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CHROMOSOME NUMBER DETERMINATIONS FOR NEWFOUNDLAND SPECIES OF *ANTENNARIA* GAERTNER (ASTERACEAE: INULEAE)

JERRY G. CHMIELEWSKI

ABSTRACT

Chromosome numbers were determined for 54 individuals of Newfoundland *Antennaria* representing 8 species: *A. cana* ($2n=56$), *A. columnaris* ($2n=56$), *A. confusa* ($2n=56$), *A. eucosma* ($2n=56$), *A. gaspensis* ($2n=56$), *A. howellii* ($2n=56$), *A. pulvinata* ($2n=56$), and *A. staminea* ($2n=56$). The tetraploid determinations for populations of *both A. eucosma* and *A. howellii* (reported as *A. neodioica*) support previous determinations for these two species. Chromosome number determinations for all other species represent first reports.

Key Words: *Antennaria*, Newfoundland, chromosome numbers, taxonomy

INTRODUCTION

The dioecious genus *Antennaria* occurs predominantly throughout the cold temperate and arctic regions of the Northern Hemisphere. Polyploidy is extensive in the genus, as is the associated agamospermy. Chromosome number determinations are available for approximately 2500 individuals of North American *Antennaria* representing 66 described species and 15 naturally occurring hybrids (Stebbins, 1932a,b; Love and Love, 1964, 1982; Johnson and Packer, 1968; Mosquin and Hayley, 1968; Strother, 1972; Packer and McPherson, 1974; Bayer and Stebbins, 1981, 1987; Morton, 1981; Urbanska, 1983; Bayer, 1984, 1988, 1989a,b, 1990, 1991, 1992; Chinnappa, 1984, 1986; Evert, 1984; Bayer and Crawford, 1986; Chmielewski and Chinnappa, 1988a,b, 1990). Of these reports, only two, Morton (1981) and Urbanska (1983), have documented chromosome numbers for Newfoundland species of *Antennaria*, specifically six tetraploid determinations for *A. eucosma* Fernald and Weigand.

Reproductive mode in association with polyploidization have directed the evolutionary history of the genus. These factors combined with hybridization have led to the formation and establishment of numerous, morphologically variable, races and clones, many of which are apomictic. Fernald (1933) stated that 16 species and 2 varieties of *Antennaria* occurred on the island of Newfoundland. These taxa are, however, technically difficult and the status of some of these taxa has since been questioned (*e. g.* Bouchard *et al.*, 1991) and various resolutions proposed (*e. g.* Bayer, 1989c; Bayer and Stebbins, 1993; Chmielewski, 1993, 1994). Chmielewski (1994) most recently placed *A. bayardi* Fernald, *A. brunnescens* Fernald and *A. foggii* Fernald in synonymy with *A. pulvinata* Greene. Widespread acceptance has not yet occurred for any of the recently proposed changes. Revision of the Newfoundland *Antennaria* is necessary, however, to determine whether 8 of the taxa cited by Fernald (1933), that is, *A. albicans* Fernald, *A. cana* (Fernald & Wiegand) Fernald, *A. columnaris* Fernald, A. *gaspensis* Fernald, *A. petaloidea* (Fernald) Fernald var. *subcorymbosa* (Fernald) Fernald, *A. straminea* Fernald, A. *vexillifera* Fernald, and *A. wiegandii* Fernald legitimately warrant rare status and therefore protection (see Bouchard *et al.* 1991) or more appropriately should be placed in synonymy with other species and therefore relieved of this designation. Additionally, the status of *A. confusa* Fernald, *A. eucosma*, Fernald and Weigand, *A. neodioica* Greene var. *attenuata* Fernald, A *neodioica* var. *chlorophylla*

Fernald, *A. neodioica* var. *typica* Fernald, *A. rupicola* Fernald and *A. spathulata* (Fernald) Fernald need to be established as these taxa were excluded from the rare list for Newfoundland because they: (1) were considered to be too widespread or common in their habit, even though they may be restricted geographically or (2) are minor variants of other more widespread or common species (Bouchard *et al.* 1991).

The only study to date which has dealt specifically, but not exclusively, with documenting morphological variation in Newfoundland species of the genus *Antennaria* is that of *Chmielewski (1994)*. Until a satisfactory, detailed, taxonomic treatment of the Newfoundland *Antennana per se* is prepared, the nomenclature proposed by Fernald (1933) and Chmielewski (1994) for these taxa will be retained. The present report which deals with chromosome number determinations for these taxa is intended to stimulate subsequent revisionary studies.

MATERIALS AND METHODS

Rootstocks were washed free of soil particles and debris in the field and subsequently returned to the campus greenhouse where they were transplanted into a mixture of equal parts soil, vermiculite and sand. Plants were watered as necessary and grown under natural daylight conditions and a temperature range of 15-25°C. Voucher specimens were identified using the key to Newfoundland *Antennaria* following Fernald (1933) and Chmielewski (1994). All vouchers of *Antennaria cana* (Fernald and Weigand) Fernald, *A. columnaris* Fernald, *A. confusa* Fernald, *A. eucosma* Fernald and Weigand, *A. gaspensis* Fernald, *A. howellii* Greene, *A. pulvinata* Greene, and *A. staminea* Fernald were collected by the author and subsequently deposited at SLRO (Holmgren et al., 1990). Duplicate collections were deposited at MT.

Mitotic chromosome counts were made from root-tips that were collected at approximately mid-morning of sunny days, treated with a saturated PDB solution for 2 h, fixed in a mixture of ethanol and glacial acetic acid (3:1), subsequently hydrolized in 1N HCl at 60°C for 10-15 minutes and then squashed in 2% acetic orcein stain.

RESULTS AND DISCUSSION

Chromosome numbers were determined for 54 individuals representing 8 species of *Antennaria* (Table 1). The somatic chromosome number of 56 is widespread in the genus and in North America is generally considered to represent the tetraploid condition as no species with somatic numbers lower than 28 have been reported. European authors have, however, historically treated the somatic count of 28 as tetraploid as the somatic number of 14 is known for the sister genus *Gnaphalium* (Gustafsson, 1947; Urbanska, 1983, a and b.). Except for tetraploid chromosome number determinations for *A. eucosma* and *A. howellii* which support previous counts for the species, all other determinations represent first reports and are presented without further comment. Tetraploid determinations previously reported for *A. eucosma,* are also from Newfoundland populations (Morton, 1981; Urbanska, 1983). Thus, based on available determinations, this species is tetrapoloid throughout its distribution. The same is not true for *A. howellii (=A. neodioica),* as both aneuploid and euploid determinations have been previously reported (Stebbins, 1932b; Bayer and Stebbins, 1981, 1987; Bayer, 1984; Bayer and Crawford, 1986; Chinnappa, 1986; Chmielewski and Chinnappa, 1988, a and b, 1990). Tetraploid determinations for *A. howellii* occur throughout the more southern portion of the species distribution intermingled with other cytotypes (Bayer, 1984; Bayer and Stebbins, 1981,1987; Bayer and

Crawford, 1986; Chinnappa,1986). No other cytogeographic trends are recognizable for the species at this time.

Table 1.

Chromosome number determinations for 8 species of *Antennaria* from Newfoundland. Listed are species, chromosome number, location, date of collection and collection number. Staminate individuals are designated with an asterisk (*) following the collection number. All collections by J.G.Chmielewski.

A. cana Fernald, $2n = 56$. **Newfoundland**: District of St. Barbe North, Boat Harbour, July 13, 1993, *2973*.

A. columnaris Fernald, $2n = 56$. **Newfoundland**: District of St. Barbe South, Pointe Riche Peninsula, Port au Choix National Historic Park, Gar gamelle Cove, July 16, 1993, *3007, 3008*.

A. confusa Fernald, $2n = 56$. **Newfoundland**: District of Port au Port, Nfld 462, Port au Port, Table Mtn, July 6, 1993, *2963*. District of St. Barbe North, Boat Harbour, July 13, 1993, *2974*. Cape Norman region, July 13, *1993, 2977, 2979*. Nfld 435, 0.5 km south of Cook's Harbour, July 13, 1993, *2981, 2986* . East of Big Brook, July 13, 1993, *2989, 2990*. District of St. Barbe South, Pointe Riche Peninsula, Port au Choix National Historic Park, vicinity of Pointe Riche, July 15, 1993, *3003*

A. eucosma Fernald & Wiegand, $2n = 56$. **Newfoundland**: District of Port au Port, Nfld 462, Port au Port, Table Mtn, July 6, 1993, *2967*. District of St. Barbe North, Boat Harbour, July 13, 1993, *2971**. Cape Norman region, July 13, 1993, *2975**. Nfld 435, 0.5 km S of Cook's Harbour, July 13, 1993, *2987**. East of Big Brook, July 13, 1993, *2992*, 2993*. District of White Bay North, Nfld 430, west of St. Anthony airport, July 15, 1993, *2994*, 2995*

A. gaspensis Fernald, $2n = 56$. **Newfoundland**: District of Port au Port, Nfld 462, Point au Mal, Ragged Ass road, July 5, 1993, *2959*. Nfld 460, Lower Cove, July 5, 1993, *2961*. District of St. Barbe South, Nfld 430, Table Point Ecological Reserve, north of Bellburns, July 16, 1993 , *3011, 3013*.

