New England Plant Conservation Program

Botrychium lunaria (L.) Sw.
Moonwort

Conservation and Research Plan
for New England

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Approved, Regional Advisory Council, 2003

SUMMARY

Moonwort (*Botrychium lunaria* (L.) Sw.) is a rare fern in the Ophioglossaceae. It occurs in a very few locales in northern New England, where it is at the southern edge of its range. The reasons for its rarity are not well understood, but it appears to have always been very rare in the region and does not appear to have suffered declines due to land-use practices. The species is a poor competitor and its habitats are typically small patches (tens to hundreds of square feet) where some soil disturbance has occurred or where other factors prevent dense turf or thick duff layers from occurring. Such habitats occur in maritime grasslands along the coast of eastern Maine, in northern white cedar forests in northern Maine, and possibly on forested hilltop areas in southeastern Vermont. Calcareous soils, whether derived from bedrock, calcareous till deposits, or from ongoing calcium deposition from ocean debris (i.e., mussel shells) or sea-spray are required for this species.

Four current (within the past 20 years) sites are known only in Maine, of which two are confirmed as this species. Although no vouchers have been seen for the other two current Maine sites, they are presumed to be of *Botrychium lunaria*. However, moonwort can be difficult to identify because of other similar species in the region. The Maine sites all enjoy protection through public ownership or conservation easements, or from interested landowners.

Several historical records are known in Vermont; however, these have also not been taxonomically verified. The sites of these early collections are in federal or state ownership. No current sites are known in Vermont. Reports from other New England states are not verified.

Given the apparent extreme rarity of *Botrychium lunaria* in the region, the primary goals are to maintain and, if possible, increase the sizes of the two verified population(s), and to search suitable habitats in coastal Maine and in northern Maine and Vermont for additional populations. Maintenance of the existing populations (if, indeed, still extant) can be measured through regular monitoring. Extant moonwort stations appear to be secure, but it is likely that others occur on the New England landscape. Searches for new stations are likely to be difficult because the species' habitat is not specific. However, directed searches are encouraged at locations along the Maine coast. Non-invasive demographic studies at extant sites may aid in understanding the population biology of the species.

PREFACE

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

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

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

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

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

This document should be cited as follows:

Gilman, A. V. 2003. *Botrychium lunaria* (L.) Swartz (Moonwort) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

I. BACKGROUND

INTRODUCTION

Moonwort, *Botrychium lunaria* (L.) Sw., is a member of the adder's-tongue family, Ophioglossaceae (Clausen 1937). It is a small, fleshy fern characterized by producing only a single frond each year, which frond is typically less than 25 cm tall. The species is frequent and widespread at higher latitudes, but New England is at the southern edge of its range in eastern North America. Moonwort is listed in *Flora Conservanda*: New England (Brumback and Mehrhoff et al. 1996) as a Division 2 or Regionally Rare species, on the basis of extant (20-year time frame) sites in Maine, historical sites in New Hampshire and Vermont, and a report from Massachusetts. Two verified colonies have been seen in Maine within the past 20 years and two other Maine colonies have been reported within the past 20 years, but there is some doubt in regard to their identification. Fortunately, two of the four Maine sites enjoy formal protection, and interested landowners are protective of the other two. There are no other current sites or recent records in New England, and this species is rightfully regarded as one of the rarest plants in the region.

DESCRIPTION

Botrychium is a genus of ferns normally characterized by having only a single leaf or frond, which is divided into two members: a leafy green member ("trophophore") and a non-green, spike-like portion ("sporophore") that carries numerous small, globular, spore-bearing organs ("sporangia"). The sporangia each produce hundreds of spores.

The plant known as moonwort, *B. lunaria* (Figure 1), is a member of *Botrychium* subgenus *Botrychium*, which is also collectively known as "moonwort," and which has approximately 20-25 species worldwide, concentrated in the American West (Wagner and Wagner 1993). In moonworts in general, the entire frond is quite small, normally only 2 –25 cm tall, and the two parts, trophophore and sporophore, are joined above the ground. The trophophore is pinnately divided into several opposite pairs of leaflets ("pinnae") that are more or less "half-moon" in shape, hence the common name. The sporophore is raised on a short stalk. The plant is fleshy, soft, and smooth. Moonworts have a short growing season, typically appearing in early to mid-June, with spores ripening in July, and the entire frond yellowing and drying away in August. For this reason, it is difficult to locate the plant after mid-July.

For well-grown plants, identification of *B. lunaria* is generally straightforward. As noted by Wagner and Wagner (1993), the species is remarkably uniform over a very large range. Unfortunately, the close resemblance of a shade-form of moonwort, *B. lunaria* f. *onandagense* (Underw.) Clute, to another species, Mingan moonwort (*B. minganense* Vict.) can cause misidentifications. In New England some – indeed most –

published records and some Element Occurrence reports of *B. lunaria* are based on specimens of *B. minganense*, misconstrued as *B. lunaria* f. *onandagense*. Also, large individuals of a third and quite common species, least moonwort (*B. simplex* E. Hitchc.), have sometimes been misidentified as *B. lunaria* as well.

