbicular-ovate and 2 mm by 1 mm. Below the leaves the stem is glabrous; the peduncle and rachis are slightly glandular-puberulent. The bracts, pedicels, and ovaries are glabrous. A plant may have 5–25 reddish purple flowers. The dorsal sepal is ovate-elliptic, obtuse, concave, and 1.5 mm by 1 mm, and the lateral sepals are ovate, obtuse, falcate, and 1.5 mm by 1 mm. The petals are oblong, obtuse, recurved, and 1.5 mm by 0.5 mm. The lip is linear and is split one-third to one-half of its length, forming two filamentous lobes with a small tooth in the sinus. The base of the lip has a pair of linear, obtuse lobes, partly surrounding the column, which is 0.5–1 mm by 0.5–1 mm. Seed capsules are ovoid, 8 mm by 5 mm, and horizontal. A capsule holds relatively few seeds, compared to most orchids. Curtiss (1893) says the seeds average 0.36 mm by 0.20 mm.

There are eight North American species in the genus *Listera*; *L. australis* overlaps in distribution with three in New England: *L. cordata* (heart-leaved twayblade), *L. auriculata* (auricled twayblade), and *L. convallarioides* (broad-leaved twayblade). (Conservation plans for these three species in New England are also available [Hoy 2001, 2002a, 2002b].) *Listera australis* has pointed tips on a deeply split lip, and rounded basal auricles that project back, partly surrounding the column. These features distinguish it from *L. auriculata* and *L. convallarioides*, with their rounded, notched lip, and from *L. cordata*, with its pointed auricles that project out like horns.

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 australis was first described by John Lindley in 1840. Linnaeus originally included the twayblades in the genus *Ophrys*, but in 1813 R. Brown segregated the genus *Listera*. Two published synonyms, *Ophrys australis* (House 1905) and *Bifolium australe* (Nieuwland 1913), were based on publication priority of those names. *Listera* has been conserved as the genus name (Gleason and Cronquist 1991). The synonym *Diphryllum australe* O. Kuntze can be dismissed; *Diphryllum*, proposed in 1808, was never clearly connected to *Listera* Brown. *Listera* is part of the Neottieae tribe (Dressler 1993), which has several genera, including one other North American genus, *Epipactis*.

SPECIES BIOLOGY

Little is known specifically of *Listera australis* biology; however, results from studies of other members of the genus may be applicable to *L. australis*. Rasmussen (1995) reviews the research done, mostly on *L. ovata* (common twayblade), a widespread, weedy European species, including seed storage and culture. Details from that review that may be pertinent to *L. australis* are mentioned below.

The size of northern populations of *L. australis* is usually a few to a few dozen scattered individuals. I have found a single report of hundreds to thousands of plants in a population on Long Island (Lamont et al. 1988; Steve Young, New York Natural Heritage Program, personal communication). Because the plants are scattered and hard to see, average population size is speculative. It also may vary within the wide latitudinal range of the plant.

I could find no studies of *L. australis* mycorrhizal partners. Fungal infection of *L. cordata* (heart-leaved twayblade) sprouts persists in mature plants. *Listera ovata* roots

harbor fungi, but its rhizomes do not (Rasmussen 1995). Mellichamp (1881) thought that *L. australis* might be parasitic on two frequent associates, cinnamon fern (*Osmunda cinnamomea*) and royal fern (*O. regalis*); this potential for parasitism has not been explored, as far as I know.

The only reports of herbivory I found were of attempts to cultivate *L. australis* in gardens, where it was invariably destroyed by slugs (Correll 1950). I saw no signs of herbivory in Vermont.

Listera australis flowers mostly in June in the northern part of its range (Case 1987, Reddoch and Reddoch 1997, Hinds 2000). It blooms as early as January in Florida, before the trees are in full leaf, and disappears in a few weeks (Luer 1972). Flowers remain fresh-looking while the ovary ripens (Luer 1975, Coleman and Magrath in preparation). By most reports, the plant appears for just a few weeks above ground. However, Henry et al. (1975) report that it blooms for "a fairly long period." It is not known how long it takes *L. australis* to mature. Smith (1993) says that *L. cordata* plants seem to live for only a few years. Estimates for the age at first reproduction of *L. ovata* range from 7 to 15 years (Rasmussen 1995).