A. howellii Greene, $2n = 56$. **Newfoundland:** District of Grand Falls, Trans Canada Highway, 4.5 km west of Red Cliff Road, west of Grand Falls, July 23, 1993, *3020*. District of Lewisporte, Nfld 331, 1.1 km east of Nfld 340, July 23, 1993, *3021, 3022*. District of Placentia West, Nfld 210, 1.1 km south of Cow Head exit, Marystown area, July 26, 1993, *3031*. District of Port au Port, Nfld 460, Lower Cove, July 5,1993, *2960*. Nfld 460, Cape St. George, July 5, 1993, *2962*. Nfld 462, Port au Port, Table Mtn, July 6, 1993, *2970*. District of St. Barbe South, south of Bellburns, July 16, 1993, *3015*. Gros Morne National Park, just west of Bear Cove, July 18, 1993, *3017*. District of Twillingate, Nfld 340, 1.8 km south of Summerford, July 23, 1993, *3023*. Nfld 340, 0.3 km south of Newville, July 23, 1993, *3024, 3025*. Twillingate, summit of Smith' s Lookout Road, July 23, 1993, *3028, 3029*. Nfld 340, 0.3 km north of William B. Elliott Causeway, July 23, 1993, *3030*.

A. pulvinata Greene, $2n = 56$. Newfoundland: District of St. Barbe South, Pointe Riche Peninsula, Port au Choix National Historic Park, vicinity of Pointe Riche, July 15, 1993, *2998, 3000, 3001*. Gargamelle Cove, July 16, 1993, *3009*.

A. straminea Fernald, $2n = 56$. **Newfoundland**: District of St. Barbe South, Pointe Riche Peninsula, Port au Choix National Historic Park, vicinity of Pointe Riche, July 15, *1993, 2997, 3002, 3004*. Gargamelle Cove, July 16, 1993, *3010*. Nfld 430, Table Point Ecological Reserve, N of Bellburns, July 16, *1993, 3012, 3014*. S of Bellburns, July 16, 1993, *3016*. Gros Morne National Park, Trout River Valley Road, Tableland Mtn., barren knob at mouth of Winter House Gorge, July 19, 1993, *3018, 3019*. District of Twillingate, Twillingate, summit of Smith's Lookout Road, July 23, 1993, *3027*.

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ADDITIONS TO THE PRELIMINARY CHECKLIST OF VASCULAR FLORA OF CONNECTICUT

LESLIE J. MERHOFF

ABSTRACT

Forty-six native or naturalized species, varieties, or hybrids are reported as additions to Dowhan's Preliminary Checklist of the Vascular Flora of Connecticut. These represent 21 native taxa and 25 apparently naturalized taxa. Each taxon is presented with a brief history of its discovery in Connecticut. Dates are presented for the earliest known voucher specimen for each addition.

Key words: Connecticut, flora, vascular plants, additions

The following list of taxa represents additions to the non-cultivated flora of Connecticut that have been discovered since the publication of the PRELIMINARY CHECKLIST OF THE VASCULAR FLORA OF CONNECTICUT (Dowhan 1979). Most are new discoveries although the recent annotation of specimens collected prior to 1979 accounts for some of the new records. In some cases taxa considered here were not included in regional floristic treatments such as Fernald (1950), Seymour (1969), or Gleason and Cronquist (1963, 1991). Some taxa appear to be adventive and it remains to be seen whether or not these will become established in Connecticut

41 species, 2 varieties, and 3 naturally occurring hybrids in 29 families are reported. 21 taxa appear to be native while the remaining 25 appear to be non-native or ruderal taxa and should be considered as adventive or naturalized. One new family, the Hymenophyllaceae, is added to the flora. (Six taxa are listed as Endangered and three as Special Concern Species on the Connecticut list of Endangered, Threatened, or Special Concern Species (Department of Environmental

Protection 1993). 34 records are from recent discoveries and 12 records represent additions due to revisionary reevaluations.

It seems prudent to follow the family order as presented in Dowhan (1979). Taxa within families are alphabetized by genus, and those within genera are alphabetized by species. However, familial names used here all end in *-aceae*, alternative names being used for the sake of consistency in certain families. Nomenclature follows the Flora of North America (Flora of North America Editorial Committee 1993) for pteridophytes and Gleason and Cronquist (1991) for angiosperms.

A single specimen is cited at the end of the discussion for each taxon. Citations are for the earliest voucher specimen known to me. No attempt has been made to include multiple vouchers from different herbaria where duplicates may have been deposited, although I am aware many exist. These records represent collections deposited at CONN, GH, MASS, NCBS, NEBC, NYS, and YU (Holmgren *et al.* 1990).

Distributional information comes from Flora of North America, Volume 2 (Flora of North America Editorial Committee 1993) for pteridophytes and Gleason and Cronquist (1991) for angiosperms unless otherwise noted. A table summarizing all additions and a map showing Connecticut's 8 counties are included. .

LYCOPODIACEAE

Lycopodiella alopecuroides (L.) Cranfill

Foxtail Club-moss

This taxon was originally reported as *Lycopodium alopecuroides* L. by Edwin H. Eames from Milford, New Haven County in 1908. Eames also collected *L. alopecuroides*

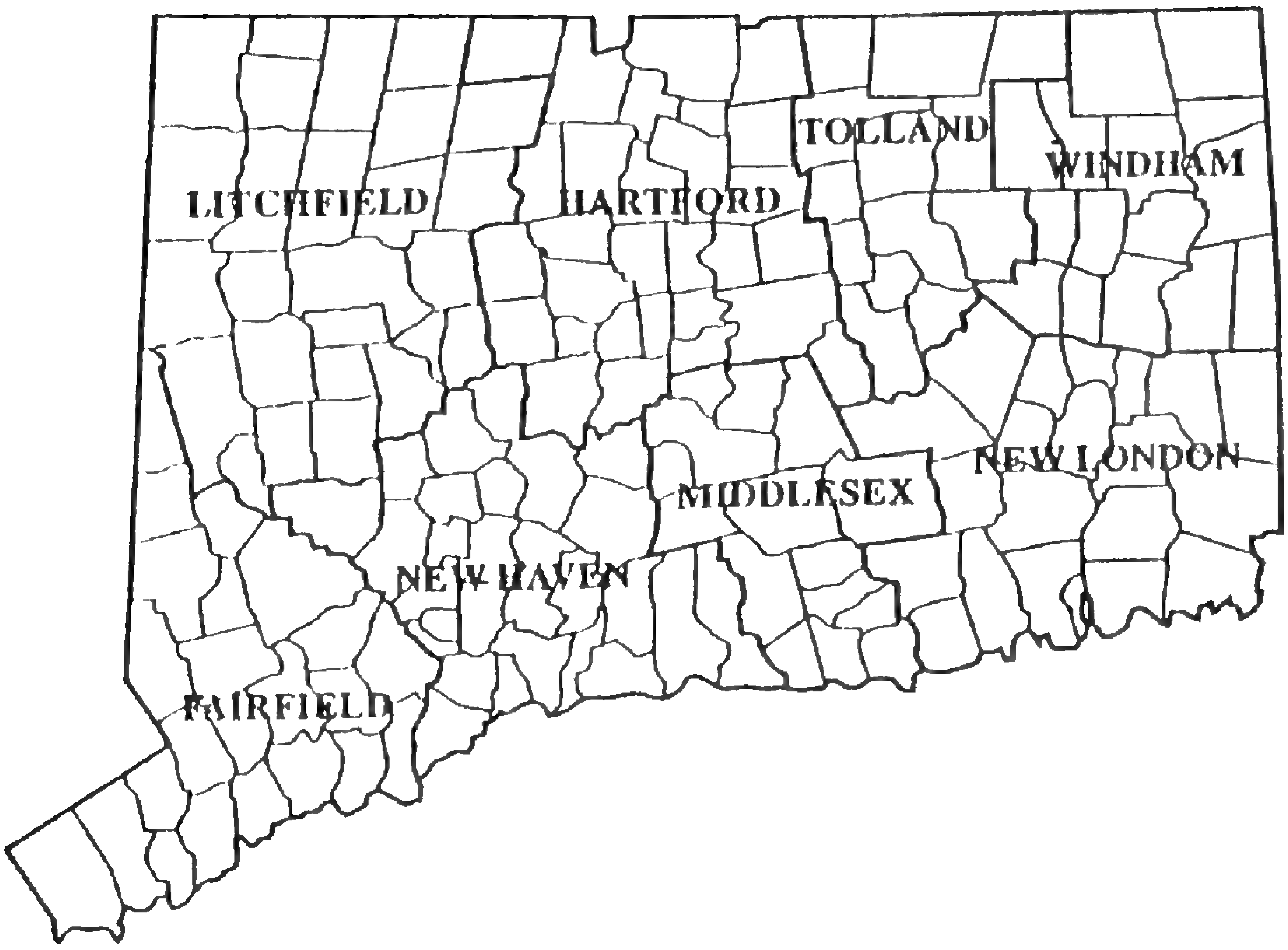

Figure 1. Map of Connecticut showing County and Town Boundaries.

in Fairfield County. The correct identification of the specimemens had been questioned by Joseph Dowhan and others. Revisionary work by the late Joseph Beitel and Warren H. Wagner, Jr. has confirmed Eames' original determination. This species, under the synonym *Lycopodium alopecuroides* L. is listed as a Species of Special Concern in Connecticut (DEP 1993).

Distribution: Texas and Louisiana, north to Rhode Island and Massachusetts, mostly on coastal plain but inland to western North Carolina and northern Georgia.

