

New England Plant Conservation Program

Juncus vaseyi Engelm.
Vasey's Rush

Conservation and Research Plan
for New England

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SUMMARY

Juncus vaseyi Engelm. (Juncaceae) is a perennial graminoid species of north-temperate and boreal United States and Canada. It is rare over much of its southern range in the United States and is known from 14 total extant and historical occurrences in New England. The species has been found in a variety of plant communities and its rarity is difficult to explain. Extant locations are primarily sites that are either inundated in the spring or have seasonally-saturated soils. However, several of these sites would be classified as dry-mesic or xeric during much of the growing season, contrary to most published habitat descriptions for this species. Most extant locations in New England are also influenced by high pH bedrock.

In addition to monitoring and protection of populations, it is recommended that a detailed study of site characteristics and seed germination occur to help fill the many knowledge gaps that exist for this species. As with many rare species in New England, very little is known about their biology and ecology. Conservation of *Juncus vaseyi* will be difficult to achieve without careful studies that target requirements of colonization, growth, and reproduction. Detailed knowledge of the life history of *J. vaseyi* will allow for better-informed conservation decisions and an increased ability to locate new and historic populations.

The overall conservation objectives for *Juncus vaseyi* in New England are to protect known sites, study extant populations, and locate/relocate additional populations. A goal of ten total populations with a C-rank or better distributed in at least five biophysical regions of New England would be considered successful application of this Conservation and Research Plan.

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

Juncus vaseyi Engelm. (Juncaceae), colloquially known as Vasey's rush, is a perennial grass-like herb that occurs in the northern United States and adjacent Canada (Brooks and Clements 2000). Though it has been collected from a variety of plant communities, *J. vaseyi* appears to have an affinity for seasonally saturated or inundated sites. Further, most extant locations in the New England are influenced by high pH bedrock. It is currently known only from Maine and Vermont in New England and is listed as a Division 2 species in New England (i.e., fewer than 20 regional occurrences; Brumback and Mehrhoff et al. 1996).

This Conservation and Research Plan summarizes known information for *Juncus vaseyi* and outlines possible research to fill information gaps for this species. As the majority of regional occurrences are found on river shore ledges, management of watersheds will be an important measure for conservation of this species in New England. Successful application of this Plan is outlined in Section II (Conservation). In summary, along with several monitoring, research, and education goals, it is suggested that both increases in the number of extant populations and a broadened distribution of *J. vaseyi* will be very important for securing its long-term survival in New England.

DESCRIPTION

Juncus vaseyi is tufted plant 20–70 cm tall that arises from a branched, compact rhizome. Its narrow, terete (i.e., circular in cross-section) leaves are largely confined to the basal portion of the plant. Unlike many familiar rushes in the northeast that also have terete leaves, the blades of *J. vaseyi* lack prominent transverse septa. The terminal inflorescence, a dichasial cyme with monochasial branches, typically includes 5–30 flowers that are subtended by two or more bracts. The inflorescence may be somewhat open, but is more commonly congested in the northeast. Flowers of *J. vaseyi* are borne singly at each node, are closely subtended by a pair of small bracteoles, and are dichlamydeous (i.e., have two cycles of perianth). Each whorl of perianth members contains three, green to tan tepals 3.3–4.4 mm long. The stamens, numbering six in each flower, are 0.9–1.7 mm long. The three-carpellate ovary matures as a gold-tan to light brown, trilocular capsule (3.3–)3.8–4.7 mm tall that exceeds the persistent and appressed tepals. Each capsule contains many seeds 0.7–1.2 mm long with an evident white appendage at each end (each appendage 0.2–0.4 mm long).

Though I have seen no misidentified material of *Juncus vaseyi* in any herbarium in New England, the species is most likely to be confused with *Juncus greenei* Oakes & Tuckerm. (Greene's rush) and *J. ×oronensis* Fern. (Orono rush). *Juncus greenei* is a species of dry-

mesic to xeric sandy and stony substrates and would not likely be found growing with *J. vaseyi* in New England. It closely resembles *J. vaseyi* in many morphological features. *Juncus greenei* has leaf blades that are channeled on the upper surface, dark green to brown tepals, dark brown capsules mostly 2.9–3.5 mm tall, and seeds 0.5–0.7 mm long. Many floras utilize, among other characters, the presence and absence of white appendages (“tails”) on the seeds to discriminate between *J. vaseyi* and *J. greenei*, respectively (Gleason and Cronquist 1991, Magee and Ahles 1999, Brooks and Clements 2000). *Juncus greenei* does, however, have appendaged seeds (Voss 1972, Haines and Vining 1998) that are visible with a 10× hand lens. The white appendages in *J. greenei* are very short (less than 0.2 mm) and are not gradually curved as in *J. vaseyi*.