Listera species have a small nectary that attracts nonspecific small flying insects. Many species of *Listera* have fetid-smelling nectar, including *L. australis* and *L. cordata* (Ramsey 1950, Brackley 1985). 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 other Diptera and some Hymenoptera (Ackerman and Mesler 1979). Hapeman (2000) shows a photograph of *L. auriculata* being visited by a small dipterid, perhaps a fungus gnat. Fungus gnats are active in early spring, so it is possible that the early-blooming *L. australis* is also pollinated by fungus gnats.

All *Listera* species 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 (four of them in *L. australis* [Ramsey 1950]). A dab of glue squirts on the insect, and the pollinia are immediately dropped on the glue. The stigma is covered for about a day, and then is exposed for pollination. This mechanism helps prevent self-pollination.

The dust-sized seeds are produced in the summer, while the flowers still look fresh. They most likely disperse by wind; however, if nectar-seeking insects visit the flowers while seeds are dispersing, perhaps they too carry the small seeds away. It is not known whether the seeds germinate the same year or are dormant for a time. Vinogradova (1996) reports for *L. cordata* that the first green leaf appears after 2–3 years of development underground. *Listera australis* overwinters by a shoot at the base of the current year's stem (Reddoch and Reddoch 1997).

Studies of vegetative reproduction in other species in the genus may apply to *L. australis*. *Listera cordata* did not reproduce vegetatively in California populations

studied by Ackerman and Mesler (1979) in redwood forests. However, pieces of its roots, which are slender and fibrous like those of *L. australis*, can produce shoots (Rasmussen 1995). Case (1987) reports that *L. australis* rarely forms clusters or clumps, which argues against the likelihood of vegetative reproduction.

HABITAT/ECOLOGY

Typical habitat for *Listera australis* in the northern part of its range is open or sparsely wooded poor fens, on the side and base of hummocks. It appears to prefer partial to full sun in sheltered openings (Greenwood 1962, Whiting 1971, Whiting and Bobbette 1974, Case 1987), on the southern edge or at the forest–open bog interface (Jim Goltz, Botanist, personal communication; Dwayne Sabine, Species at Risk Program, personal communication). Typical associates of *L. australis* in New England are peat mosses (*Sphagnum* spp.), black spruce (*Picea mariana*), three-leaved false Solomon's seal (*Smilacina trifolia*), swamp-laurel (*Kalmia polifolia*), leatherleaf (*Chamaedaphne calyculata*), bog-rosemary (*Andromeda glaucophylla*), Labrador-tea (*Ledum groenlandicum*), pitcher-plant (*Sarracenia purpurea*), small cranberry (*Vaccinium oxycoccos*), and sedges (*Carex pauciflora* and *C. trisperma*). In New Brunswick and Ontario it prefers areas without much competition from members of the heath family, above the water level in wet peat moss (Reddoch and Reddoch 1997; Hinds 2000; Jim Goltz, personal communication; Dwayne Sabine, personal communication). These conditions also fit the Vermont sites (Vermont Nongame and Natural Heritage Program field forms, personal observation). In New York, however, it grows beneath leatherleaf and *Vaccinium* spp. (Steve Young, personal communication) and in red maple (*Acer rubrum*) swamps, sometimes in association with *Carex collinsii* (Lamont et al. 1988, Robert Zaremba, Botanist, personal communication).

In the southern part of its range, *L. australis* is found in rich humus of low moist woods, marshes, and peat bogs (Correll 1950, Luer 1975, Webb 1978, Bates et al. 1985, Stalter and Lamont 1997, Coleman and Magrath in preparation). Other sites include a coastal plain community on a fragipan and the borders of sinkhole ponds (Paul Somers, Massachusetts Natural Heritage and Endangered Species Program, personal communication). *Listera australis* grows at elevations from sea level to 1,000 meters. Frequent associates are cinnamon fern (*Osmunda cinnamomea*) and royal fern (*O. regalis*), on which it may be parasitic (Mellichamp 1881).

Listera australis can grow in a wide range of climates, although it always appears and blooms in early spring. It apparently needs, or at least tolerates, acidic soil wherever it grows: peatlands in the north, and moist pinewoods and hardwood forests in the south (Correll 1950).

THREATS TO LISTERA AUSTRALIS

In the north, the peatland habitat of *Listera australis* faces common threats: vehicular traffic, wetland draining, peat harvesting, nutrient influx from agricultural lands

and pollution, and global climate change (Moore and Bellamy 1974, Damman and French 1987). Nutrient loading from adjacent farms and trampling by researchers at the small peatlands where *L. australis* has been found in Vermont could damage the populations there.