[26 SEP 1908, E. H. Eames *s. n.* (CONN)]

Lycopodiella* x*copelandii (Eiger) Cranfill. [*Lycopodiella alopecuroides* (L.) Cranfill x L. *adpressa* (Lloyd & Underw.) Cranfill] . Hybrid Bog Club-moss

Numerous Connecticut specimens were annotated as this hybrid by Florence S. Wagner and Warren H. Wagner, Jr. These records were from Fairfield, New Haven, and Middlesex Counties. The late Joseph Beitel had called my attention to a collection in the G. Safford Torrey Herbarium (CONN) from Simsbury, Hartford County, of a *Lycopodiella* which he determined to be *L.* x*copelandii*. Subsequent evaluation of material from that herbarium did not yield a specimen which the Wagners felt comfortable in assigning to this hybrid taxon.

Distribution: This taxon can be expected anywhere within the range of either parent species.

[30 AUG 1907, E. H. Eames *s. n.* (CONN)]

SELAGINELLACEAE

Selaginella eclipes Buck. Buck's Meadow Spike-moss

This spike-moss is confused with the common *Selaginella apoda* (L.) Spring and may have been overlooked in the northeast. In 1982 Terry R. Webster found specimens determined as *S. apoda* collected in western Connecticut which matched Buck's description of this species (Buck 1977). Numerous calcareous localities in western Connecticut have yielded plants whose morphologies are intermediate between *S. eclipes* and *S. apoda*, adding to the confusion surrounding this taxon. Specimens, which we identified as *S. eclipes*, taken from the floor of an abandoned limestone quarry have recently been confirmed by Iván A. Valdespino at the New York Botanical Garden. Shortly after collecting these specimens from the quarry floor, the quarry was reactivated for processing marble.It now appears to have been abandoned again and should be revisited. Any specimen from calcareous areas and growing in full sun presumed to be *S. apoda* should be given more than a cursory glance.

Distribution: Western Quebec and eastern Ontario south through western New York to Oklahoma and Arkansas.

[26 APR 1983, L. J. Mehrhoff *7546*, with T. R. Webster (CONN)]

OSMUNDACEAE

Osmunda xruggii Tryon [Osmunda claytoniana L. x O. regalis L. var. spectabilis (Willd.) Gray]

Interrupted Royal Fern

This very rare hybrid was first collected in Wilton, Fairfield County, Connecticut in 1931 by Leonard J. Bradley. The type specimen came from a garden in Hartford, by way of the garden of Dr. Harold G. Rugg of Dartmouth College in New Hampshire (Tryon 1940). The last Wilton collection appears to be from 1938. It is not currently known to be extant in Connecticut.

Distribution: Fairfield County, Connecticut and Craig County, Virginia.

[14 JUN 1931, L. J. Bradley *s. n.* (GH)]

HYMENOPHYLLACEAE

Trichomanes intricatum Farrar. Appalachian Trichomanes

The species name *Trichomanes intricatum* Farrar has only recently been published (Farrar 1992) although the gametophyte has been known for several years (Farrar *et al.* 1983). This fern gametophyte, which apparently never produces a sporophyte, was reported from Kent and Norfolk, Litchfield County in 1983 by Donald R. Farrar, James C. Parks, and

Bruce W. McAlpin (Farrar *et al.* 1983). Gametophytic plants of *Trichomanes intricatum*, once described to me by Rolla Tryon as "resembling green steel wool" can be easily overlooked. It has recently been found in Hartland, Hartford County and should be looked for in other areas. It is a Species of Special Concern in Connecticut, listed as *Trichomanes* sp. (DEP 1993).

Distribution: Central Vermont and New Hampshire south along the Appalachian uplands to Alabama and Georgia, disjunct in southern Illinois and Indiana and western Kentucky.

[30 SEP 1991, L. J. Mehrhoff *15299,* with M. Ardwin, J. Barrett, and N. Proctor (CONN)]

PTERIDACEAE

Pellaea glabella Mett. ex Kuhn subsp. **glabella**
Smooth Cliff-brake

The smooth Cliff-brake was first reported from Connecticut in 1988 from a single calcareous outcrop in Salisbury, Litchfield County by Karen S. Hansen and Robert E. Schneider. The population seems to be well established as there are many individuals in the population. It is listed as an Endangered Species in Connecticut (DEP 1993).

Distribution: Vermont to Minnesota and south to Tennessee, Virginia, and western Maryland.

[27 JUN 1988, K. S. Hansen and R. E. Schneider *241* (CONN)]

ALISMATACEAE

Echinodorus tenellus(Mart.)Buchenau Burhead

This small aquatic was first reported in Connecticut from a pond margin in Glastonbury, Hartford County in 1989 by William Moorhead. No individuals of *Echinodorus* were observed at this station for three subsequent years. This is not atypical for this taxon (C. B. Hellquist pers. comm.). A small number of plants of *Echinodorus* were seen at this site in 1993 (K. J. Metzler pers. comm.). Numerous plants in flower and fruit were observed in 1994. This appears to be the only extant New England population. It is listed as an Endangered Species in Connecticut (DEP 1993).

Distribution; Tropical America north along the Atlantic Coast irregularly to Massachusetts, up the Mississippi River to Illinois, Missouri, occasionally Kentucky and Kansas.

[18 AUG 1989, K. J. Metzler *89001* (CONN)]

HYDROCHARITACEAE

Egeria densa Planch.

This aquatic species is commonly grown in aquaria. *Egeria densa* was introduced, apparently intentionally, in Westport, Fairfield County where it has persisted. It also has been occasionally introduced in Massachusetts and Vermont (Crow and Hellquist 1982). It should be watched for elsewhere in southern New England. It might be confused with species of *Elodea*.

Distribution: Occasional in northeastern United States. Na tive of South America, from southeastern Brazil to northern Argentina.

[20 AUG 1992, P. Aarrestad *s. n.* (CONN)]

POACEAE

Aira praecox L.

This European Hairgrass was first reported from Norwich, New London County in 1992. The population was well established in sandy soils of a "jug-handle" at the junction of Routes 2 and Interstate I-395. It was not noticed at this site in 1982 when collections were made in the same locality. A second station was found near an exit ramp off the interstate in Old Lyme, New London County in 1994.

Distribution: Eastern Connecticut to Virginia, usually near the coast. Native of Europe.

[12 JUN 1992, L. J. Mehrhoff *15618* (CONN)]

Microstegium vimineum (Trin.) A. Camus

The precise history of this species in Connecticut is somewhat unclear. Lauren Brown (pers. comm.) observed this species in Branford, New Haven County in the early 1980s but apparently no specimens were taken. In 1990 a population of this species was observed in East Haddam, Middlesex County by T. Hendrickson and collected under the name *Eulalia viminea* (Trin.) Ktze. By 1991 it appeared to be well established at numerous sites in New London (W. Dreyer pers. comm.) and Fairfield Counties and at single sites in both Hartford and Litchfield Counties. Tolland County specimens are from unwanted volunteers, probably from fruits falling from New Jersey material while it was being pressed. (Repeated attempts have been made to eradicate this species at this site.) The first North American collection of *Microstegium vimineum* was made in 1919 in Knoxville, Tennessee (Fairbrothers and Gray 1972). It was first collected in New Jersey in 1959 (Fairbrothers and Gray 1972). This invasive grass is now well established in many areas in northern New Jersey, Pennsylvania, and southeastern New York (Hunt and Zaremba 1992; pers. obs.). It occurs along roadsides, in alluvial woods, on serpentine barrens, and ruderal habitats and can form extensive stands to the exclusion of almost every thing else. This species should be closely monitored and controlled if at all possible.

Distribution: Connecticut and New York southward. Native of tropical Asia.

[19 SEP 1990, T. Hendrickson *s. n.* (NCBS)]

Panicum amarulum A. Hitchc. & Chase

Panicum amarulum was first taken in Connecticut from a roadside in Hebron, Tolland County in 1983. It is also known from North Haven, New Haven County. *P. amarulum* may have been originally introduced as an ornamental or accidentally introduced with roadside plantings or seeding at these sites. It is now spreading and appears to be well established. *Panicum amarulum* is not thought to be native north of New Jersey. Massachusetts records from Cape Cod are thought to be introductions (B. Sorrie pers. comm.). It is treated here as distinct from *Panicum amarum* Ell.

Distribution: New Jersey to Mexico, occasionally inland in North Carolina and West Virginia.

[12 SEP 1983, L. J. Mehrhoff *9240* (CONN)]

Panicum scabriusculum Elliott

This species was originally collected as *Panicum aculeatum* Hitchc. & Chase in Stafford, Tolland County on 21 JUN 1911 by Charles H. Bissell. A specimen from this collection was determined not to be *Panicum aculeatum* by Joseph J. Dowhan (1979). A duplicate collection was later discovered at the Smithsonian Institution (US) that had been annotated as *Dichanthelium scabriusculum* (Elliott) Gould & Clark by the late F. C. Gould and C. A. Clark. A recent specimen of *Panicum scabriusculum* was collected in Voluntown, New London County, in 1989 by William J. Crins. This species is listed under *Dichanthelium scabriusculum* as an Endangered

Species in Connecticut (DEP 1993).

Distribution: Connecticut and New Jersey to Florida and Texas.

[13 JUN 1989, W. J. Crins *7628* (NYS)]

Vulpia myurus (L.) C. Gmelin Rat-tail Fescue

Vulpia myurus was collected at two sites less than 1 km from each other near Long Island Sound in Fairfield, Fairfield County on 28 JUL 1992. Both sites were open, sandy disturbed areas. One site was along a path to Long Island Sound and the other was adjacent to a gravel parking area removed from the coast, The spikelets were disarticulating at the time of collection, specimens from other localities should be sought at an earlier date.

Distribution: Widespread. Native of Europe.