Juncus ×oronensis, the hybrid between *Juncus tenuis* Willd. (path rush) and *J. vaseyi*, has been a source of confusion in Maine (see Taxonomic Relationships, History and Synonymy, below). This hybrid, which has been found growing with *J. vaseyi* at both known locations in Maine, has a more open inflorescence in which the branches have secund flowers, most often has leaf blades with a channel on the upper surface, and has imperfectly trilocular capsules (i.e., the placentas do not extend completely to the center of the capsule) that are shorter than the persistent tepals.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Juncus vaseyi belongs to the Juncaceae. This is a family of grass-like plants that have six sepaloid perianth members and capsules that open by three valves, which are very unlike the flowers and fruits of the Cyperaceae (sedge family) and Poaceae (grass family). More specifically, *J. vaseyi* belongs to the subgenus *Poiophylli*. This subgenus is recognized by annual or perennial habit, terminal inflorescences, and flowers that are subtended by a minute pair of bracteoles (called prophylls). The leaves of this subgenus vary from flat to terete in cross-section, but never have the transverse septae found in some other members of the genus, such as *J. canadensis* J. Gay ex LaHarpe (Canada rush) or *J. militaris* Bigelow (bayonet rush).

Juncus vaseyi was described as a new species by Engelmann (1866). Since that time, it has not been challenged as a valid taxonomic entity. Boivin (1967) included *J. vaseyi* within *J. greenei* as a variety—*Juncus greenei* Oakes & Tuckerman var. *vaseyi* (Engelm.) Boivin. However, this treatment has not been followed by later experts in the genus (Brooks 1989, Clemants 1990).

As noted in the Description section of this document, *Juncus vaseyi* shares morphological similarity with *J. greenei*. Brooks (1989) noted that these two species are likely close relatives, based on results of phenetic and electrophoretic analyses. The two are united by a likely synapomorphy—low, irregular nodules along the ridges of the inner integuments of the seed—a feature not found in other members of the subgenus (Brooks 1989). Despite many

similarities, the two species are sufficiently distinct in morphology and habitat use to be regarded as separate species.

Fernald (1904) described a new species of rush from material collected in Orono, Penobscot County, Maine. He named the new species *Juncus oronensis* Fernald. This species was also found by Kate Furbish in Rangeley, Franklin County, Maine. Later, Raup (1934) reported *J. oronensis* from Alberta, Canada. *Juncus oronensis* was treated differently by varying authors through the 1900s (i.e., it was treated as distinct species or a potential hybrid or a form of another common species; see Catling and Spicer [1988] for summary). The unlikely phytogeographic pattern of Maine and Alberta, coupled with discrepant taxonomic treatments prompted Catling and Spicer (1987, 1988) to study *J. oronensis* in the attempt to unravel the origin of this poorly known species. Their work, based largely on morphological and anatomical analyses, showed that the material of *J. oronensis* from Maine was the hybrid derivative of *J. tenuis* Willd. and *J. vaseyi*. This hypothesis is corroborated by the fact that collections of *J. oronensis* (properly referred to as *J. ×oronensis*) at the Gray Herbarium (GH!) are mixed with *J. tenuis* or *J. vaseyi*. The material from Alberta reported by Raup (1934) was determined to be the hybrid derivative of *Juncus dudleyi* Wieg. (Dudley's rush) and *J. vaseyi*. Therefore, the Canadian material represents a separate hybrid taxon that was incorrectly referred to as *J. oronensis* in past literature.

SPECIES BIOLOGY

Little is known about the biology of rushes. *Juncus vaseyi*, like other members of its family, is an anemophilous (i.e., wind-pollinated) species. This is indicated by its reduced, sepaloid perianth (usually with dull green to brown color), stigmatic surfaces with numerous, hair-like structures for collecting air-borne pollen (superficially resembling pipe cleaners), and absence of nectaries (Judd et al. 1999).

Most details of the phenology of *Juncus vaseyi* in New England are unknown. Review of herbarium specimens provides some information on fruiting dates in New England. Collections in regional herbaria have occurred from 12 July to 22 August, all of which were at a stage where mature seeds were present. Also, field observations of *J. vaseyi* in Vermont showed the plants to be in fruit on 1 July and a population visited in northern Maine on 9 July was also in fruit. Therefore, *J. vaseyi* appears to first set seed in July. However, capsules will still contain seeds at least through August. This indicates that seeds are slowly released over at least a two month period (and likely somewhat longer).

The seeds of *Juncus vaseyi* are small: 1.7–2.2 mm long. Though wind may play a role in short-distance dispersal, water is more likely a primary factor in long-distance movement of propagules. This hypothesis is corroborated by the fact many of New England's occurrences (historic and extant) are found on shorelines. Additionally, wet seeds could adhere to animals (such as waterfowl) and be transported between watersheds.