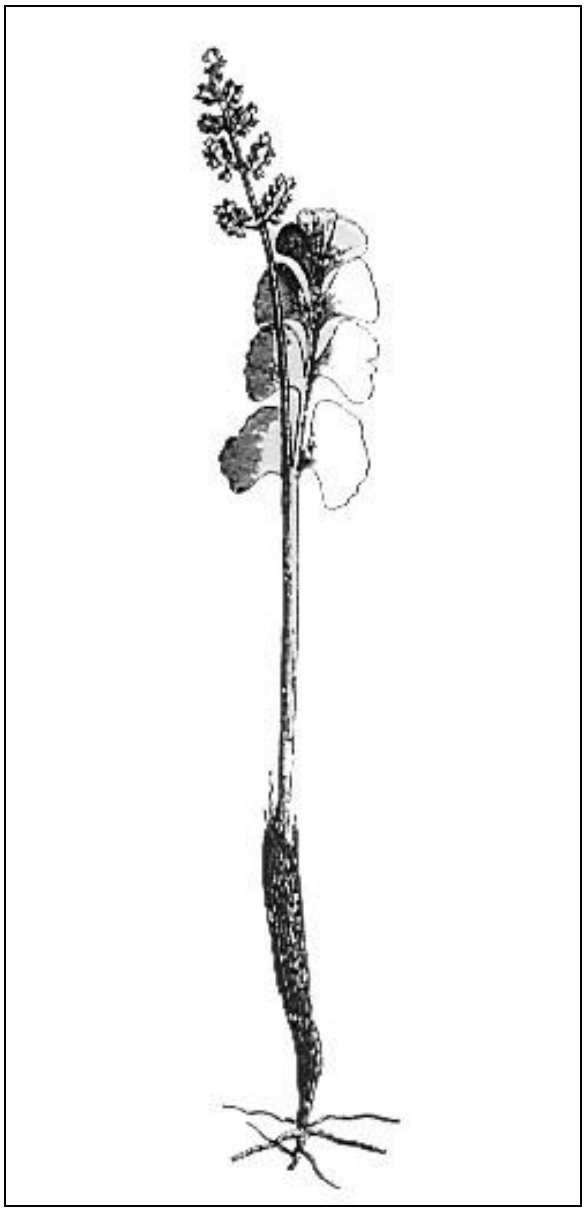

Figure 1. Moonwort, *Botrychium lunaria.* Reprinted from Bennett and Murray (1889).

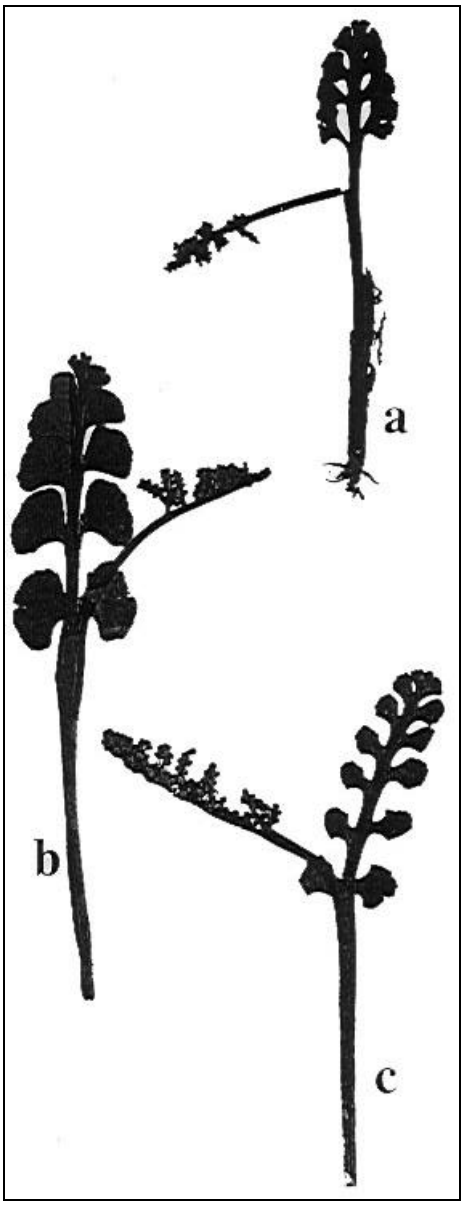

Figure 2. Similar species of moonworts: (a) *B. lunaria*, (b) *B. simplex*, and (c) *B. minganense*. (Gilman, personal herbarium).