[28 JUL 1992, L. J. Mehrhoff *15919*, with W. E. Brumback (CONN)]

CYPERACEAE

Carex backii Boott

Vegetative material, thought to be *Carex backii*, was collected on a marble ridge in Canaan, Litchfield County by Thomas Rawinski in 1988. In 1992, Elizabeth Thompson, reportedly unaware of Rawinski's find, collected fertile material of *C. backii* from the same calcareous ridge. It seems reasonable, in light of Thompson's collection, to assume Rawinski's specimen's belongs to this taxon. Because of its apparent rarity in the state, this species should be considered for inclusion on Connecticut's list of protected species.

Distribution:Quebec to New Jersey, west across to Minnesota, Utah, Oregon, and British Columbia.

Carex emoryi Dew.

A 1907 Edgar B. Harger collection of *Carex aquatilis* Wahlenb. was determined by Lisa Standley in 1990 to be *Carex emoryi*. Harger had collected the specimen in "wet ground at Selden's Cove", Lyme, New London County, Connecticut. This is the same locality from which nineteenth century specimens of *Nelumbo lutea* (Willd.) Pers. were taken. *Nelumbo lutea* and *Carex emoryi* have similar distributions. I am suspicious of the nativeness of *Nelumbo* at this site.

Distribution: Southern New York to North Dakota and Manitoba, south to Virginia, Arkansas, and Texas.

[22 JUN 1907, E. B. Harger *5141* (NEBC)]

Cyperus echinatus (L.) Wood

Collections of William R. Dudley from North Branford made in 1881 found in Yale's D. C. Eaton Herbarium (YU) have been annotated by Gordon C. Tucker to *Cyperus ovularis* (Michx.) Torr. a synonym for *Cyperus echinatus*.

Distribution: Connecticut and New York to southern Ohio, Illinois, and eastern Kansas, south to Florida and northeast ern Mexico.

[1 JUL 1881, William R. Dudley *s. n.* (YU)]

Rhynchospora scirpoides (Vahl) Griseb.

This was originally reported as *Psilocarya scirpoides* Torr. from a shallow pond margin in Simsbury, Hartford County in 1981 (Mehrhoff 1982b). It has been reported as recently as 1990 at the same site. A 1994 visit to Great Pond yielded no plants of *Rhynchospora scirpoides* and little suitable habitat due to increased water level. Active management is urgently needed at this site. It is listed under *Psilocarya scirpoides* l as an Endangered Species in Connecticut (DEP 1993),

Distribution: Eastern Massachusetts and Rhode Island, nortwest Indiana, southwest Michigan, southeastern Virginia and eastern North Carolina.

[3 SEP 1981, L. J. Mehrhoff *5454* (CONN)]

LILIACEAE

Ornithogalum nutans L. Nodding Star-of-Bethelehem

Ornithogalum nutans was collected from Groton, New London County in 1983 by E. A. Christensen, M. W. Lefor, and R. Piacentini (Christensen and Lefor 1985). A previously unidentified collection of this taxon from East Haddam, Middlesex County was identified by Eric Christensen in 1984. It is questionable whether or not either of these populations are established.

Distribution: Occasionally escaped from cultivation. Native of western Asia.

[20 MAY 1983, E. A. Christensen, M. W. Lefor, R. Piacentini *842* (CONN)]

ORCHIDACEAE

Malaxis bayardii Fernald

Recent annotations of specimens of *Malaxis unifolia* Michx. from the New England Botanical Club Herbarium (NEBC) by Paul M. Catling of Agriculture Canada have shown *Malaxis bayardii* to have occurred in Connecticut. Annotated records come from Enfield, Hartford County and Bolton and Somers, Tolland County. The differences between these two species are slight and easily overlooked (Catling 1991). Other herbarium holdings of *M. unifolia* should be checked. *M. unifolia* is listed as an Endangered Species in Connecticut (Department of Environmentat Protection 1993). *M. bayardii* should be added to the list as a Species of Special Concern until it can be ascertained whether or not it is extant in the state.

Distribution: Massachusetts and New York south to Virginia and North Carolina (Catting 1991).

[1896, Arthur S. Pease *s. n.* (NEBC)]

URTICACEAE

Pilea fontana (Lunell) Rydberg

This taxon has probably been overlooked in the northeast for many years. Seymour (1969) does not include this species. I collected specimens of it from the edge of a wooded swamp in Farmington, Hartford County in September, 1992. This prompted a close scrutiny of material of *Pilea pumila* (L.) Gray from Connecticut at the G. Safford Torrey Herbarium (CONN). It appears that in 1991 Nels E. Barrett, while working on freshwater tidal vegetation along the Connecticut River, had collected specimens of *Pilea fontana* (as *P. pumila*) from East Haddam, Middlesex County.

Distribution: Prince Edward Island to North Dakota and Nebraska south to Indiana and Virginia.

[9 SEP 1991, Nels E. Barrett *00501* (CONN)]

CHENOPODIACEAE

Bassia hirsuta (L.) Aschers.

Individuals of this taxon were reported from a disturbed salt marsh in Mystic, Stonington, New London County in 1979 by William R. Linke, Jr. A small population was growing at the edge of the salt marsh with *Phragmites australis* Cav.) Trin.

Distribution: Massachusetts to Virginia. Native of Europe.

[18 SEP 1980, L. J. Mehrhoff *3333*, with W. R. Linke (CONN)]

Kochia sieversiana (Pall.) C. C. A. Meg.

Connecticut's only record for this species was collected as *Bassia hyssosifolia* (Pallas) Kuntze from sea wrack along the Mystic River in Stonington, New London County, by Gordon C. Tucker in 1981. A specimen of this collection in the New England Botanical Club Herbarium (NEBC) was annotated to *Kochia sieversiana* by the Curator, Ray Angelo, in 1989.

Distribution: Apparently not previously reported from the Northeast. Native of Siberia (Shishkin, ed. 1970).

[17 AUG 1981, G. C. Tucker *1668* (NEBC)]

AMARANTHACEAE

Amaranthus pumilus Raf. Seabeach Amaranth

An 1893 specimen of this species, collected in New London, New London County, has recently been located in the New York State Museum. The label has no additional locality information. This species is listed as a Threatened Species by the U. S. Fish & Wildlife Service (USFWS 1993) and as a Connecticut Species of Special Concern (DEP 1993).

Distribution: Massachusetts to North Carolina.

[11 JUN 1893, *sine* collector (NYS); the specimen originally from Union college]

CARYOPHYLLACEAE

Sagina japonica (Sw.) Ohwi

This species was first reported from a stairwell in New London, New London County in 1988 by Virginia Magee.Collections were determined to be *Sagina japonica* by Garrett E. Crow (Mitchell and Tucker.1991). It may be overlooked (cf. Gleason and Cronquist 1991, Mitchell and Tucker 1991) and should be sought elsewhere.

Distribution: Massachusetts, Connecticut, and New York. Native of Japan and China.

[5 JUL 1988, Virginia L. Magee *88-33* (NCBS)]

PAPAVERACEAE

Glaucium flavum Crantz

Glaucium flavum is occasionally adventive in southern New England. A specimen in the G. Safford Torrey Herbarium (CONN) was collected in Groton, New London County in 1933. *Glaucium flavum* appears to persist on sandy shores of nearby eastern Long Island although there is some confusion as to whether it is an annual, biennial, or perennial. It is surprising that more seeds from the New York populations do not become established along the eastern Connecticut shoreline.

Distribution: Massachusetts to Virginia, and occasionally inland to Michigan. Native of Europe.

[6 JUL 1933, K. P. Jansson *s. n.* (CONN)].

FUMARIACEAE

Corydalis bulbosa Pers.

This early spring ephemeral was first reported in Connecticut from a wooded bank near a road and along an abandoned rail road right-of-way in Salisbury, Litchfield County in 1982 by H. Lincoln Foster and me. Photographs, but no specimens, were taken at that time (29APR 1982). It appeared to be well established. Although the source of the original plants is not known, we suspected that they may have come from a compost heap a dozen meters away. This seems likely given that the seeds are readily dispersed by ants (pers. obs.) and this taxon has proved to be troublesome by virtue of its invasive nature in some gardens (W. E. Brumback pers. comm.). However, no check of the compost pile was made as the property was heavily posted. The site was revisited in 1992 and the plants appeared to be persisting but the numbers of observed individuals seemed to have declined. The long-term persistence of this taxon at this station is questionable.

Distribution: Garden escape. Native to central Europe (Bailey 1949).

[11 MAY 1992, L. J. Mehrhoff *15461* (CONN)]

BRASSICAEAE

Bunias orientalis L.

This species was first observed in Ridgefield, Fairfield County in 1989 by D. Norris. . A second population was noticed in Goshen, Litchfield County in 1994. This population is uncomfortably close to the entrance to an exclusive country club and may have been planted and escaped. It is unclear whether or not *Bunias orientalis* will become established in Connecticut. There are collections from Rockland County, New York at the New York Botanical Garden.

Distribution: Occasional in the eastern United States. Native of Europe.

[5 JUL 1989, David Norris *s. n.* (CONN)]

Teesdalia nudicaulis (L.) R. Br.

Teesdalia nudicaulis was first reported in Connecticut from a roadside in New London County in 1985 by Robert J. Craig and me. It appears to be well established at this site but apparently not spreading far beyond the intersection where it was first observed.

Distribution: Occasional in the United States. Native of Europe.

[9 MAY 1985, L, J. Mehrhoff *11255* (CONN)]

ROSACEAE

Agrimonia microcarpa Wallr. Low Agrimony

Genevieve J. Kline, in working on her treatment of *Agrimonia* for the Flora of North America, annotated two specimens in the New England Botanical Club Herbarium (NEBC) as this species. These had been collected in East Granby, Hartford County and Stamford, Fairfield County. Both had been previously identified as *Agrimonia striata* Michx. Other herbaria should be searched for this more southern taxon.