Frequent visits to peatlands create trails in the peat, which changes microhabitat, and can disturb the fragile, shallow roots of small herbs like *L. australis* (Moore and Bellamy 1974). It is easy to overlook this orchid, even in bloom, and walking on it at any time of year is likely to damage the plants (Frankie Brackley Tolman, Botanist, personal communication). Research efforts at Vermont sites have left a trail into the bog, and should be kept to a minimum.

Driving vehicles through a bog creates scars that do not disappear quickly in the slow-growing groundcover. If traffic is frequent (ATVs) or heavy (logging equipment), it can seriously alter water flow and drainage by creating microdams and channels and by compacting the substrate (Thompson and Sorenson 2000). In 2002, there were no signs of vehicle traffic at the Vermont sites. Logging of black spruce (*Picea mariana*) could affect habitat for *L. australis*, but it is presently not an issue at the sites described in this plan.

Peat mining and wetland draining threaten habitat in some parts of *L. australis* range (e.g., southern Canada [Rocheffort 2000]). They are not presently a threat at the sites in this plan.

Nutrient loading may be the most serious threat to the peatlands that *L. australis* inhabits (Moore and Bellamy 1974). Enrichment sources include agricultural fertilizer, soil leaching and erosion, household effluents, and rain pollution (such as soot, sulfur dioxide, and fertilizer dust) (Tallis 1983). In a study by Drexler and Bedford (2002), nutrients from adjacent agricultural land supported vegetation that outcompetes the usual inhabitants of kettle-hole peatlands. Two of the Vermont *L. australis* sites (VT .001 [Morristown and Stowe] and the new site) could be affected by fertilizer or manure from nearby dairy and tree farms, although at present the farms' operations have not apparently affected the peatlands.

Hydrological changes in the peatlands that *L. australis* inhabits could eliminate the plant. Roads can obstruct water flow, making a site too wet or too dry for the plants. Road salt and artificial impoundments also affect the habitat (Thompson and Sorenson 2000). Beavers, of course, can alter hydrology. Groundwater that feeds the peatlands can be altered, primarily by withdrawals for human use. Hydrological change does not appear to threaten the Vermont sites presently.

There are several reasons for preserving fringe populations of even common species, such as the northern *L. australis* populations (Hunter 1993, Lesica and Allendorf 1995). These populations are expected to be genetically and morphologically different from central populations, because of genetic drift and natural selection. In the long run, species conservation is likely to depend on the survival of genetically different populations that could be adaptive in a changing environment.

Disruption of pollinators by changes in habitat, from either nearby logging or climatic effects, cannot be evaluated without knowing more about *L. australis* 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, road traffic, and site visitors. McCarty (2001) suggests that invasive plants in general could become more and more troublesome as the climate warms.

DISTRIBUTION AND STATUS

General Status

Listera australis is a North American endemic, with a global rank of G4 (widespread and apparently secure, NatureServe 2001). It seems to be uncommon but widespread in the Gulf states, and stretches north to Maryland, Delaware, and North Carolina in a patchy distribution. Vermont lists it as S1 (Endangered); other states and provinces that list it as S1 or S2 are Alabama, Georgia, Kentucky, New Brunswick, New Jersey, New York, Nova Scotia, Oklahoma, Ontario, Pennsylvania, Quebec, and Tennessee. Its status in Canada is N2 (Imperiled), because there are less than 20 occurrences.

Table 1. Occurrence and status of <i>Listera australis</i> in the United States and Canada based on information from Natural Heritage Programs and Canadian Conservation Data Centres			
OCCURS & LISTED (AS S1, S2, OR T & E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED	HISTORICAL (LIKELY EXTIRPATED)
Alabama: S2	Arkansas: S?	Louisiana: SR	
District of Columbia: S1	Delaware: S3	Mississippi: SR	
Georgia: S2	Florida: S3S4	Texas: SR	
Kentucky: S1	Maryland: S3		
New Jersey: S2	North Carolina: S3		
New York: S1S2	South Carolina: S?		
Oklahoma: S1	Virginia: S3S4		
Pennsylvania: S1			
Tennessee: S1S2			
Vermont: S1			
New Brunswick: S1			
Nova Scotia: S1			
Ontario: S2			
Quebec: S2			

It is conceivable that the northern distribution of *L. australis* is slowly expanding, so that more populations are being reported. It is more likely that the plant has been overlooked, however, given its near invisibility and relatively brief aboveground appearance. The first Canadian report was in Ontario in 1893; the first New England report is from 1922.