Distinguishing between these taxa – *B. lunaria* (especially *f. onandagense*), *B. minganense* and *B. simplex* – is complicated by the fact there are actually very few reliable characters to work with because of the small size and basic simplicity of the plants. It is, therefore, much easier to reliably identify populations comprising numerous individual plants than single individuals alone. One might compare identifying a single moonwort plant to identifying an oak from a single leaf (see Clausen [1937] for a similar analogy). A key to separate the three species is given in Appendix 3, and a representative specimen of each is shown in Figure 2.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Since moonwort also occurs in Europe, it has long been known to herbalists and botanists, and was included in a broad genus *Osmunda* by Linnaeus, on the basis of its large sporangia and the fact that each sporangium produces copious spores in a manner similar to *Osmunda*. It was transferred to the genus *Botrychium* by Swartz in 1801. Several European varieties and forms have been described on the basis of the "cutting" or dissection of the pinnae, presence of superfluous sporangia on the trophophore, etc., but these forms are considered taxonomically meaningless (Wagner and Wagner 1990). The shade form, *B. lunaria* f. *onandagense*, was first described from central New York state, but it, too, is likely to be taxonomically meaningless. It was not accepted by Wagner and Wagner (1993).

In North America, there are approximately 25 species of moonworts. In New England, there are five species: *B. angustisegmentum* (Pease & Moore) Fern. (= *B. lanceolatum* ssp. *angustisegmentum* (Pease and Moore) Clausen), *B. lunaria* (L.) Sw., *B. matricariifolium* A. Br., *B. minganense* Vict., and *B. simplex* E. Hitchc.). The species most closely related to *B. lunaria* is *B. minganense*. Described from islands in the Gulf of St. Lawrence (Victorin 1927), some authors have regarded it as a variety of moonwort, *B. lunaria* var. *minganense* (Vict.) Dole. Wagner and Lord (1956) pointed out numerous morphological differences that distinguish the two taxa at the species level. Also, *B. minganense* is tetraploid, while *B. lunaria* is diploid (Wagner and Lord 1956; Wagner 1993). Molecular evidence from the rbcL gene of the chloroplast DNA (Hauk 1995) and from isozymes (Hauk and Haufler 1999) clearly demonstrate that the two are not conspecific. On rbcL gene data, they occur on different clades (i.e., monophyletic lineages, the *B. lunaria* clade and *B. simplex-campestre* clade), and on isozymic data, *B. minganense* does not share a marker allele for triosephosphate isomerase (TPI) that characterizes *B. lunaria* (Hauk and Haufler 1999). Moonwort, *Botrychium lunaria*, is, therefore, to be considered a good, stand-alone species with no significant taxonomic problems – even if some specimens present difficulties of identification to the field botanist.

SPECIES BIOLOGY

Like other ferns, moonworts reproduce by spores and have independent, separate sporophyte and gametophyte generations. The leafy sporophyte, which is the above-ground plant observed in nature, produces numerous spores that are wind-dispersed, and that in appropriate habitats germinate to produce the gametophyte. The gametophyte produces gametes – egg and sperm – and, upon fertilization, the resulting embryo becomes the next sporophytic generation.

Germination of the spore requires dark (Whittier 2000) and both germination and growth of the gametophyte are entirely subterranean, as is fertilization and the young growth of the sporophyte. Five to eight years of sporophytic growth can occur before the plant appears above ground (Bennett and Murray 1889, Bower 1908). During this time, the plant is dependent on nutrition supplied by a fungal partner (Campbell 1911), which has not been identified.

It is of interest that all above-ground plants are capable of producing spores; that is, even very small individuals are not “juveniles” in a reproductive sense. Plants are perennial and individuals are apparently able to persist many years. Some species of *Botrychium* can proliferate by small bulbils produced at the base of the plant (Farrar and Johnson-Groh 1990), but these are not known in *B. lunaria*.

The breeding system is not entirely known, although the genus is broadly demonstrated to be primarily inbreeding (Hauk and Haufler 1999). Widespread but rare hybridization in the genus (Wagner and Wagner 1988) suggests, however, that inbreeding may be only facultative, and outbreeding rates may be substantial in certain habitats. Often, several *Botrychium* species can be found in growing together in mixed "genus communities" (Wagner 1981).

As to population biology, *Botrychium* species apparently employ a k-strategy, colonizing available but potentially short-term habitats. The dispersal units are light, wind-blown spores, presumably capable of great vagility. Establishment and persistence of populations is dependent on the availability of colonizable habitat patches, contact with the fungal associate, and the maintenance of open habitat by disturbance over time as most species are poor competitors, but good long-distance dispersers.

Within a habitat, the abundance and distribution of sporophytes is not necessarily coordinate with the abundance and distribution of the subterranean gametophytes, as demonstrated by Johnson-Groh et al. (2000). Gametophytes are likely to outnumber visible sporophytes significantly, leading to underestimates of numbers of individuals at a given locale.