Distribution: New Jersey and Pennsylvania to Florida and Texas.

[25 JUN 1916, Perley Spaulding *s. n.* (NEBC)]

FABACEAE

Lespedeza cuneata (Dumont) G. Don

The first Connecticut report of this species came from the side of southbound Interstate I-95 in Groton, New London County in 1978 by William R. Linke, Jr. It has since been collected along interstate highways in Hartford, Middlesex, Windham, and Tolland Counties. Perhaps it was introduced as a component of a seed mixture used in hydroseeding roadside embankments. It appears to be well established and spreading at most sites. Volunteers should be watched for away from highway roadsides.

Distribution: Southeastern United States north to Long Island, New York and Connecticut. Native of eastern Asia.

[25 SEP 1978, W. R. Linke, with L. J. Mehrhoff *s. n.* (CONN)]

Lespedeza striata (Thunb.) Hook. & Arn. Japanese Clover

Lespedeza striata was first reported from a roadside in Groton, New London County in 1991. The source of the original plants at this site is unclear but it may have been introduced to stabilize roadsides. This species appears to be well established and spreading at this station.

Distribution: Gulf states north to Kansas, Indiana, and Connecticut. Native of eastern Asia.

[3 OCT 1990, L. J. Mehrhoff 14075 (CONN)]

Pueraria lobata (Willd.) Ohwi Kudzu-vine

The first Connecticut specimens of this species were taken in Fairfield, Fairfield County in 1928 by Edwin H. Eames. The labels read "Fence-row bordering field of Phleum pratense." It appears that he again visited the Fairfield to collect Kudzu in 1947, this time in the company of J. J. Neale. Neale collected another specimen (this time in bud) from Fairfield on which he wrote, "Another colony in 1928 by E. H. Eames." A 19 AUG 1947 specimen from Fairfield collected by J. J. Neale at the Herbarium of the Connecticut Botanical Society (NCBS) reads,"On walls and spreading for yards into field. Benson Road". It is not clear if these records represent one Fairfield population or two. Lauren Brown collected this species in 1978 in New Haven, New Haven County.*Pueraria lobata* was well established at this site. At that time, lianas reached the top of a four story building, and persisted for a number of years (L. Brown pers. comm.). It appears to have become well established at this site in spite of attempts to eradicate it. Kudzu is also established on nearby Fishers Island, Suffolk County, New York. It should be watched for anywhere along the Connecticut coast. It may not become established far from Long Island Sound.

Distribution: Southeastern states north to New York and Connecticut. Native of Japan.

[30 JUN 1928, E. H. Eames *s. n.* (CONN)]

Strophostyles leiosperma (T. & G.) Piper

This species was reported from an abandoned gravel pit in Milford, New Haven County in 1990 by William Moorhead. *Strophostyles leiosperma* may have been introduced where it occurs, to stabilize gravel banks, but appears to be established and spreading (W. Moorhead pers. comm.). This species has recently been reported from Cape May County, New Jersey by David Snyder (1990). He questions its nativeness at the New Jersey station.

Distribution: Ohio to Wisconsin and North Dakota, south to Florida and Texas.

[20 SEP 1990, W. Moorhead *90-01-0179* (CONN)]

GERANIACEAE

Geranium nepalense Sweet var. **thunbergii** (Sieb. & Zucc.) Kudo

The first report of this taxon appears to be from a roadside in New Milford, Litchfield County in 1981. That same year, the late H. Lincoln Foster had this species as a weed in his gardens at his home "Millstream" in Falls Village, Canaan,Litchfield County. The source of his material was unknown to him but it probably arrived with nursery material. This is an aggressive weed which easily spreads by seeds. Tolland County specimens are volunteers from seeds unintentionally introduced into Willington from Litchfield County by way of Coventry, Tolland County. This taxon has become a persistent pest, even in mowed lawns. It should be assiduously sought out and removed before it becomes established.

Distribution: Massachusetts. Native of eastern Asia.
[27 AUG 1981, L. J. Mehrhoff *5252* (CONN)]

EUPHORBIACEAE

Croton glandulosus L. var. ***septentrionalis*** Muell. Arg.

William R. Linke, Jr. first reported a single individual of this taxon from cinder ballast at the side of a railroad in Mystic, Stonington, New London County in 1978. This individual was destroyed by construction equipment working on a nearby bridge. Seeds were produced, but subsequent visits to the site failed to reveal new plants. I recently identified a specimen of *Croton glandulosus* var. *septentrionalis* from North Haven, New Haven County in 1993. collected by John W. Souther.

Distribution: Tropical America north to Virginia, Indiana, Idaho, and Nebraska, Occasionally adventive farther north.
[10 OCT 1978, L. J. Mehrhoff *2387* (CONN)]

RHAMNACEAE

Rhamnus citrifolia (Weston) Hess & Stearn

Individuals of this taxon were first reported by Joe D. Pratt (1980) as *Rhamnus davurica* Pallas in 1976 from an overgrown old field in West Hartford, Hartford County. Label information states that numerous individuals were observed with many producing fruit. The species was extant at the same site as recently as 1986. The commonly used epithet *davurica* was replaced with the epithet *citrifolia* in 1979.

Distribution: Occasional within the Northeast. Native of northeastern Asia.

6 AUG 1978, H. E. Ahles *86054* (MASS)]

HALORAGACEAE

Myriophyllum asiaticum (Vell.) Verdc. Parrotfeather

This species was originally collected on 12 SEP 1946 as *Proserpinaca palustris* L. in shallow water of West Lake, Guilford, New Haven County by Edwin H. Eames and William I. Starr. It had been filed accordingly in the G. Safford Torrey Herbarium (CONN) until recently when it was accidently noticed as a mis-identification by Donald H. Les. He and I recently visited West Lake, searching in vain for *Myriophyllum aquaticum*. It was not present in collections I made from the lake in 1981. It appears that this species, native to south America, may not have persisted in the colder climates of southern New England. Other herbaria should be checked for collections of this taxon. It may be filed under a synonym, *Myriophyllum brasiliense* Camb.

Distribution: Southern United States north to New York, West Virginia and Missouri. Native of South America.

[14 SEP 1946, E. H. Eames and W. I Starr *12,195* (CONN)]

GENTIANACEAE

Centaurium pulchellum (Sw.) Druce Centaury

This European species was reported from a grassy roadside, well removed from houses, in Canaan, Litchfield County in 1984 by Robert Moeller. It was collected from another roadside in Canaan in 1992.

Distribution: Locally introduced in the Northeast. Native of Europe.

[29 JUL 1984, L. J. Mehrhoff *10401* (CONN)]

CUSCUTACEAE

Cuscuta indecora Choisy

A specimen of *Cuscuta indecora,* originally labeled *Cuscuta coryli* Engelm., was recently determined by Tania Beliz from the University of California at Berkeley [UC]. It had been collected by L. B. Bradley from a dooryard in Wilton, Fairfield County.

Distribution: Illinois to California, south to Florida and South America.

[17 AUG 1940, L. B. Bradley *s. n.* (NEBC)]

LAMIACEAE

Elsholtzia ciliata (Thunb.) Hylander

Elsholtzia ciliata was first collected in Connecticut from an overgrown roadside near the Connecticut River in Cromwell, Middlesex County in 1990 by Claudia Polsky and me. It has recently been collected along the side of a highway in Canton, Hartford County. Tolland County records are of unwanted volunteers from seeds of plants originally brought to Connecticut from Morris County, New Jersey.

Distribution: Quebec, New York, and New Jersey to Wisconsin. Native of Asia.

25 SEP 1990, L. J. Mehrhoff *14007*, with C. Polsky (CONN)]

SCROPHULARIACEAE

Linaria dalmatica L William R. Linke, Jr., Lois Tefft, and Gordon Tucker first reported *Linaria dalmatica* from a roadside in Ledyard, New London County in 1984 (Tucker 1987). It has also been collected from a disturbed site in Torrington, Litchfield County in 1991.

Distribution: Occasional in northeastern United States. Native of eastern Mediterranean region.

[29 MAY 1984, G. C. Tucker *2415A* (NCBS)]

Veronica beccabunga L. Brooklime

This European species was first reported from Great Falls in the Amesville section of Salisbury, Litchfield County in 1980. It did not appear to persist at this site but may well have become established below the falls where similar habitat is extensive. A second population was discovered in 1994 in a brook on the east side of Washining Lake (East Twin Lake) in Salisbury.

Distribution: Sparingly established from Quebec to Michigan and south to New Jersey and West Virginia. Native of Eurasia.

[21 OCT 1980, L. J. Mehrhoff *3417*, with Sarah Fried (CONN)]

ASTERACEAE

Aster xblakei (Porter) House [*Aster nemoralis* Ait. x *A. acuminatus* Michx.]

The first Connecticut record for *Aster* x*blakei* comes from plants growing along a mesic woodland fire road in Pachaug State Forest, Voluntown, New London County in 1982. These were collected by William R. Linke, Richard Blodgett, Edmund Smith, and Gordon Tucker (Tucker 1987). It occurs in nearby Rhode Island.

Distribution: Newfoundland, Quebec, and Nova Scotia south to New Jersey.

[16 AUG 1982, G. C. Tucker *1789* (NCBS)]

Eupatorium album L.

This southern taxon was first reported in Connecticut from thickets and rock outcrops in Groton, New London County in 1981 by William R. Linke, Jr. (Tucker 1987). He also located a second population approximately 1 km away from the first in a similar habitat. Both populations appear to be native and well established and were doing well in 1990.