Though *Juncus vaseyi* may be more or less persistent at some sites (e.g., rock outcrops along the St. John River), it appears this species is relatively ephemeral in its occurrence at many locations. The species is apparently capable of utilizing disturbed sites (these often, but not always, low areas in cleared land and ditches) as a temporary location for growth and reproduction. It is not known if *J. vaseyi* utilizes seed-banking or merely relies on sites as a temporary “stop-over,” awaiting dispersal of propagules to another suitable location (or both). *Juncus vaseyi* appears to be somewhat similar in ecology to *Carex adusta* Boott (swarthy sedge), in regard to reliance on disturbance and short-term site longevity (Anton Reznicek, University of Michigan Herbarium, personal communication). Both species are early successional plants that colonize sites after disturbance only to be outcompeted through community succession and growth of woody species. It does appear that most (if not all) of the eastern Maine occurrences, unlike many of those in northern Maine, fit a category of short-term site occupation. This obviously creates difficulties for conserving *J. vaseyi* in that region.

HABITAT/ECOLOGY

Juncus vaseyi has been found in a wide variety of plant communities. Its rarity, therefore, is difficult to understand and the species is considered enigmatic (Ralph Brooks, Black and Veatch, personal communication). Following is a list of habitats that the species has been located in within New England compiled from examination of herbarium specimens, literature reports, and personal observations.

- Sparsely vegetated folists on coastal headlands (folists are organic soils where decomposition is slowed by cool climate rather than saturation)
- Wet ditches within peaty meadows
- Sandy edges/ditches of infrequently used, single-lane roads
- Graminoid marshes
- Shrub swamps
- Dry-mesic mixed conifer-hardwood forests
- Circumneutral river shore outcrops
- Hydric meadows

As the above list of communities clearly illustrates, *Juncus vaseyi* is tolerant of varied pH, hydrology, and substrate. That stated, current extant locations, with one exception, do share a number of similarities. These occurrences are influenced by high pH bedrock (e.g., limestone, calcareous slate and shale) and/or occur on river shore ledges.

Juncus vaseyi is generally considered a species of exposed, permanently moist soils (Brooks and Clements 2000). Though this may often be the case range-wide, in New England, *J. vaseyi* is frequently located on substrate that would be classified as dry-mesic to xeric much of the season (e.g., open river shore ledges, upland forests). Further, *J. vaseyi* is noted to

occur in “sandy excavations” in Michigan (Voss 1972). It is perhaps more accurate to state this species occupies areas that are seasonally saturated or inundated.

In most cases, *Juncus vaseyi* is found growing in open areas that are devoid of woody competitors (e.g., ice-scoured river shore ledges, cleared fields, open headlands, and edges of roads). *Juncus vaseyi* is capable of utilizing human-modified habitats and is considered “weedy” by Ralph Brooks (personal communication). Zika (1991) considers this plant to be an early-successional species. He further hypothesizes that *J. vaseyi* has always been rare in New England given the heavily forested condition prior to European settlement. Agriculture in the region would have created a number of open communities; however, this would have been offset by competition from hay grasses, wetland alteration, and recruitment difficulties faced by *J. vaseyi* near the limit of its range.

The following species have been found to occur with *Juncus vaseyi* at two or more sites in New England:

- *Anemone multifida*
- *Juncus dudleyi*
- *Carex conoidea*
- *Viola novae-angliae*
- *Juncus ×oronensis*

Juncus vaseyi is likely an opportunistic species that utilizes recently disturbed areas in north-temperate and boreal climates. Sites are occupied for a period of time until plant community succession eliminates the population. Seeds produced by *J. vaseyi* during site occupation largely fall near the parent and may be banked in the soils until a later disturbance. However, the longevity of the seeds is unknown. Some seeds are likely also dispersed by various vectors for colonization of other sites.

THREATS TO TAXON

New England occurrences of *Juncus vaseyi* are most threatened by plant community succession. This species is apparently unable to tolerate dense woody vegetation or tall, aggressive herbaceous species. Known sites that occur in areas where trees and shrubs can encroach will likely require management to maintain populations (such as extant site ME .004 [Baileyville] and VT .001 [Ferrisburg] and historical sites ME .011 [Centerville] and ME .012 [Pembroke]). The gradual development and change of use of properties in eastern Maine is also eliminating potential sites that *J. vaseyi* could colonize.

Other significant threats to *Juncus vaseyi* in New England are changes to watershed dynamics (e.g., damming, alterations of flows). Watershed protection is an increasingly difficult feat to achieve due to the number of parties involved and multitude of issues involved. This is

especially true of the St. John River (where three out of six extant New England occurrences are found — ME .005 [T12 R16 WELS], ME .003 [Allagash Plantation], and ME .007 [T16 R12 WELS]), which would include cooperation of many unorganized townships, several land management companies, and two countries (a portion of the headwaters of the St. John River are located in Quebec). Nonetheless, land acquisition and/or easement, conscientious forestry practices, and prevention of water control structures, among other factors, will be important to the long-term security of *J. vaseyi* in New England.