HABITAT/ECOLOGY

Botrychium species are disturbance-adapted plants (Wagner 1990) that colonize available but potentially ephemeral habitats. However, it is difficult to characterize suitable habitats for colonization because sporophytes may appear only several years after spore arrival. Suitable patches for colonization events for *B. lunaria* appear to be open (non-forested) areas that have experienced soil disturbance sufficient to remove any surficial organic layer (duff, litter, mosses, lichens, etc.) and to expose mineral soils (Gilman, personal observation). In areas where no disturbance events are likely, such as underneath northern white cedar (*Thuja occidentalis*), there may be accelerated litter decomposition that provides a bare soil surface allowing colonization. Gametophyte establishment, being dependent on a soil fungus, may be related to current soil conditions and subsequent soil development, especially soil chemistry as it changes due to leaching, organic deposition, etc. Past land use history, such as cultivation or pasturage, may also influence current and future soils and potential for establishment of *Botrychium*.

The non-specific nature of *Botrychium* habitats in general has been noted in literature (Lellinger 1985). The common characteristic is some level of intermittent or past soil disturbance. Frequently, mature *B. lunaria* is found in areas that are noticeably beginning to revert back from some past disturbance event, where a very sparse plant community is just becoming established over otherwise bare soil. In such areas, there is often a thin growth of young ground-layer lichens, or a layer of leaf litter from nearby trees is just beginning to accumulate (Gilman, personal observation). However, it can also occur among pasture grasses, under cedar trees, on damp quarry floors, on roadbanks cut into calcareous till soils, along woods logging roads, on cliffs, on stabilized dunes or relict beaches, and in other disparate habitats (Gilman, personal observation; W. H. Wagner, Jr., University of Michigan, personal communication). In general, habitats are dry (hardly xeric) to mesic; the species is not tolerant of saturated soils.

Botrychium lunaria is a calciphile species, typically found in areas of calcareous bedrock, and is negatively associated with strongly acidic soils (Page 1997). Combined with its association with generally boreal habitats, this limits the species on the New England landscape to areas of northern Maine and, possibly, northern Vermont. Calcium is apparently supplied to the soil at the coastal site in Maine not from bedrock, but from ocean spray or from decomposing mussel shells. At one site in northern Maine, the species is strongly associated with the calciphilic northern white cedar (landowner, personal communication).

Associated "indicator" species are few, although wild strawberry (*Fragaria virginiana*) is typically present, and the general plant community is usually calciphilic. For this reason, it may be noted that acid-loving clubmosses (*Lycopodium* and *Diphasiastrum*), which are also spore-dispersed plants with subterranean gametophytes, are usually contra-indicators.

Since New England is at the southern limit of range of moonwort in eastern North America, temperatures – air and/or soil – may be a limiting factor.

THREATS TO TAXON

Threats to existing populations include competition from rank growth of grasses and herbs and establishment of thick duff layers. Moonwort is a poor competitor in these situations. Overshading by trees has been mentioned as a threat in element occurrence (EO) records. Although shade may limit or reduce growth of sporophytes, it may also limit competition from other species and allow establishment and persistence of gametophytes. In the northern Maine (ME .003 [Fort Kent]) population, for example, even some sporophytes were found in very dark shade (landowner, personal communication). Excess soil stabilization by efforts to prevent erosion (e.g., in soil borrow areas and/or along roadsides) may limit available colonizable habitats. Soil acidification as a result of organic buildup or from leaching of calcium ions is also a likely threat to current populations, especially as this may prevent new colonization in the local area.

Climatic warming may be a threat to a species like this that is well-distributed in cooler areas but here at the southern limit of range. This is more likely to impact inland populations subject to a continental or subcontinental climate (Brouillet and Whetstone 1993) than coastal Maine populations, which may continue to be subject to cooler summers due to the influence of the inshore Labrador current.

Given the small sizes of the known populations, stochastic or random events may be of great significance over time. Simple events such as uprooting of trees by a storm, herbivory, or persistent drought may have drastic consequences to a population. Human impacts may be either positive or negative. Soil-disturbing activities (logging, for instance) may increase available habitat and provide necessary soil disturbance – or alternatively may damage established populations.

Collection of specimens may be a threat as well. Several collections (totaling at least 8 fronds) are known from one site; one frond from a second site has also been collected. Wagner and Wagner (1993) stated, “Taking many samples will have little effect on the populations as long as the underground shoots and roots are left intact.” Nevertheless, although collecting at least one frond is necessary for documentation, and collecting multiple specimens is useful for taxonomic studies, it is not justifiable to collect additional fronds from the verified populations in New England.

DISTRIBUTION AND STATUS

General Status

Botrychium lunaria is a species of cold-temperate and cold regions, primarily in the Northern Hemisphere, where it is circumboreal (Wagner 1990). It also occurs in cool to cold habitats in the austral regions of New Zealand and Chile. It has a global rank of G5. In North America, *B. lunaria* occurs in the boreal forest regions of Canada and the mountainous West, north to the arctic, with occurrences as far south as Arizona (Table 1).

In the northeast, it occurs in all the provinces of eastern Canada, with the possible exception of New Brunswick, where it is only "questionably documented" (Hinds 2000), but has only very scattered occurrences as far south as New England (Table 1), New York, and Pennsylvania.