Distribution: Connecticut to Florida and west to Missis sippi, southern Appalachian Mountains.

[14 AUG 1981, L. J. Mehrhoff *4987* (CONN)]

Eupatorium hyssopifolium L. var. ***laciniatum*** A.Gray

The only Connecticut collection of *Eupatorium hyssopifolium* var. *laciniatum* came from the side of Interstate I-84 in Tolland, Tolland County in 1992. The typical variety of *Eupatorium hyssopifolium* occurs at many sites in the four Connecticut counties adjacent to Long Island Sound. This variety, more typically found to the south of Connecticut according to Gleason and Cronquist (1991), appears never to have been reported from New England. It is noticeably larger than the typical variety. *E. hyssosifolium* var. *laciniatum* has recently been collected in nearby New York (O. Blanchard pers. comm.) The proximity of plants to the highway suggests this taxon should be considered as a ruderal species in Connecticut. It may have been accidentally introduced by recent highway maintenance work in its vicinity. It should be watched for along interstates in Southern New England.

Distribution: Southern New York to Georgia, northern Florida, and Louisiana, occasionally inland to southern Ohio, Kentucky, and Tennessee.

[6 SEP 1992, L. J. Mehrhoff *16202* (CONN)]

Euthamia tenuifolia (Pursh) Nutt. var. ***microcephala*** Nutt.
Coastal Plain Flat-topped Goldenrod

The presence of *Euthamia tenuifolia* var. *microcephala* was brought to my attention in 1981 when Marie Pickhardt, a well known Connecticut plant collector, gave me a specimen she called *Solidago microcephala* that had been collected in Killingworth, Middlesex County that year (Mehrhoff 1982a). A check of the G. Safford Torrey Herbarium (CONN) revealed an earlier collection of *S. tenuifolia* from Groton, New London County, that had been annotated to *S. microcephala* by the late Harry Ahles, and left unmentioned. Sieren (1981) sinks this species into *Euthamia tenuifolia*, giving it no varietal status and effectively removing it from the flora of the state. Because of the similarity with *Euthamia tenuifolia* var. *tenuifolia*, *E. tenuifolia* var. *microcephala* may have been overlooked in our flora.

Distribution: Louisiana and Florida north to Maryland and Connecticut.

[7 SEP 1933, K. P. Jansson *s. n.* (CONN)]

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THE CONNECTICUT GEOLOGICAL AND NATURAL HISTORY SURVEY
AND
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Table 1. Taxa added to the Preliminary Checklist of the Vascular Flora of Connecticut (Dowhan 1979). E=State Endangered, FT=Federally Threatened, SC=State Species of Special Concern

TAXON	First County Record	Year of First Record	Conservation Status
Lycopodiella alopecuroides	New Haven	1906	SC
Lycopodiella xcopelandii	New Have	1907	
Selaginella eclipes	Litchfield	1983	
Osmunda xruggii	Fairfield	1931	
Trichomenes intricatum	Litchfield	1983	SC
Pellaea glabella subsp. glabella	Litchfield	1988	E
Echinodorus tenellus var. parvulus	Hartford	1989	E
Egeria densa	Fairfield	1992	
Aira praecox	New London	1992	
Microstegium vimineum	Middlesex	1990	
Panicum amarulum	Tolland	1983	
Panicum scabriusculum	New London	1989	E
Vulpia myurus	Fairfield	1992	
Carex backii	Litchfield	1988	
Carex emoryi	Middlesex	1907	
Cyperus echinatus	New Haven	1881	
Rhyncospora scirpoides [syn. Psilocarya scirpoides]	Hartford	1981	E
Ornithogalum nutans	New London	1983	
Malaxis bayardii	Tolland	1896	
Pilea fontana	Middlesex	1991	
Bassia hirsuta	New London°	1980	
Kochia sieversiana	New London	1981	
Amaranthus pumilus	New London	1893	SC, FT
Sagina japonica	New London	1988	
Glaucium flavum	New Londonn	1933	
Corydalis bulbosa	Litchfield	1992	
Bunias orientalis	Fairfield	1989	
Teesdalia nudicaulis	New London	1985	
Agrimonia microcarpa	Hartford	1916	
Lespedeza cuneata	New London	1978	
Lespedeza striata	New London	1990	
Pueraria lobata	Fairfield	1928	
Strophostyles leiosperma	New Haven	1990.	

TAXON	First County Record	Year of First Record	Conservation Status
Geranium nepalense var. thunbergii	Litchfield	1981	
Croton glandulosus var. septentrionalis	New London	1978	
Rhamnus citrifolia	Hartford	1978	
Myriophyllum aquaticum	New Haven	1946	
Centaurium pulchellum	Litchfield	1984	
Cuscuta indecora	Fairfield	1940	
Elsholtzia ciliata	Middlesex	1990	
Linaria dalmatica	New London	1984	
Veronica beccabunga	Litchfield	1980	
Aster xblakei	New London	1982	E
Eupatorium album	New London	1981	E
Eupatorium hyssopifolium var. laciniatum	Tolland	1992	
Euthamia tenuifolia var. microcephala	New London	1933	

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THE VEGETATION OF PEQUAWKET BOG, OSSIPEE, NEW HAMPSHIRE

LINDA L. FAHEY AND GARRETT E. CROW

ABSTRACT

Peatlands, while ecologically interesting and abundant in the northeast, have gone largely unstudied in New Hampshire. This baseline study focuses on a vegetation analysis of the vascular flora of Pequawket Bog, Ossipee, New Hampshire. A total flora of 109 species, including *Eriophorum angustifolium*, an endangered plant species for the state of New Hampshire, was documented for the bog. Using stratified random sampling, 287 plots from 10 transects were sampled for percent cover of vascular plant species. Five vegetation cover types and nine subtypes were determined using the computer classification program TWINSPAN. The five cover types include: a *Nymphaea odorata* cover type, a *Carex lasiocarpa* cover type, a *Chamaedaphne calyculata-Woodwardia virginica* cover type, a *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type, and an *Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina* cover type.

Key Words: bog, peatland, plant community, plant classification, New Hampshire, vegetation.

INTRODUCTION

Peatlands occur widely, developing chiefly in cool to cold regions, and often vary considerably in physical character, nutrient status, and vegetation and floristic composition. Gore (1983b) provides a detailed account of peatlands on a worldwide level. As a result of the wide geographic distribution of peatlands, there is a plethora of terms and classification schemes associated with these ecosystems. Moore and Bellamy (1974), Stanek (1977), Worley and Sullivan (1980), Worley (1981), and Gore (1983a) discuss and clarify this often overwhelming aspect of peatland studies. In general,

Figure 1. Aerial photograph of Pequawket Bog, looking north (October, 1991)

peatlands of the northern hemisphere are often referred to as "mires" in Europe (Moore and Bellamy, 1974), "muskegs" in Canada (Stanek, 1977) or simply "bogs" in the United States.

Peatlands may be defined as "three-dimensional portions of the earth's landscape that are wetlands; have organic soils; include the full depth of the organic materials, regardless of origin; include all waters within or on top of the organic materials; and include all organisms living within or atop the organic materials and water" (Worley and Sullivan 1980, pp. 13-14). In this definition the term "wetland" is used as defined by Cowardin *et al.* (1979) for the U.S. Fish and Wildlife Service, and "organic soils" as defined by the U.S. Soil Conservation Service (Soil Survey Staff, 1975).

Peatlands are frequently classified based on hydrology and nutrient status (Sjors, 1959; Jeglum *et al.*, 1974; Moore and Bellamy, 1974; Worley and Sullivan, 1980), and two major classes are typically distinguished: ombrotrophic and minerotrophic peatlands. Ombrotrophic peatlands receive all their nutrients and water through precipitation only. Consequently, these peatlands are very poor in nutrients and are very acidic. Minerotrophic peatlands, conversely, receive nutrients and water from both surface runoff and groundwater as well as from precipitation. Because the water entering has run over and percolated through mineral soils, these peatlands tend to be relatively nutrient rich and typically less acidic. The amounts and quality of these nutrients vary greatly from one geographic location to another due to a number of factors, including bedrock, soil characteristics, and topography (Gorham, 1956, 1957).

A fundamental distinction is also made between bogs and fens when classification is based on hydrology and nutrients. "True" bogs are strictly ombrotrophic, and the vegetation is typically dominated by *Sphagnum* spp., low ericaceous shrubs, and scattered conifers. Fens, on the other hand, are minerotrophic peatlands and the vegetation is largely dominated by sedges and grasses, with *Sphagnum* spp. functioning in a subordinate role.

While such classification systems appear useful, it is often difficult to classify certain peatlands satisfactorily into one class or the other. This is especially true for kettle-hole or basin peatlands, where nutrient status and hydrology change through successional development (Crum, 1988). At the base of the upland there tends to be a strong minerotrophic influence, yet further away from the edge the peat mat may be essentially ombrotrophic, as the inflowing of waters through the peat is impeded.

Damman and French (1987) prefer not to utilize the term bog in the strict sense, based on the fact that weakly minerotrophic fens are floristically similar to the vegetation of ombrotrophic peatlands, and have few floristic similarities to nutrient-rich fens. In a community profile of peat bogs of the glaciated northeastern United States their term "bog" is used to refer to "peatlands with a well-developed moss carpet dominated by *Sphagnum*" (Damman and French, 1987, p. 1). Other recent ecologists who do not restrict their use of the term "bog" solely to ombrotrophic peatlands include Golet and Larsen (1974), Jeglum *et al.* (1974), Rawinski (1984), and Sperduto (1994).