Juncus vaseyi is also threatened by site development, which would include such activities as building construction and road expansion/maintenance. As several historical occurrences were located in pastures and ditches (e.g., ME .011 [Centerville] and ME .012 [Pembroke]), these sites, may be extirpated by facilities construction and road expansion, as well as by threats from community succession. This is believed to have occurred for ME .001 (Orono), which may have been extirpated by the construction of a livestock barn. One extant location (ME .004 [Baileyville]) is threatened by a natural gas pipeline. Despite the fact that the site was located and protected prior to construction, future visits and repairs may unknowingly impact the population if site details are not communicated to the field workers.

One site in New England (ME .003 [Elliotville]) is along a hiking corridor that receives intense recreational pressure. The plants are at risk of trampling if steps are not taken to mitigate the threat. This will be especially difficult as obvious methods, such as barriers or features to route hiking traffic, would impact the visual aesthetics of the site.

Several sites, both historical and extant (e.g., ME .005 [T12 R16 WELS], ME .006 [Allagash Plantation], ME .008 [T18 R10 WELS]), are found along rock outcrops of the St. John River. These sites have been created by severe ice scour that removed woody and herbaceous competitors. This same phenomenon (i.e., vernal ice scour) can also extirpate plants, which points to the need of securing protection of many sites along the river system that can be colonized by *Juncus vaseyi*.

DISTRIBUTION AND STATUS

General Status

Juncus vaseyi is a species of the northern United States and Canada and it is endemic to North America (Brooks and Clemants 2000). It ranges from Labrador, south to Maine, Vermont, and New York, west through Colorado and Wyoming to British Columbia, and north to Mackenzie (Northwest Territories). In New England, *J. vaseyi* is known only from Maine and Vermont. Figure 1 shows the distribution of *J. vaseyi* in North America.

Juncus vaseyi is considered secure range-wide (global rank of G5?) but is noted to be rare over its large, southern range in the United States (The Nature Conservancy 1997). It is

protected in many of the states and provinces it occurs by both regional laws and remoteness/inaccessibility. However, Ralph Brooks (personal communication) states that this rush is apparently declining over its range. In 1988, he noted that this species had been collected from a mere half-dozen sites since 1950 in the United States. Further, most populations of *J. vaseyi* consisted of 25 or fewer individuals, contributing to the rarity of this species. Table 1 lists the current status of *J. vaseyi* in each state and province from which it is known.

Status of All New England Occurrences — Current and Historical

New England has a total of 14 occurrences of *Juncus vaseyi*, 13 in Maine and 1 in Vermont. Of the six extant occurrences, one is provided an Element Occurrence (EO) rank of B, one is B/C, two are C, one is E, and one is unranked. The remaining eight occurrences are provided EO ranks of historic (H; 7) or extirpated (X; 1).