Status of All New England Occurrences

Listera australis has been reported for three sites in New England, all in Vermont. Two sites have been known for many years. A new site was found in 2002, not far from one of the previously known sites. No reports or herbarium specimens have turned up to indicate a larger New England presence in the past.

Listera australis may occur in New England more frequently than the three known occurrences, as the small plants are hard to see and may disappear quickly after they set seed. Its habitat occurs in other New England states: for example, peatlands in Maine and northern New Hampshire and red maple swamps in Massachusetts.

Element occurrence (EO) quality ranks are based on the size, condition, and landscape context of a rare species population. These terms collectively refer to the integrity of natural processes or the degree of human disturbances that may sustain or threaten long-term survival. 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.

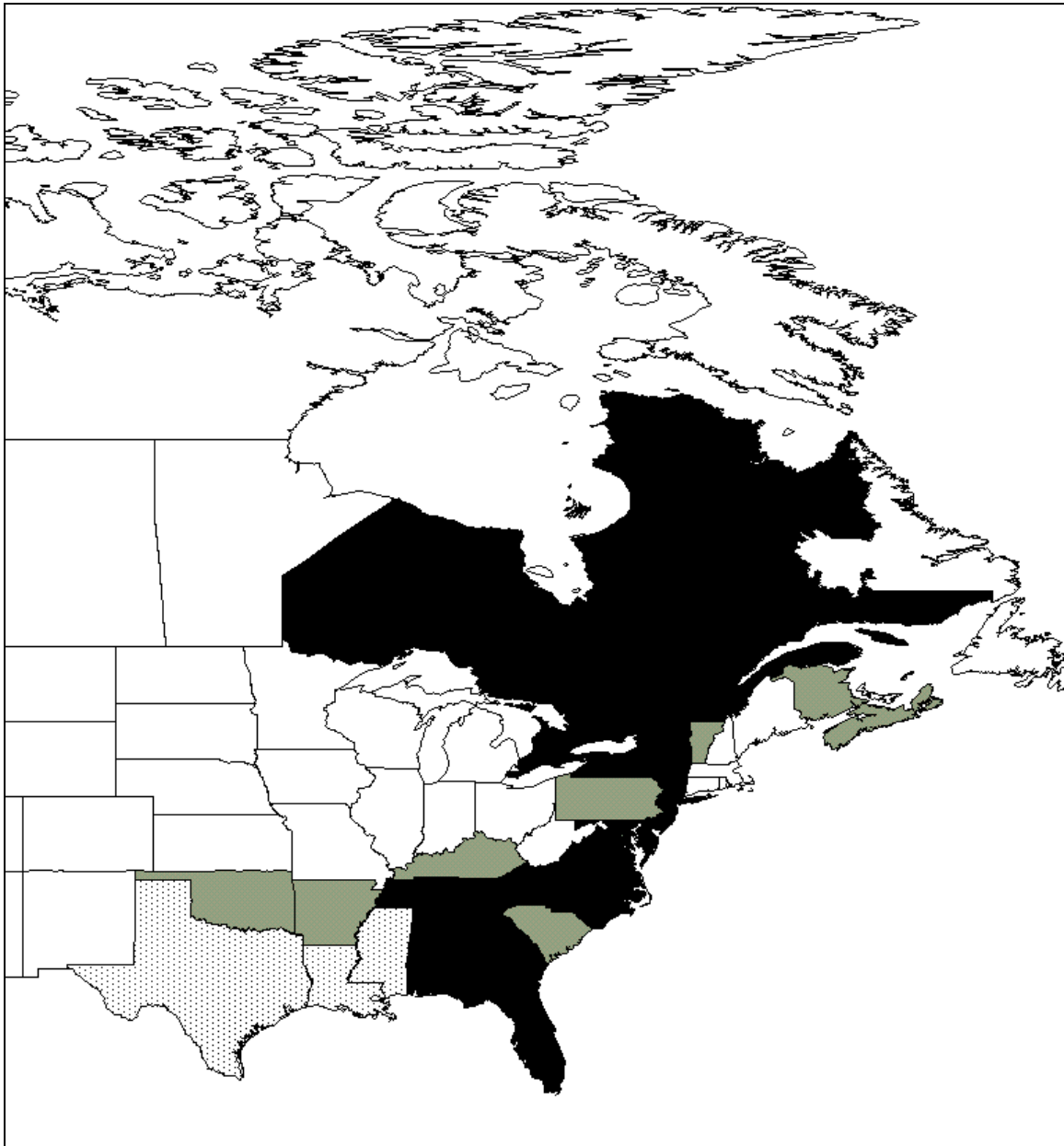


Figure 1. Occurrences of *Listeria australis* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with stippling are ranked SR (status "reported" but not necessarily verified). See Appendix for explanation of state ranks.