Damman and French (1987) treat peatlands as landforms and base the divisions on the nature of the water that controls their development. In this scheme four major types are recognized: 1) limnogenous, 2) topogenous, 3) ombrogenous, and 4) soligenous. Limnogenous peatlands occur along lake-margins and slow flowing streams. Topogenous peatlands develop in sites where there is an accumulation of water, and are maintained by a permanent ground water table or seepage; these include kettle hole bogs. Ombrogenous peatlands include raised bogs which form independently from ground water or seepage, and are restricted to humid, cold temperate climates. In eastern North America these occur from northern Maine to Nova Scotia and western Newfoundland. Soligenous peatlands are dependent on minerotrophic seepage water, and are found in regions with high precipitation and less evapotranspiration. These include sloped fens.

Sperduto (1994) classifies peatlands in New Hampshire into three general categories based on nutrient and pH levels: 1) bogs, 2) acidic fens, and 3) calcareous fens, as well as three broad climatic influences: coastal/southern, boreal/transitional, and alpine/subalpine. Rawinski (1984) classifies as bogs, ombrotrophic to weakly minerotrophic peatlands, and distinguishes between level and raised bogs. Fens, on the other hand, are treated in this classification as peatland communities influenced by seepage waters with alkalinity ranging from low to high. A distinction is also made between calcareous and acidic fens, and whether each is sloping or level.

Although it is often the goal to classify a particular peatland into one specific category, in reality this is not an easy task. It is usually better to treat these ecosystems as peatland complexes comprised of different zones, each with differing nutrient levels and plant associations.

The importance of water chemistry in relation to vegetation in peatlands has been demonstrated in numerous studies (Bay, 1967; Heinselman, 1970; Jeglum, 1971; Moore and Bellamy, 1974; Vitt and Slack, 1975; Schwintzer, 1978, 1981; Wells, 1981; Schwintzer and Tomberlin, 1982; Vitt and Bayley, 1984). Patterns of plant associations in the successional development of kettle-hole peatlands have been shown to correlate strongly to variations in pH (Crow, 1969; Vitt and Slack, 1975; Vitt and Bayley, 1984; Dunlop, 1987).

An important source of acidity in peatlands is the activity of *Sphagnum*. It has been well documented that these mosses have the ability to actively acidify their environment through the process of cation exchange (Clymo, 1963, 1964; Craigie and Maass, 1966), the site of exchange being an unesterified polyuronic acid (Clymo, 1963). Other important sources of acidity include sulfuric and humic acids (Mitsch and Gosselink, 1986). However, "acid rain" apparently does not function as an acidifying agent in peatlands. This acidic input is apparently negated by an increase in alkalinity by sulfate reduction and nitrate uptake (Hemond, 1980).

Numerous descriptive studies have focused on the floristics and phytosociology of peatlands. Some include: Heinselman (1963, 1970) in northern Minnesota; Janssen (1967) in northwestern Minnesota; Conway (1949) in central Minnesota; Hansen (1933) in the driftless area of Wisconsin; Rhodes (1933) in the drift-covered area of Wisconsin; Gates (1942) in northern lower Michigan; Transeau (1905, 1906), Brewer (1966), Crow (1969), and Keogh and Pippen (1981) in southern Michigan; Dansereau and Segadas-Vianna (1952) in eastern Canada; Sjors (1959, 1963) in the Hudson Bay Lowlands, and Attawapiskat River in northern Ontario, respectively; Wells (1981) in Newfoundland; Damman and French (1987) in the glaciated regions of eastern United States; Dunlop (1987) in southern New Hampshire; and Montgomery and Fairbrothers (1963) in New Jersey.

While peatlands are a common and interesting component of the New England landscape, relatively few detailed studies on the major plant cover types of these ecosystems have been conducted. This is especially true in New Hampshire. Johnson (1985) provides a broad overview of peatlands in New England. In Massachusetts, Motzkin and Patterson (1991) investigated vegetation patterns of a moat bog in relation to basin morphometry, Hemond (1980) investigated the biogeochemistry of Thoreau's Bog in Concord, while Swan and Gill (1970) studied the role of *Chamaedaphne calyculata* in the succession of an artificially made kettle hole bog. In

Maine, Worley and Sullivan (1980) and Worley (1981) have focused on classification, while in a northern Vermont peatland complex, Osheyack and Worley (1981) investigated primary production. In New Hampshire, Barrett (1966) studied succession in a southern New Hampshire peatland in relation to physical and edaphic factors. Other peatlands of the state have been used in palynological studies which have focused on post-glacial vegetation during the Holocene (Kraus and Kent, 1944; and Davis *et al.*, 1980). But only one other detailed study of New Hampshire peatland vegetation has been published (Dunlop, 1987).

The purpose of this study is to describe and map the vegetation cover types of Pequawket Bog and to add to our overall base-line information on the vegetation and floristic composition of peatlands in New Hampshire.

STUDY AREA

Pequawket Bog is located in the Town of Ossipee, near the Effingham town line, in Carroll County, New Hampshire. While it has no official name, Pequawket Bog is referred to herein as such because of the historical influence of the Pequawket Indians in the area (Cook, 1989), and its proximity to Pequawket Trail road. Pequawket Trail was originally used by the Pequawket Indians to travel between the regions of Ossipee and Conway (Ruth Loring, pers. comm.). This peatland complex is situated between Long Sands Road and Pequawket Trail Road, off of State Route 25 at 43° 47' N. Lat., 71° 06' W. Long. It lies just southeast of Ossipee Lake at an elevation of approximately 123.7 meters above sea level (406 ft.). The size of the peatland is approximately 9.9 hectares (24.4 acres), including a 2.8 hectare (7 acre) pond. Hellquist (1971) conducted a survey of the aquatic plants of Ossipee Lake and its associate bays, but did not include

Pequawket Bog.

Although it is referred to as a bog, it is more appropriate to classify Pequawket Bog as a peatland complex, as it clearly has two very different zones with a peat substrate, each with a unique floristic character. On the west of the pond is a sedgy meadow, or level fen (Figure 1). The south, east and southwest sides of the pond are characterized as having a more typical bog flora with *Sphagnum* spp. and low ericaceous shrubs dominating.

The upland soils in the general area surrounding the two peatlands are of glacial outwash origin, and are part of the Hinckley-Windsor-Deerfield association characterized as "nearly level to very steep, excessively drained and moderately well drained gravelly and sandy soils; on terraces, kames, and eskers" (Diers and Vieira, 1977, p. 4). The Greenwood-Chocorua-Namburg association is more typical of the lower lying areas and is defined as "nearly level, very poorly drained organic soils and somewhat poorly drained and poorly drained sandy soils; along broad drainageways and depressions" (Diers and Vieira, 1977, p. 5).

The upland area along the eastern border of Pequawket Bog fits the concept of excessively drained soils of the Hinckley series, that are characterized as gravelly loamy sands. The esker to the southwest of the pond in Pequawket Bog is of the Windsor series and is a loamy sand.

The soil within the bog is classified as a Greenwood mucky peat, which is characterized as organic soil composed of partly to well decayed herbaceous and woody material. This organic layer may range from 50 inches to over 10 feet, with an underlying layer of sand, gravel, silt, or loam. According to the Carroll County soil survey (Diers and Vieira, 1977), the area encompassing Pequawket Bog is classed as a fresh water marsh, and broadly defined as a land type covered by shallow water most of the time, found around edges of lakes and ponds and also in depressions that are ponded much of the year. This assessment has been incorrectly applied to the entire peatland complex. While it may be descriptive of the sedgy meadow to the west of the pond, it has been inappropriately applied to the areas south and east of the pond. These are clearly Greenwood mucky peat.

Based on interpretation of the Ecologic Map and Structure Sections of the Ossipee Lake Quadrangle, New Hampshire" (Wilson, 1969) the bedrock which underlies the glaciofluvial deposits around the bog appears to be Conway Granite of the New Hampshire Plutonic Series, which dates back to the Middle Devonian. This rock is generally characterized as: a "medium grained, light-colored, equigranular and contains plagioclase with a composition of about An_{20}, microcline, quartz, biotite, and Muscovite" (Wilson, 1969, p. 26).

The climate in this area can be characterized as having relatively mild summers, cold winters, and abundant rainfall (Diers and Vieira, 1977). The climate is considered continental, mainly influenced by westerly winds, but because of the relative proximity to the Atlantic ocean there is increased precipitation in the fall and winter. Low spots, especially peaty soils, are more frost prone on cold clear nights. The climatological data presented were recorded at the weather station in Conway, approximately 15 miles north of the bog, and are representative of areas within the county at lower elevations. Temperature fluctuations in Carroll County are prone to frequent changes, as the county lies in a region where weather systems tend to alternately bring in warmer and colder air.
Weather records (Diers and Vieira, 1977) showed an average annual temperature at Conway (elevation 145 m) of 6.3 °C (43.3 °F), with average annual maximum and minimum temperatures of 13.4 °C (56.1 °F) and -0.8 °C (30.6 °F) respectively. The average annual extreme maximum is 35.6 °C (96 °F) and extreme minimum is -32.2 °C (-26 °F). July is the

warmest month averaging 19.7 °C (67.5 °F), with a mean daily maximum of 27.4 °C (81.4 °F) and a mean daily minimum of 12 °C (53.6 °F). The average extreme maximum recorded for July was 33.9 °C (93 °F) and extreme minimum was 3.9 °C (39 °F). January is the coldest month averaging -8.3 °C (17 °F), with a mean daily maximum and minimum of -1.3 °C (29.7 °F) and -15.4 °C (4.3 °F), respectively. The average extreme maximum is 8.3 °C (47 °F) and minimum is -30 °C (-23 °F).