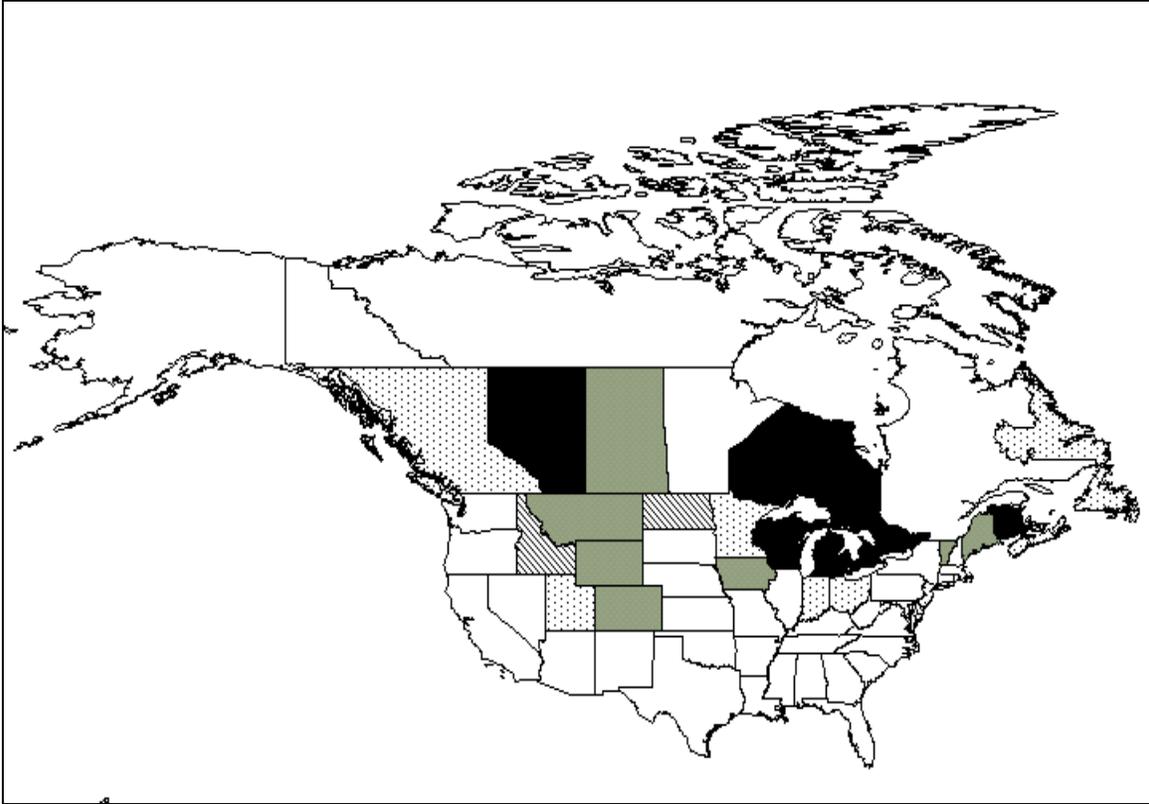


Figure 1. Occurrences of *Juncus vaseyi* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. Areas with diagonal hatching is designated "historic," where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

Table 1. Occurrence and status of <i>Juncus vaseyi</i> in the United States and Canada based on information from The Nature Conservancy 1997 (except New Brunswick) and NatureServe 2001.			
OCCURS & LISTED (AS S1, S2, OR T & E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Colorado (S1)	Alberta (S3)	British Columbia (SR)	Idaho (SH)
Illinois (S1)	Iowa (SU)	Mackenzie (SR)	North Dakota (SH)
Maine (S1): 5 extant and 8 historic occurrences	Manitoba (S4?)	Indiana (SR)	
Michigan (S1S2); reported from 4 counties by Voss (1972)	Montana (SU)	Labrador (SR)	
New Brunswick (S2); considered very rare (Hinds 2000)	Ontario (S3)	Minnesota (SR)	
Vermont (S1): 1 extant occurrence	Saskatchewan (S?)	New Jersey (SR); but see Brooks and Clemants (2000) — no record listed	
Wyoming (S1)	Wisconsin (S3)	New York (SRF); see Clemants 1990	
		Nova Scotia (SR); but see Brooks and Clemants (2000) — no record listed	
		Ohio (SR)	
		Quebec (SR)	
		Utah (SR)	