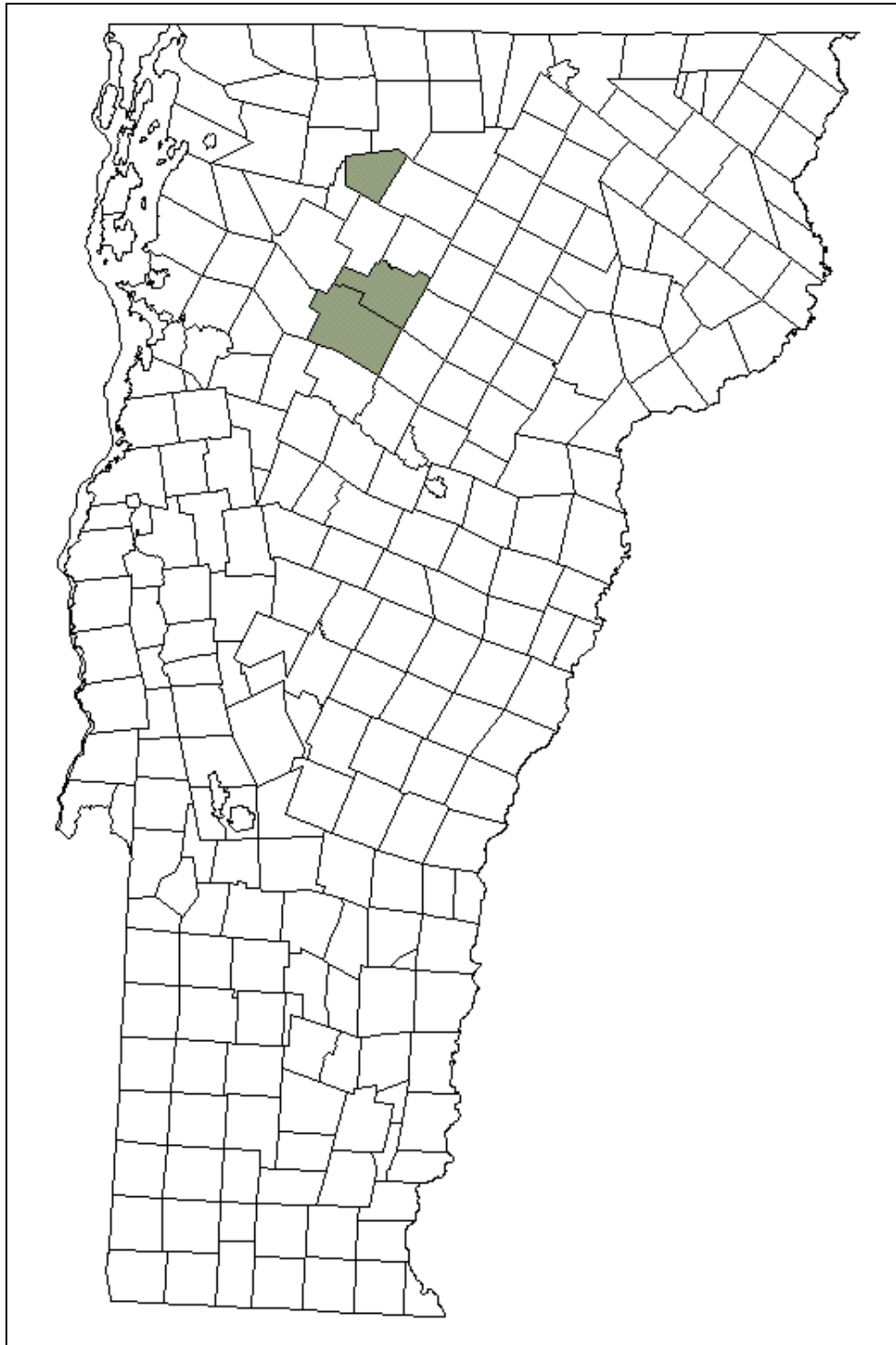


Figure 2. Extant occurrences of *Listera australis* in New England. Town boundaries for Vermont (the only New England state in which the taxon occurs) are shown. Towns shaded in gray have one to five extant occurrences of the taxon. Historical populations for this taxon have not been reported.