Currently, no national rank has been assigned in Canada; the United States rank is "N4?, apparently secure." This rank is defined (NatureServe Explorer 2001) as follows: "Uncommon but not rare and usually widespread in the nation. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals." Obviously, since moonwort is rare in the eastern United States, this rank is assigned primarily on the basis of the species' abundance in the West.

Any stations along the eastern coast of Maine may best be regarded as disjunctions from a more northerly range, a pattern that is found in several other herbs and small shrubs, such as Hooker's iris (*Iris hookeri* Penny), blinks (*Montia lamprosperma* Chamisso), roseroot (*Sedum rosea* L.), marsh felwort (*Lomatogonium rotatum* (L.) Fries) and northern comandra (*Geocaulon lividum* (Richards) Fern.) This pattern is apparently a result of the cooler temperatures along the immediate coast induced by the Labrador current as it enters the Bay of Fundy.

Table 1. Occurrence and status of *Botrychium lunaria* in the United States and Canada Based on information from Natural Heritage Programs (NatureServe Explorer 2001), Wagner and Wagner (1993), and Kartesz and Meacham (1999).

OCCURS & LISTED (AS S1, S2, OR T&E)	OCCURS & NOT LISTED (AS S1, S2, OR T&E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Arizona (S1)	Alaska	Massachusetts (SR)	South Dakota
California (S2)	Alberta (S4)	New Brunswick	Vermont (SH, E)
Colorado (S2)	British Columbia (SU)	New Mexico (SR)	
Idaho (S1)	Labrador (S4)	North Dakota (SR)	
Maine (S1, E)	Manitoba (S4)	Nevada (SR)	
Minnesota (S2)	Michigan (SU)	Nova Scotia (SR)	
New York (S1)	Montana	Pennsylvania (SR)	
Oregon (S2)	Newfoundland (S4)		
Saskatchewan (S1)	Northwest Territories		
Utah (S1)	Nunavut		
Wisconsin (S1)	Ontario (S4)		
Wyoming (S2)	Prince Edward Island (SU)		
	Quebec		
	Yukon Territory (SR)		
	Washington (S3)		

Massachusetts: Report possibly erroneous, see Sorrie and Somers (1999).
Vermont: See discussion in text; specimens possibly misidentified.
New Brunswick: "Extremely rare, questionably documented, " Hinds (2000).

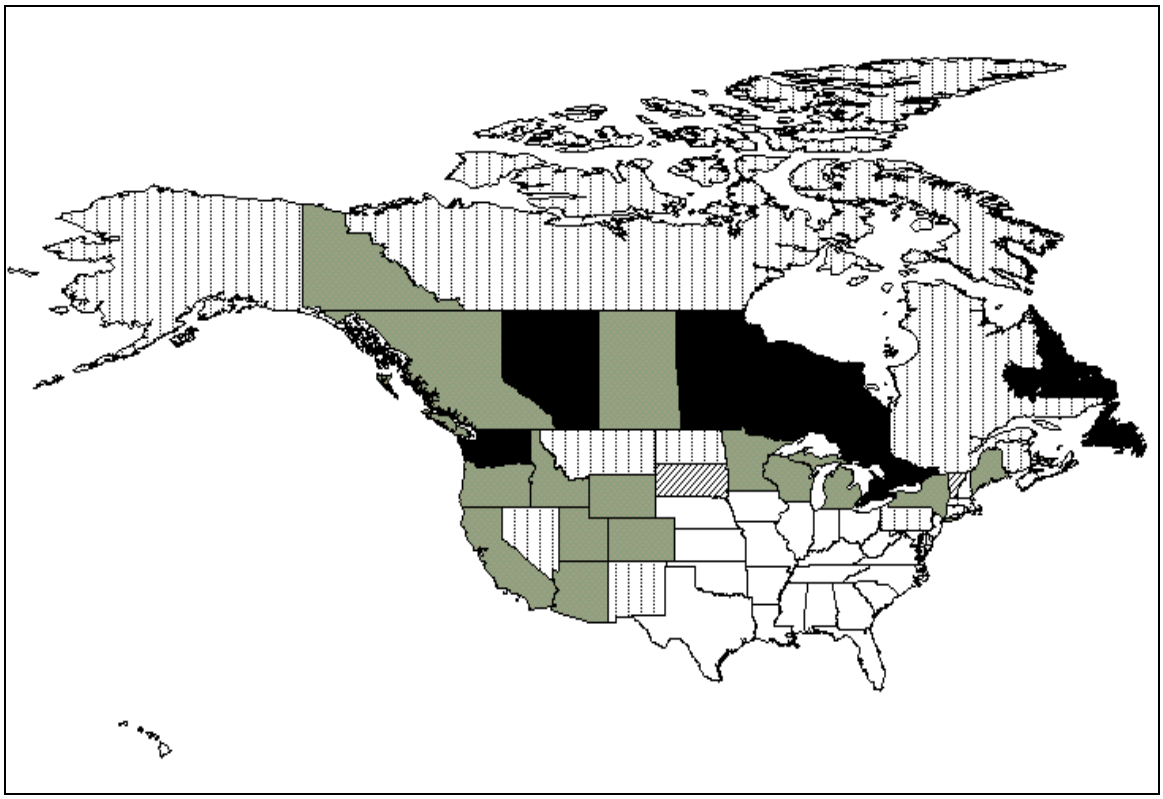

Figure 3. North American occurrences of *Botrychium lunaria*. States and provinces shaded in black have more than five confirmed, extant occurrences of the taxon. Areas shaded in gray have listed the taxon as S1 or S2, *or* have an unspecified (perhaps numerous) number of occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. Areas with stippling have been ranked "SR" ("Reported" with no further information). See Appendix for explanation of state ranks).