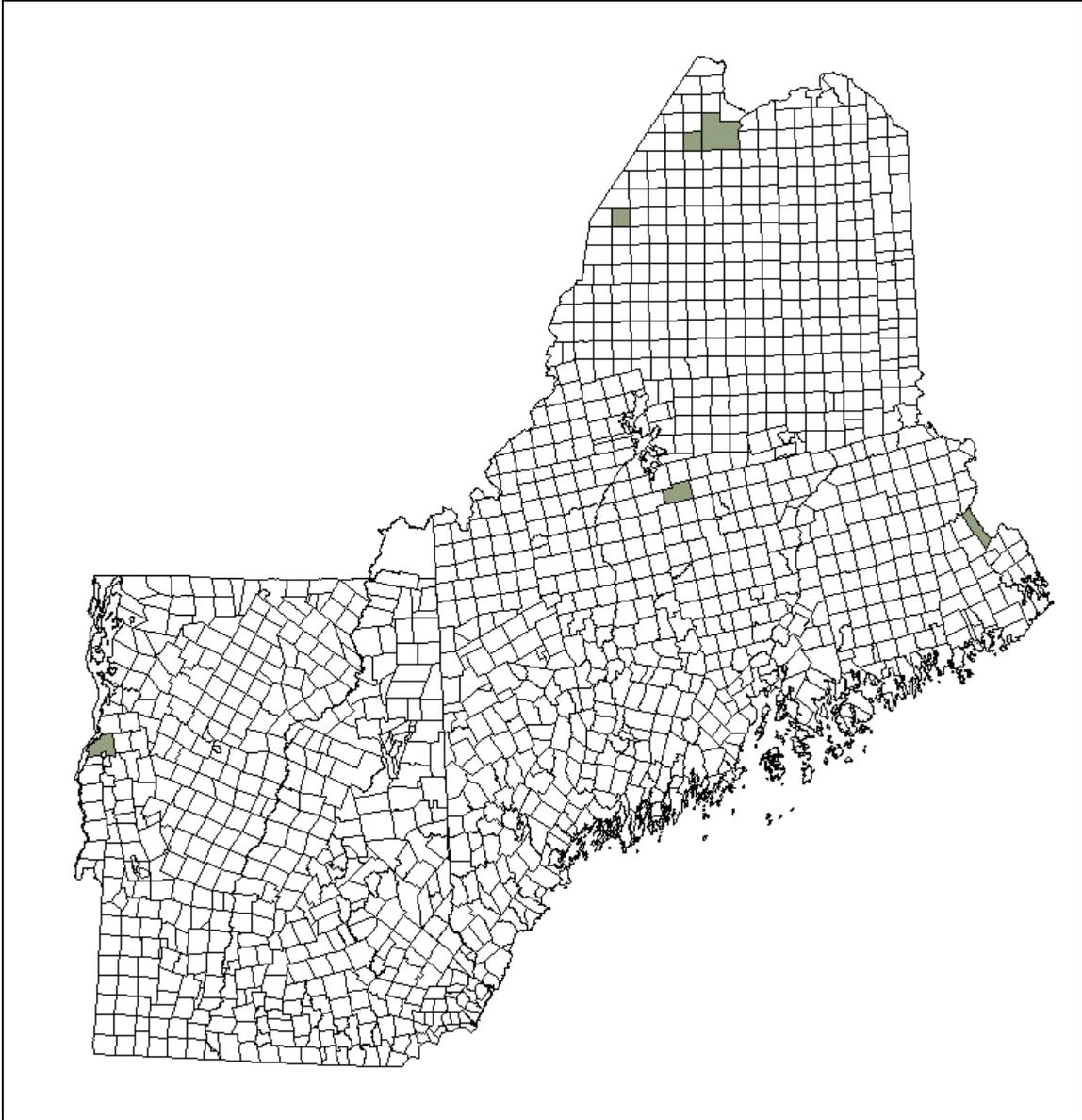


Figure 2. Extant occurrences of *Juncus vaseyi* in New England. Town boundaries for northern New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

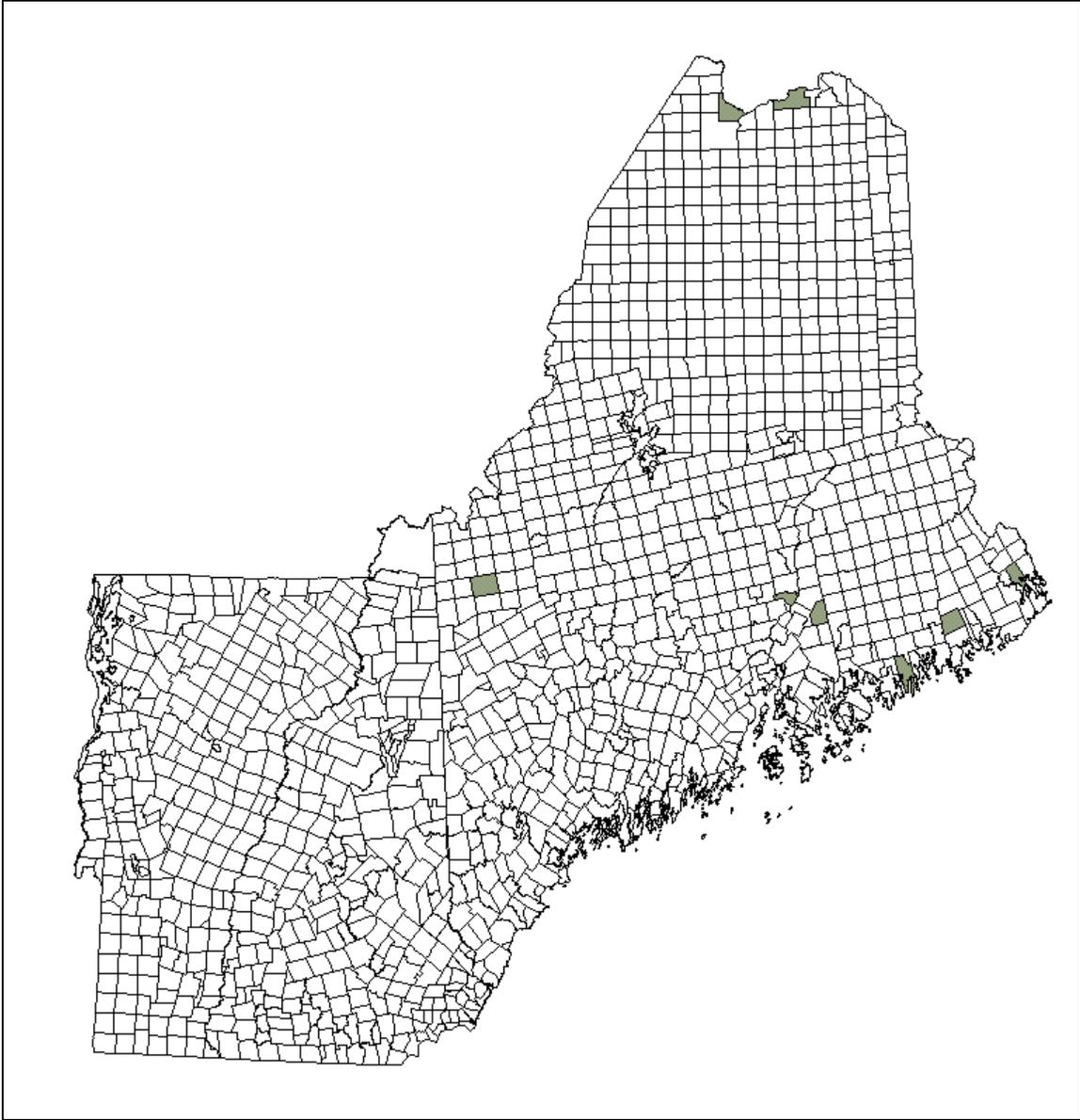


Figure 3. Historical occurrences of *Juncus vaseyi* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 2. New England Occurrence Records for *Juncus vaseyi*. Shaded occurrences are considered extant.