Table 2. New England occurrence records for *Listera australis*. Shaded occurrences are considered extant.

State	EO Number	County	Town
VT	.001	Lamoille	Morristown and Stowe
VT	.002	Lamoille	Belvidere
VT	new	Lamoille	Morristown

II. CONSERVATION

CONSERVATION OBJECTIVES FOR *LISTERA AUSTRALIS* IN NEW ENGLAND

Listera australis is widespread in the southern United States, with disjunct populations north of Tennessee and New Jersey. In New England, it has been found only at three sites in Vermont, and its continuing existence there is vulnerable to local changes in hydrology (beaver activity or human withdrawals) or land use.

The conservation objectives are to preserve the three known populations in Vermont and to search for and protect good-sized populations (25+ plants) in likely habitat elsewhere in New England. This population size is based on published population sizes for northern sites; a small population in one year may be large the next and should not automatically downgrade the occurrence. The goals for *L. australis* in New England are to protect peatlands that harbor populations and to search for new populations. The plant has a disjunct distribution, with populations in Ontario, New Brunswick, New York, and Pennsylvania; it is possible that it has been overlooked in the states between.

GENERAL CONSERVATION ACTIONS FOR *LISTERA AUSTRALIS*

The following actions are listed in order of priority for New England, with the highest priority first. They are discussed in detail below.

1. **Protect populations.** Contact landowners about the species' status and its sensitivity to habitat disturbance. Investigate long-term management and protection at known sites.
2. **Search for new populations** in peatlands that have likely habitat. Collect detailed information, including size of population, condition, associated species, landscape context, and threats.
3. **Regularly monitor** extant sites for presence of *Listera australis* and integrity of the habitat. This information can be used to head off possible threats to extant populations.
4. **Produce global occurrence rank specifications.** Specifications should be based on occurrences throughout the species' range.
5. **Study species biology**, such as dispersal mechanisms and germination requirements. This information might aid the search for new populations.

III. LITERATURE CITED

- Ackerman, J. D. and M. R. Mesler. 1979. Pollination biology of *Listera cordata* (Orchidaceae). *American Journal of Botany* 66: 820–824.
- Bates, V., L. M. Wilson, and P. Lewis. 1985. Notes and new distributional records for several Tennessee orchids. *Journal of the Tennessee Academy of Science* 60: 45–47.
- Brackley, F. E. 1985. The orchids of New Hampshire. *Rhodora* 87: 1–117.
- Case, F. W., Jr. 1987. *Listera*. Pages 130–143 in *Orchids of the Western Great Lakes Region*, Revised Edition. 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.
- Child, H. W. 1922. A New England occurrence of *Listera australis*. *Rhodora* 24: 187–188.
- Cody, W. J. and D. Munro. 1980. The genus *Listera* (twayblades) in New Brunswick. *Canadian Field-Naturalist* 94: 443–446.
- 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.
- Curtiss, C. C. 1893. An examination of the seeds of some native orchids. *Bulletin of the Torrey Botanical Club* 20: 183–192 and plate 151.
- Damman, A. W. H. and T. W. French. 1987. *The Ecology of Peat Bogs of the Glaciated Northeastern United States: A Community Profile*. Biological Report 85(7.16). U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, USA.
- Dressler, R. L. 1993. *Phylogeny and Classification of the Orchid Family*. Dioscorides Press, Portland, Oregon, USA.
- Drexler, J. D. and B. L. Bedford. 2002. Pathways of nutrient loading and impacts on plant diversity in a New York peatland. *Wetlands* 22: 263–281.
- Gawler, S. C. 2001. Natural landscapes of Maine: A classification of vegetated natural communities and ecosystems. Maine Natural Areas Program, Augusta, Maine, USA.