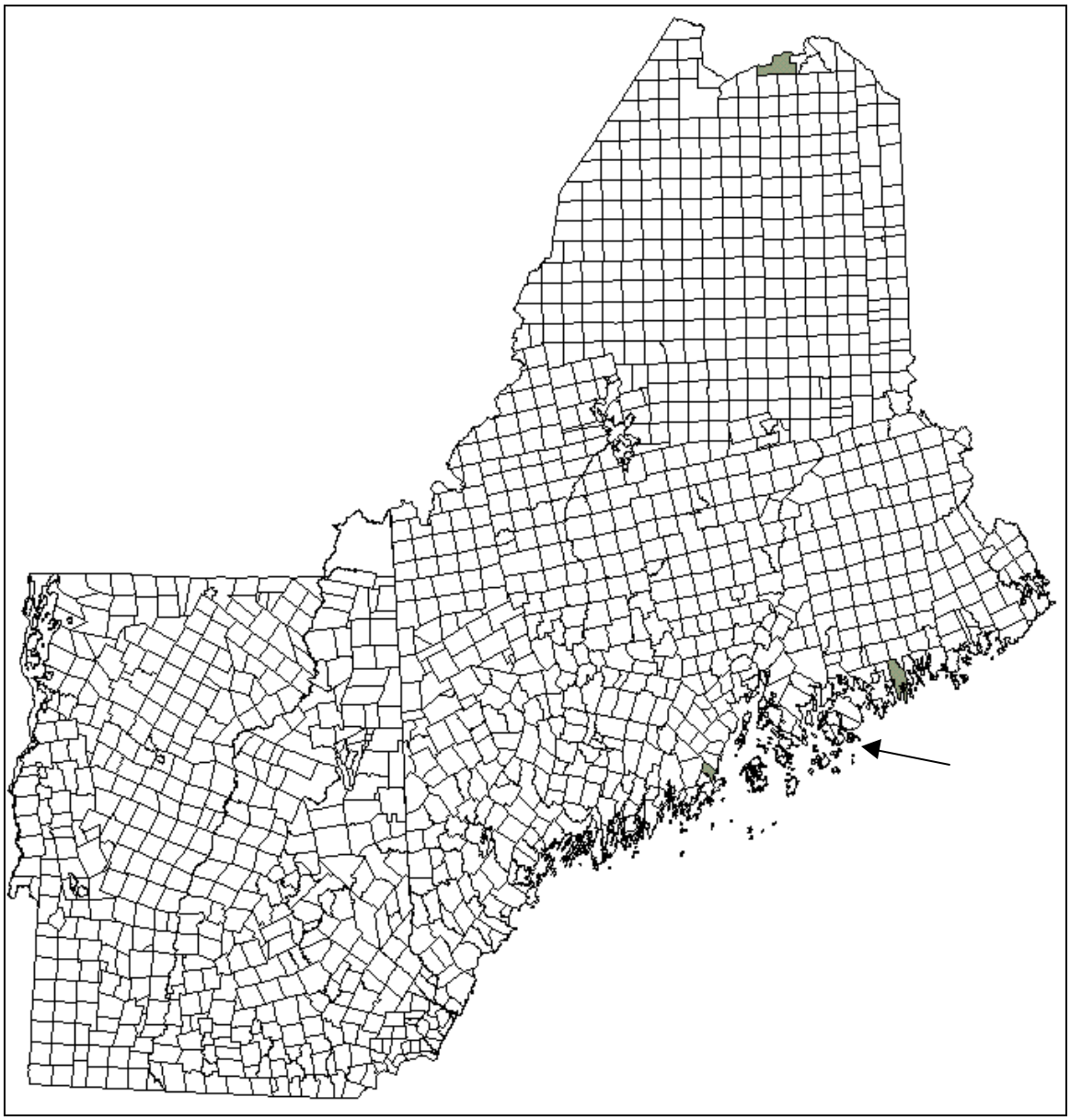

Figure 4. Extant occurrences of *Botrychium lunaria* in New England. Town boundaries for northern New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon. Arrow points to Cranberry Isles (ME .001) occurrence for clarity.