State	EO #	County	Town
ME	.001	Penobscot	Orono
ME	.002	Franklin	Rangeley
ME	.003	Piscataquis	Elliotsville
ME	.004	Washington	Baileyville
ME	.005	Aroostook	T12 R16 WELS
ME	.006	Aroostook	Allagash Plantation
ME	.007	Aroostook	T16 R12 WELS
ME	.008	Aroostook	Probably T18 R10 (but could be St. Francis)
ME	.009	Aroostook	Fort Kent
ME	.010	Penobscot	Clifton
ME	.011	Washington	Centerville
ME	.012	Washington	Pembroke
ME	.013	Washington	Steuben
VT	.001	Addison	Ferrisburg

II. CONSERVATION

CONSERVATION OBJECTIVES FOR TAXON IN NEW ENGLAND

The overall conservation objectives for *Juncus vaseyi* in New England are to protect known sites, study extant populations, and locate/relocate additional populations. A goal of ten total populations with a C-rank or better distributed in at least five biophysical regions of New England would be considered successful application of this conservation plan.

Based on such features as the known phylogeographical pattern, the relatively limited botanical survey effort in downeast Maine, and the cryptic morphology of *Juncus vaseyi*, a goal of ten extant New England populations is both suitable and attainable. Concentrated searches along circumneutral rock outcrops of the St. John River are very likely to yield more populations, as many suitable sites exist for this species. Downeast Maine (i.e., eastern Hancock and Washington Counties) has not received the intensity of survey effort as many portions of New England. Given that this region of New England has produced a total of four occurrences (28% of all New England occurrences), it is reasonable to assume that focused searches will locate more populations. Perhaps most important, *Juncus vaseyi* is a graminoid species with both short stature and limited numbers of individuals at most sites. These features combine to create a species that is easily overlooked, even at sites that have been visited many times by experienced plant biologists. A re-examination of suitable habitats, even those that have been long visited by botanists, by persons trained in locating this species will yield more populations.

Conservation effort should focus on populations that occur in habitats that are naturally maintained as open, as these occurrences appear to have the best long-term viability. Such populations are those along the St. John River and occur on circumneutral river shore outcrops. However, ephemeral populations (i.e., those that occur in fields, ditches, and other disturbed, open sites) are important and should not be overlooked. These occurrences contribute to the total number of individuals in New England and provide additional sources of propagules.

Due to the enigmatic nature of *Juncus vaseyi* and the limited information available for this plant in New England, conservation of this species will be difficult to achieve without more study. A strong focus on data collection will be necessary in order to better understand the life history and requirements of this rush. Specifically, it is recommended that detailed information be collected from all known occurrences (e.g., substrate, soil pH, hydrology, soil profile, bedrock, site history, associated species, local climate). It may be possible to better predict where and why *J. vaseyi* occurs in certain plant communities and use this information to locate/relocate occurrences in the large region between known sites (no extant occurrences are known from eastern Vermont, New Hampshire, and western Maine though suitable habitat likely exists).

In addition to data collection, several other conservation activities will be important. Continued protection and monitoring of known sites will help avoid reduction in the number of element occurrences in New England. Collection of seeds should occur for gene banking and germination studies.

III. LITERATURE CITED

- Boivin, B. 1967. Énumération des plantes du Canada. 6. Monopsides. *Naturaliste Canadien* 94: 471–528.
- Brooks, R. E. 1989. A revision of *Juncus* subgenus *Poiophylli* (Juncaceae) in the eastern United States. Ph.D. Dissertation, University of Kansas, Lawrence, Kansas, USA.
- Brooks, R. E., and S. E. Clements. 2000. Juncaceae. Pages 211–267 in Flora of North America Editorial Committee (Editors). *Flora of North America*, Volume 22. Oxford University Press, New York, New York, USA.
- Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.
- Catling, P. M., and K. W. Spicer. 1987. The perennial *Juncus* of section *Poiophylli* in the Canadian prairie provinces. *Canadian Journal of Botany* 65: 750–760.
- Catling, P. M., and K. W. Spicer. 1988. The status of *Juncus oronensis* (Juncaceae). *Canadian Journal of Botany* 66: 1574–1582.
- Clemants, S. E. 1990. Juncaceae (Rush Family) of New York State. New York State Museum Bulletin Number 475, Albany, New York, USA.
- Engelmann, G. 1866. A revision of the North American species of *Juncus*, with a description of new and imperfectly known species. *Transactions of the St. Louis Academy of Sciences* 2: 424–498.
- Fernald, M. L. 1904. Preliminary lists of New England Plants—XIII. Juncaceae. *Rhodora* 6: 34–41.
- Gleason, H. A., and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. The New York Botanical Garden, Bronx, New York USA.
- Haines, A., and T. F. Vining. 1999. *Flora of Maine*. V.F. Thomas Company, Bar Harbor, Maine, USA.