- 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.
- Greenwood, E. W. 1962. Occurrences of the orchid *Listera australis* in the vicinity of Quebec City. *Canadian Field-Naturalist* 76: 199–202.
- Hapeman, J. R. 2000. *Listera auriculata* Wieg. In Orchids of Wisconsin: An interactive flora. Available at http://www.wisc.edu/botany/Orchids/Orchids_of_Wisconsin.html.
- Henry, L. K., W. E. Buker, and D. L. Pearth. 1975. Western Pennsylvania orchids. *Castanea* 40: 93–168.
- Hinds, H. R. 2000. *Flora of New Brunswick*. Second Edition. University of New Brunswick, Fredericton, New Brunswick, Canada.
- House, H. D. 1905. Further notes on the orchids of central New York. *Bulletin of the Torrey Botanical Club* 32: 373–382.
- Hoy, J. M. 2001. *Listera auriculata* (Auricled twayblade) Conservation and Research Plan. New England Wild Flower Society, Framingham, Massachusetts, USA.
- Hoy, J. M. 2002a. *Listera convallarioides* (Sw.) Nutt. (Broad-leaved twayblade) Conservation and Research Plan for U.S. Forest Service Region 9. New England Wild Flower Society, Framingham, Massachusetts, USA.
- Hoy, J. M. 2002b. *Listera cordata* (L.) R. Br. (Heart-leaved twayblade) Conservation and Research Plan for U.S. Forest Service Region 9. New England Wild Flower Society, Framingham, Massachusetts, USA.
- 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.
- Kearsley, J. 1999. Non-forested acidic peatlands of Massachusetts: A statewide inventory and vegetation classification. Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.
- Lamont, E. E. 1996. Atlas of the orchids of Long Island, New York. *Bulletin of the Torrey Botanical Club* 123: 157–166.
- Lamont, E. E., J. M. Beitel, and R. E. Zaremba. 1988. Current status of orchids on Long Island, New York. *Bulletin of the Torrey Botanical Club* 115: 113–121.
- Lesica, P. and F. W. Allendorf. 1995. When are peripheral populations valuable for conservation? *Conservation Biology* 9: 753–760.

- Lindley, J. 1830–1840. *The Genera and Species of Orchidaceous Plants*. Ridgways, London, UK.
- Luer, C. A. 1972. *The Native Orchids of Florida*. New York Botanical Garden, Bronx, New York, 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.
- Mellichamp, J. H. 1881. Apparent parasitism of *Listera australis*. *Bulletin of the Torrey Botanical Club* 8: 47.
- Moore, P. D. and D. J. Bellamy. 1974. *Peatlands*. New York: Springer-Verlag.
- Mousley, H. 1940. *Listera australis* Lindl. in the province of Quebec. *Canadian Field-Naturalist* 54: 92–93.
- NatureServe. 2001. *Listera australis*. Association for Biodiversity Information, Arlington, Virginia, USA. Available at <http://www.natureserve.org>.
- NatureServe. 2002. Element occurrence data standard. Available at <http://whiteoak.abi.org/eodraft/>.
- Nieuwland, J. A. 1913. An older name for *Listera*. *American Midland Naturalist* 3: 128–129.
- Ramsey, C. T. 1950. The triggered rostellum of the genus *Listera*. *American Orchid Society Bulletin*, 1 September, 482–485.
- Rasmussen, H. N. 1995. *Terrestrial Orchids: From Seed to Mycotrophic Plant*. Cambridge University Press, Cambridge, UK.
- Rasmussen, H. N. and D. F. Whigham. 1993. Seed ecology of dust seeds in situ: A new study technique and its application in terrestrial orchids. *American Journal of Botany* 80: 1374–1378.
- 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.
- Rochefort, L. 2000. *Sphagnum*: A keystone genus in habitat restoration. *Bryologist* 103: 503–508.

- Rowlee, W. W. 1897. The swamps of Oswego County, N.Y., and their flora. *American Naturalist* 31: 792–800.
- Smith, W. R. 1993. *Orchids of Minnesota*. University of Minnesota Press, Minneapolis, Minnesota, USA.
- Sperduto, D. D. 2000. A classification of wetland natural communities in New Hampshire. New Hampshire Natural Heritage Inventory, Concord, New Hampshire, USA.
- Sperduto, D. D., W. F. Nichols, K. F. Crowley, B. D. Kimball, and S. J. Cairns. 2000. Exemplary bogs and fens of New Hampshire. New Hampshire Natural Heritage Inventory, Concord, New Hampshire, USA.
- Stalter, R. and E. E. Lamont. 1997. Flora of North Carolina's Outer Banks, Ocracoke Island to Virginia. *Journal of the Torrey Botanical Club* 124: 71–88.
- Swain, P. C. and J. B. Kearsley. 2000. Classification of the natural communities of Massachusetts. Draft. Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.
- Tallis, J. H. 1983. Changes in wetland communities. Pages 311–347 in A. J. P. Gore (Editor), *Mires*. Elsevier, New York, USA.
- Thompson, E. H. and E. R. Sorenson. 2000. *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont*. Vermont Department of Fish and Wildlife and the Nature Conservancy, 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.
- Wang, B. C. and T. B. Smith. 2002. Closing the seed dispersal loop. *Trends in Ecology and Evolution* 17: 379–385.
- Webb, D. H. 1978. Notes on disjunct populations of *Listera australis* Lindl. from Kentucky and Tennessee. *Castanea* 43: 23–25.
- Whiting, R. E. 1971. *Listera australis* in Nova Scotia. *Canadian Field-Naturalist* 85: 189–190.
- Whiting, R. E. and R. S. W. Bobbette. 1974. The orchid *Listera australis* rediscovered in Ontario. *Canadian Field-Naturalist* 88: 345–347.