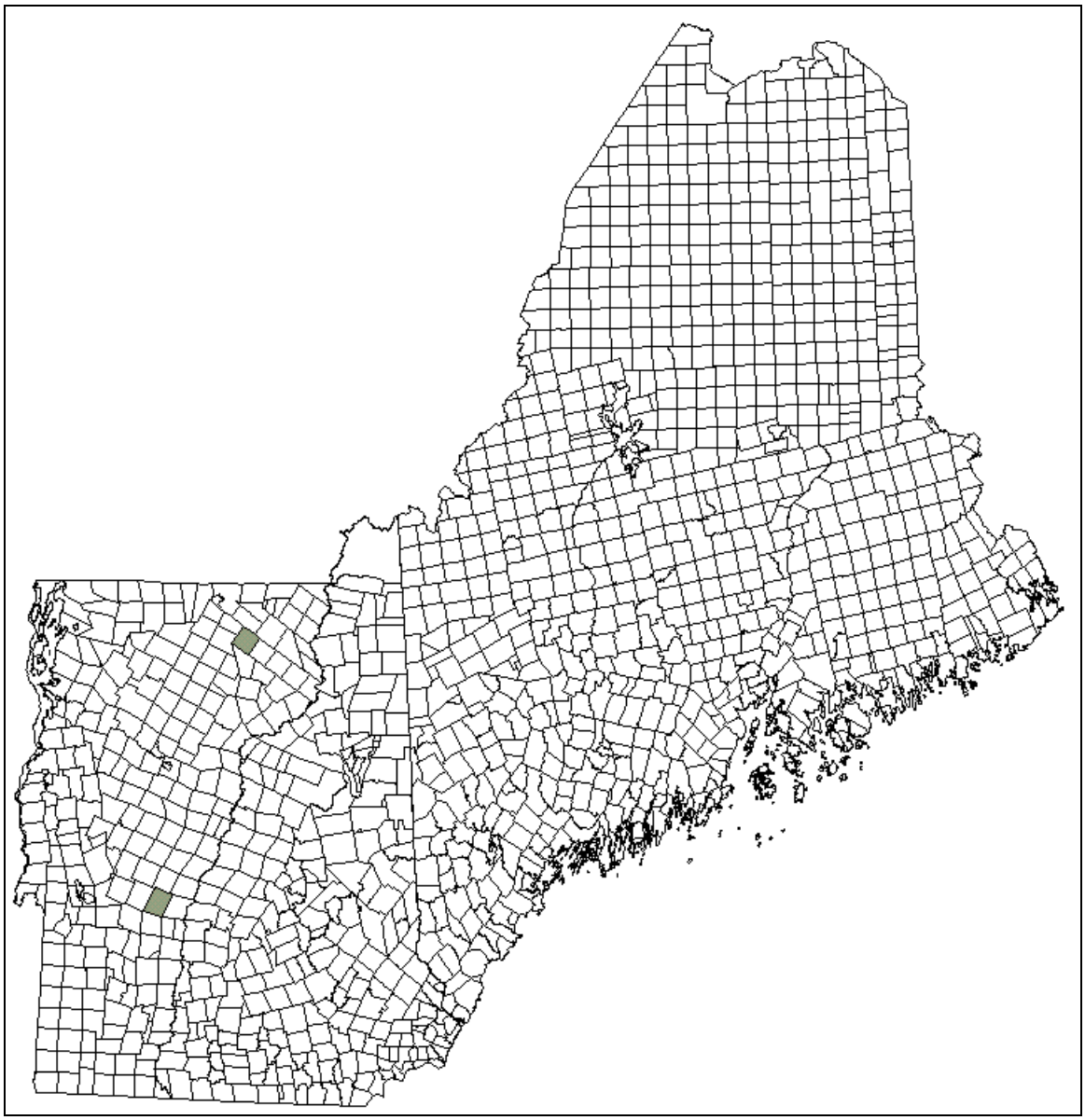

Figure 5. Historical occurrences of *Botrychium lunaria* in New England. Towns shaded in gray (Vermont) have one to five historical records of the taxon.

Table 2. New England Occurrence Records for *Botrychium lunaria.* Shaded occurrences are considered extant.

State	EO #	County	Town
ME	**.001**	**Washington**	**Cranberry Isles**
ME	**.002**	**Knox**	**Rockland**
ME	**.003**	**Aroostook**	**Fort Kent**
ME .	**.004**	**Washington**	**Steuben**
VT	.001	Windsor	Woodstock
VT	.002	Windsor	Woodstock
VT	.003	Orleans	Westmore
VT	.004	Bennington	Dorset
VT	.005	Caledonia	St. Johnsbury

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Given the apparent extreme rarity of *Botrychium lunaria* in the region, the primary goals are to maintain and, if possible, increase the sizes of the two verified population(s), and to search suitable habitats in coastal Maine and in northern Maine and Vermont for additional populations. Maintenance of the existing populations (if, indeed, still extant) can be measured through regular monitoring.

Their small sizes suggest that there is potential for enhancement through management, on a site-specific basis. However, without a clear path – and courage to undertake that path, since it may mean rather disruptive actions, such as intensive soil disturbance - active management may not be beneficial.