- Hinds, H. R. 2000. *Flora of New Brunswick*. Second Edition. Department of Biology, University of New Brunswick, Fredericton, New Brunswick, Canada.
- Judd, W. S., C. S. Campbell, E. A. Kellogg, and P. F. Stevens. 1999. *Plant Systematics: A Phylogenetic Approach*. Sinauer Associates, Inc., Sunderland, Massachusetts, USA.
- Magee, D.W., and H.E. Ahles. 1999. *Flora of the Northeast*. University of Massachusetts Press, Amherst, Massachusetts, USA.
- McMahon, J. S. 1990. *The Biophysical Regions of Maine—patterns in the landscape and vegetation*. M.Sc. Thesis, University of Maine, Orono, Maine, USA.
- Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thompson. 1999. *A Practical Handbook for Population Viability Analysis*. The Nature Conservancy, Arlington, Virginia, USA.
- NatureServe 2001. NatureServe Explorer: An online encyclopedia of life [web application]. Version 1.6. Arlington, Virginia, USA: NatureServe. Available at <http://www.natureserve.org/explorer> (Accessed July 2003).
- Raup, H. M. 1934. Phytogeographic studies in the Peace and Upper Liard River regions, Canada, with a catalogue of the vascular plants. *Harvard University, Arnold Arboretum Contributions VI*: 1–230.
- The Nature Conservancy. 1997. Element Stewardship Abstract for *Juncus vaseyi*. Arlington, Virginia, USA.
- Thompson, E. H. and E. R. Sorenson. 2000. *Wetland, Woodland, Wildland, A Guide to the Natural Communities of Vermont*. University Press of New England, Hanover, New Hampshire, USA.
- Voss, E. G. 1972. *Michigan Flora. Part I: Gymnosperms and Monocots*. Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.
- Zika, P. F. 1991. Discovery of *Juncus vaseyi* (Juncaceae) in Vermont. *Rhodora* 93: 395–397.

IV. APPENDICES

- 1. Specimens Observed**
- 2. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. Specimens Observed

United States. Maine. Aroostook County. Shore of St. John River, northern Maine, 22 Aug 1879, *Pringle s.n.* (GH, NEBC). Rocky islet at mouth of St. Francis River, valley of St. John River, 14 Aug 1902, *Fernald s.n.* (NEBC). Roadside, Fort Kent, 10 Aug 1901, *Williams s.n.* (GH). Franklin County. Rangeley Lake, 1882, *Furbish s.n.* (NEBC). Penobscot County. Dry thicket, NW slope of Peaked Mt. (altitude 700 ft), Clifton, 22 Aug 1897, *Fernald s.n.* (GH, NEBC). Alder swamp, Orono, Aug 1890, *Fernald s.n.* (MAINE). Orono, Aug 1890, *Fernald 1052* (MAINE). Alder swamp, valley of Penobscot River, Orono, 21 Jul 1892, *Fernald 329* (GH, NEBC). Alder swamp, lower Penobscot Valley, Orono, 13 Aug 1890, *Fernald 329* (NEBC). Thicket, Orono, 13 Jul 1892, *Fernald s.n.* (NEBC). Damp thicket, Orono, 13 Jul 1892, *Fernald s.n.* (NEBC). Piscataquis County. Growing on the rim of the slate gorge of Little Wilson Falls, S side of stream, ca. 12 plants, all will few-flowered infl[orescences], Elliotsville, 14 Aug 1994, *Haines s.n.* (MAINE). Washington County. Growing on dry (very fine sandy loam) shoulder of logging road, Associations: *Betula papyrifera*, *Betula populifolia* saplings, *Diervilla lonicera*, *Euthamia graminifolia*, *Solidago* ssp., *Anthoxanthum odoratum*, *Antennaria* spp., and *Rumex acetosella*, Baileyville, 5 Aug 1997, *Hall and Royte s.n.* (MAINE). Occasional, dry sandy roadside, logging road near St. Croix River, Baileyville, 5 Aug 1997, *Royte and Hall s.n.* (MAINE). Grassy swamp, Centerville, 5 Aug 1936, *Knowlton s.n.* (NEBC). Forming broad stools by ditch in a boggy meadow; local, west of Ayer's Junction, Pembroke, 12 Jul 1909, *Fernald 1552* (GH, NEBC). Peaty barren, Petite Manan Point, Steuben, 22 Aug 1932, *Knowlton s.n.* (NEBC).

Vermont. Addison County. Damp meadow in campground, Button Bay State Park, elev. 110 feet, with *Carex annectens*, *C. tenera*, *C. lanuginosa*, *C. buxbaumii*, *Juncus effusus*, *J. dudleyi*, Ferrisburg, 11 Jul 1990, *Zika 10886* (VT).

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

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

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

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

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

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

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

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