Wiegand, K. M. 1899. A revision of the genus *Listera*. *Bulletin of the Torrey Botanical Club* 26: 157–171.

Zinck, M. 1998. *Roland's Flora of Nova Scotia*. Revised Edition. Nimbus Publishing and Nova Scotia Museum, Canada.

IV. APPENDICES

- 1. Proposed Rank Specifications for Occurrences of *Listera australis***
- 2. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. Proposed Rank Specifications for Occurrences of *Listera australis*

These proposed specifications need input from knowledgeable local botanists throughout the range of *Listera australis*. They are based on the standard described in NatureServe 2002.

Species	<i>Listera australis</i> (southern twayblade)
Heritage element code PMORC1N020	
Specifications for the element occurrence	<p>An element occurrence (EO) consists of any naturally occurring population of one or more plants and its habitat.</p> <p>EOs are separated by 1 km or more of unsuitable habitat or 1 km or more of apparently suitable habitat that is not known to be occupied.</p>
A-rank criteria	<p>500+ stems: populations with all of the following: many flowering stems, in natural site, with natural processes (primarily hydrology and nutrient levels). The number of aboveground plants fluctuates from year to year, so habitat quality outweighs population size. Typical habitat for this plant includes wetland forests, such as red maple swamps and black spruce swamps, and open peatlands in the north. Typical southern habitat is moist deciduous or pine forests, marshes, and peatlands. To receive an A rank, the natural processes of these wetlands and forests should be undisturbed.</p>
B-rank criteria	<p>25–499 stems: populations with at least two of the following: many flowering stems, in natural site, with natural processes (primarily hydrology and nutrient levels). The number of aboveground plants fluctuates from year to year, so habitat quality outweighs population size.</p>
C-rank criteria	<p>5–24 stems: populations lacking most of the following: many flowering stems, in natural site, with natural processes (primarily hydrology and nutrient levels). Minimum criteria for C rank should state that the population is likely to be viable, with emphasis on the likelihood that processes necessary for <i>Listera australis</i> will continue.</p>
D-rank criteria	<p><5 stems: populations with few stems flowering poorly, in site maintained by unnatural means (e.g., ditching).</p>
Rank justification	<p>A-rank threshold: It is not anticipated that future occurrences will exceed the best that currently exist. Therefore, A rank criteria are based on the characteristics of the larger and more viable occurrences currently in existence. Very few population sizes show up in the published literature, especially for places where <i>Listera australis</i> is most common. The A-rank population is based on a New York site that has hundreds to thousands of plants in some years. Because of fluctuations in the number of plants seen each year, habitat conditions (e.g., water level and quality) are even more important than documented population size.</p>

Species	<i>Listera australis</i> (southern twayblade)
Heritage element code PMORC1N020	
	<p>C/D-rank threshold: Populations of <i>Listera australis</i> can be small yet long-lasting (some are known to be >80 years old), according to reports in New England and Canada. EOs not meeting C-rank criteria often occur in degraded habitats and are not likely to survive for extended periods due to low viability and susceptibility to accidental extirpation. Documented or potential threats to <i>L. australis</i> include logging, vehicular traffic, trampling, nutrient loading, and changes in hydrology (e.g., inundation of plants through flooding of wetlands to create lakes, and draining wetlands for development).</p> <p>Author: Joann Hoy Source: <i>Listera australis</i> (Southern Twayblade) Conservation and Research Plan for New England, New England Plant Conservation Program, Framingham, Massachusetts, USA, 2003. Date: 14 April 2003</p>

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

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

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

G1, for example, indicates critical imperilment on a range-wide basis—that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction—that is, 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 rangewide 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 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.