The addition of even a single population would represent a significant increase in the conservation potential for this species in New England. Familiarity with the taxon, its habitats, and the New England landscape suggests to the author that a few, if not many, other populations may exist. Five or more verified populations would seem to be a realistic objective. However, it is doubtful that sufficient populations (20 or more) will be found on the New England landscape to change the species' heritage program rank to S4 ("apparently secure in the [subnational] region") or to alter the current assessment (Division 2) in *Flora Conservanda*: New England. Therefore, every current, historical, and new site should receive full conservation treatment. Even EO sites that are considered here only potential (i.e., sites where *B. minganense* has been collected) should be searched and monitored, because of the known propensity of the genus to grow in mixed communities.

Demographic study of populations may be warranted, but because there are large populations in the West that are being studied (Johnson-Groh et al. 2000), it is possible that more is to be learned by following this research than by performing additional studies on peripheral populations. Any studies should be well justified by anyone proposing them and should be non-intrusive in design. Due again to their small sizes, data on populations may have little meaning other than presence/absence.

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IV. APPENDICES

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1. Key to Confusing *Botrychium*

2. Supplemental: *Botrychium minganense* in New England

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

1. Key to Confusing *Botrychium*

Moonwort is unlikely to be confused with any other genus due to its distinctive morphology. However, because *B. lunaria* is likely to be confused with *B. simplex* and *B. minganense*, Figure 2 shows characteristic shapes and the following key may be helpful:

1. Plant with 1-5 pairs of opposite pinnae; pinnae of the lowest pair often much larger than others and sometimes themselves pinnate; pinnae typically asymmetrical, "forward-directed;" tip of trophophore blunt, often entire.

   B. simplex

1. Plant with 3-8 pairs of opposite pinnae; pinnae of the lowest pair smaller than or the same dimensions as the next most distal pair, others of similar size and shape; pinnae usually symmetrical, fan-like; tip of trophophore deeply divided or with small blunt pinnae, not entire.

   2

   2. Plant bright green, shiny, the lowermost pair of pinnae the same size as the next most distal pair; pinnae half-moon shape, "corner" where distal pinna-margin meets proximal margin sharply defined.

      B. lunaria

   2. Plant gray-green to green, not shiny, the lowermost pair of pinnae usually slightly smaller than next most distal pair; pinnae various but usually sub-orbicular, "corners" not sharply defined.

      B. minganense

Particular difficulties are presented by *B. lunaria* f. *onandagense*, a shade form that has narrower, more wedge-shaped pinnae than typical *lunaria*, the distal ends of the pinnae then shaped like the blade of a hatchet and the "corners" not as well defined.

2. Supplemental: *Botrychium minganense* in New England

Mingan moonwort, *Botrychium minganense* Vict. has at times been classified as a variety of moonwort, although it is generally accepted today at the species level. It is listed in *Flora Conservanda*: New England as a species of Indeterminate rank, due largely to confusion about the identity of certain specimens. The authors noted, "FNA (Flora of North America Editorial Committee 1993) reports this taxon from New Hampshire and Vermont, but we have not seen specimens" (Brumback, Mehrhoff, et al. 1996, p. 302). However, specimens of *B. minganense* are on file at several regional herbaria.

Vermont: There are excellent collections of *Botrychium minganense* from at least two sites in the Woodstock area of Vermont (*Kittredge,* VT, GH, NEBC; *Wherry, Leeds* and others). These collections were made between 1918 and 1935. Recent searches by the author of this plan have failed to relocate the populations. A specimen of *B. minganense* has also been seen from Dorset (*Carole A. Johnston*, Planting Fields Arboretum Herbarium, photocopy seen). The report from Manchester (Seymour 1969a 1969b) based on one specimen (*Skinner*, VT) that is here tentatively referred to *B. simplex*, may be an anomalous *B. minganense*. It is possible that the *B. lunaria* report from Willoughby (Tilton) refers to *B. minganense*; that specimen has not been seen. One other specimen seen from Willoughby (*Cheever s.n.*, GH) is surely *B. minganense*.

New Hampshire: A report of this species in Woodstock (Brown 1988) is not substantiated by a specimen and is doubtful. I have seen no specimens of *B. minganense* from New Hampshire.

Maine: A collection from Fort Kent (*Mackenzie* in 1901, NY, not seen) is listed (CAP 1981) as *B. lunaria* var. *minganense* although Ogden (1948) considered it *B. lunaria* var. *onandagense*. Reports by Brown (1988) from Acton and "Woodmanland" are not substantiated by specimens and are doubtful. Specimens recently collected (*Gilman* 2K074) from Steuben are not definitely assigned but may be *B. minganense*; they are not *B. lunaria*.

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 SH (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct)> Certain other codes, rank variants, and qualifiers are also allowed 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 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 global 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 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 EO's have received such ranks in all states, and ranks are not necessarily consistent among states as yet.