Precipitation is, for the most part, evenly distributed throughout the year, however there tends to be a slight increase in the fall and winter. The area receives an average of 116.9 cm (46.01 in.) annually. The monthly averages range from 14.3 cm (5.64 in.) in November to 7.6 cm (3.00 in.) in January.

Average annual snowfall is 287.8 cm (113.3 in.). The amount varies greatly from year to year, but is seldom less than 143.9 cm (56.65 in.) or more than 431.7 cm (169.95 in.). The first snowfall usually occurs in October, and the ground is normally covered with snow from early December to sometime in April. Even in the mildest winters the ground is rarely bare in January, February, and March.

For most of Carroll County, the frost-free season ranges from 105 to 130 days, and may extend to 140 days in more favorable spots. However, in low areas the frost-free period tends to be shorter.

METHODS

A total inventory of the vascular plant species found in Pequawket bog was initiated in mid-April of 1991 and continued through the growing season to mid-October, 1991. Voucher specimens are deposited in the Hogdon Herbarium (NHA), University of New Hampshire. The account of the flora is published elsewhere (Fahey and Crow, in press).

Quantitative sampling of the Pequawket Bog vegetation began in mid-July and continued to late August, 1991. Stratified random sampling (Mueller-Dombois and Ellenberg, 1974) was employed. Nine transects were placed at relatively equal intervals and positioned as to best sample all vegetation cover types (Figure 2). An additional transect was sampled on the west side of the pond, in an area which was particularly disturbed by beaver, and represented an ecotone between two visually distinctive cover types. This area consists of many deep channels and appeared initially to be somewhat unique in its plant associations. Each transect was divided into 10 meter segments. In areas of low growing vegetation (below 1.5 m) two 1 x 1 meter quadrats were located using random numbers. For areas with tall shrubs or trees over 1.5 meters, one 4 x 4 meter quadrat was sampled per 10 meter segment of transect. In the larger plots, two 1x1 meter quadrats in opposite corners were sampled for the lower vegetation. The lower left and upper right corners were used consistently. The data from the two 1x1 meter quadrats were averaged and combined with the taller shrub data for total plot information. This method is similar to Dunlop's (1987) sampling regime of a southern New Hampshire peatland which was found quite effective. A total of 287 quadrats was sampled for absolute percent cover and species composition. Cover is defined as the crown or shoot area of a species projected over the ground surface. This area is expressed as a percent of the reference area (Mueller-Dombois and Ellenberg, 1974).

The vegetation data were analyzed using TWINSPAN (Two-way Indicator Species Analysis), a FORTRAN program (Hill, 1979). TWINSPAN is a polythetic divisive method of classification, which results in an ordered two-way table based on a series of ordinations. This program has been employed by other ecologists in the analysis of peatland vegetation (Slack *et al.*, 1980; Dunlop, 1987; Vitt *et al.*, 1989). Using all the samples, it begins with the "primary" ordination, made by reciprocal averaging. This ordination is essentially divided in half. It proceeds to the next ordination where species that

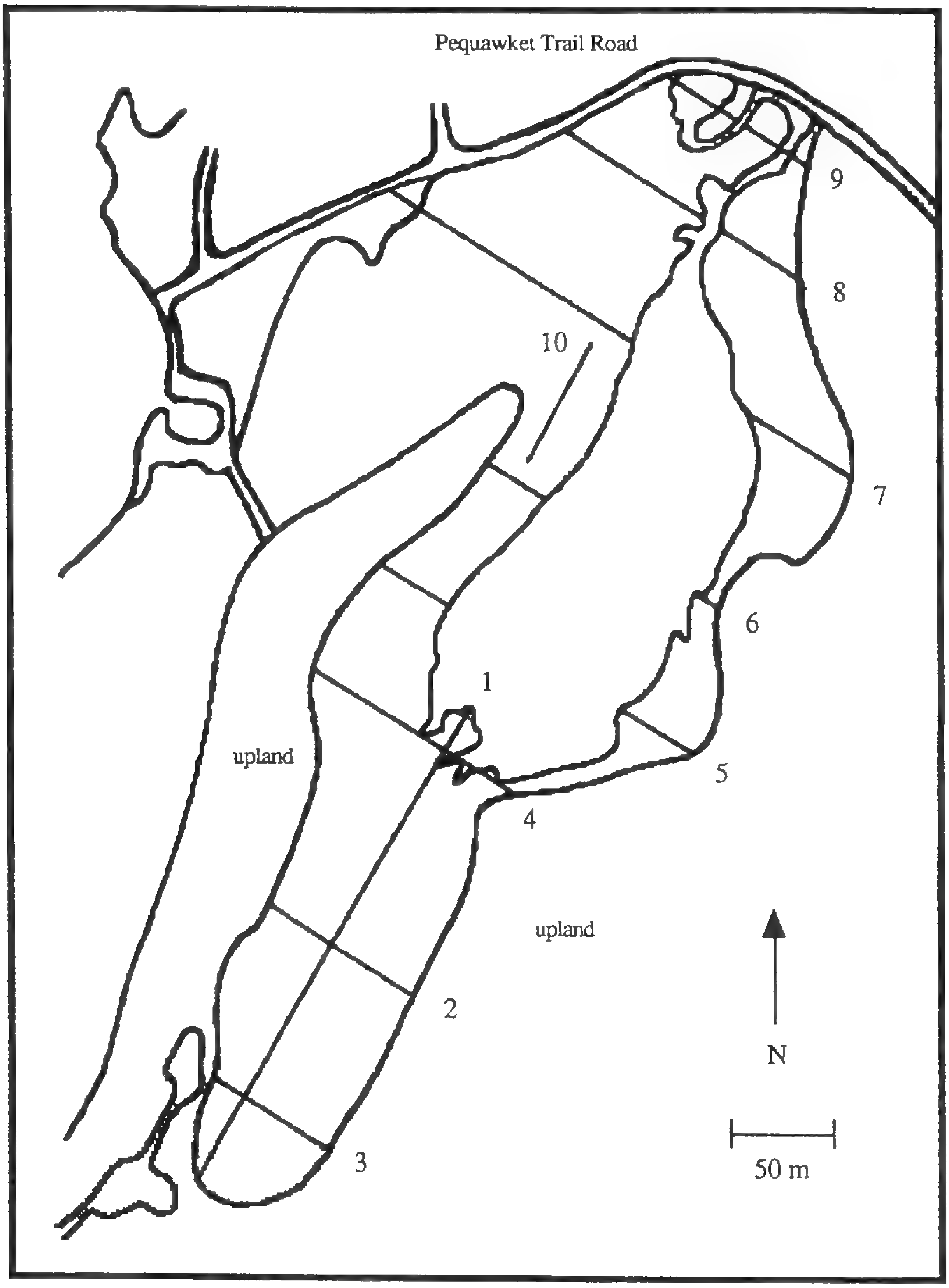

Figure 2. Locations of vegetation sampling transects

show a preference to one side or the other of the initial ordination are identified and used as a basis for this "refined" ordination. These species are referred to as "differential" or "preferential" species, and are said to be showing a preference to certain ecological conditions. The final ordination, the "indicator" ordination, identifies those species that show a particularly high preference to either side of the dichotomy. These species are referred to as "indicator" species. The ultimate dichotomy is based on the refined ordination, while the indicator ordination is simply additional information given to the investigator to further characterize the communities or vegetation types.

The pseudo-species cut levels of 1, 2, 3, 4, 5 represent the Braun-Blanquet cover values 0, 5, 25, 50, 75, respectively, of the Braun-Blanquet system of phytosociology (Hill, 1979). All pseudo-species were available as indicator species, and all cut levels were weighted equally.

In order to plot a profile of the shape of the basin and thickness of organic material, peat depths were measured using a probe of connecting steel rods. At Pequawket Bog, this was measured every 10 meters along transect 1 and transect 8 (Figure 2).

From late-August to mid-September, pH measurements were taken using a VWR Digital Mini pH Meter (model 55). At Pequawkel Bog sites within the peatland that appeared to represent distinct cover types or subtypes were sampled. Five measurements were taken at each site. A total of 25 sites was sampled with a total of 125 samples measured.

Using the TWINSPAN classification as a basis, the average species density (number of species/m^2) for the subtypes and moat cover type were calculated using the data from the 1 m^2 quadrats The means were compared via a one factor ANOVA (Scheffe F-test) for significant differences at the

95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

A flora of 109 species was documented for Pequawket Bog. The inventory included a new record of *Eriophorum angustifolium*, an endangered species for the state of New Hampshire (DRED, 1987), and now known from only two localities. A complete account of the floristic inventory is presented elsewhere as it includes a comparison to the floristic composition of a well-known nearby peatland, Heath Pond Bog (Fahey and Crow, in press).

VEGETATION

The TWINSPAN classification of vegetation for Pequawket Bog resulted in a total of five major cover types and nine subtypes, each with a relatively distinct floristic composition and physiognomy (Figure 3). While some of the subtypes are not large enough to map, they are included in the analysis as they may reflect microhabitats found within the peatland. In general, Pequawket Bog is comprised of an aquatic cover type, a sedge meadow or fen cover type, two "typical" bog cover types dominated by ericaceous shrubs, and a tall shrub or moat cover type.

Figure 3 summarizes the TWINSPAN classification of the 287 vegetation samples into five major cover types and nine subtypes at six hierarchical levels; the number of samples clustered into each is indicated. At the first hierarchical level the aquatic, *Nymphaea odorata* cover type (CT I) is distinguished from the total 287 samples. At the second level this cover type was divided further into two subtypes. From the remaining 267 samples, 83 define the *Carex lasiocarpa* cov-

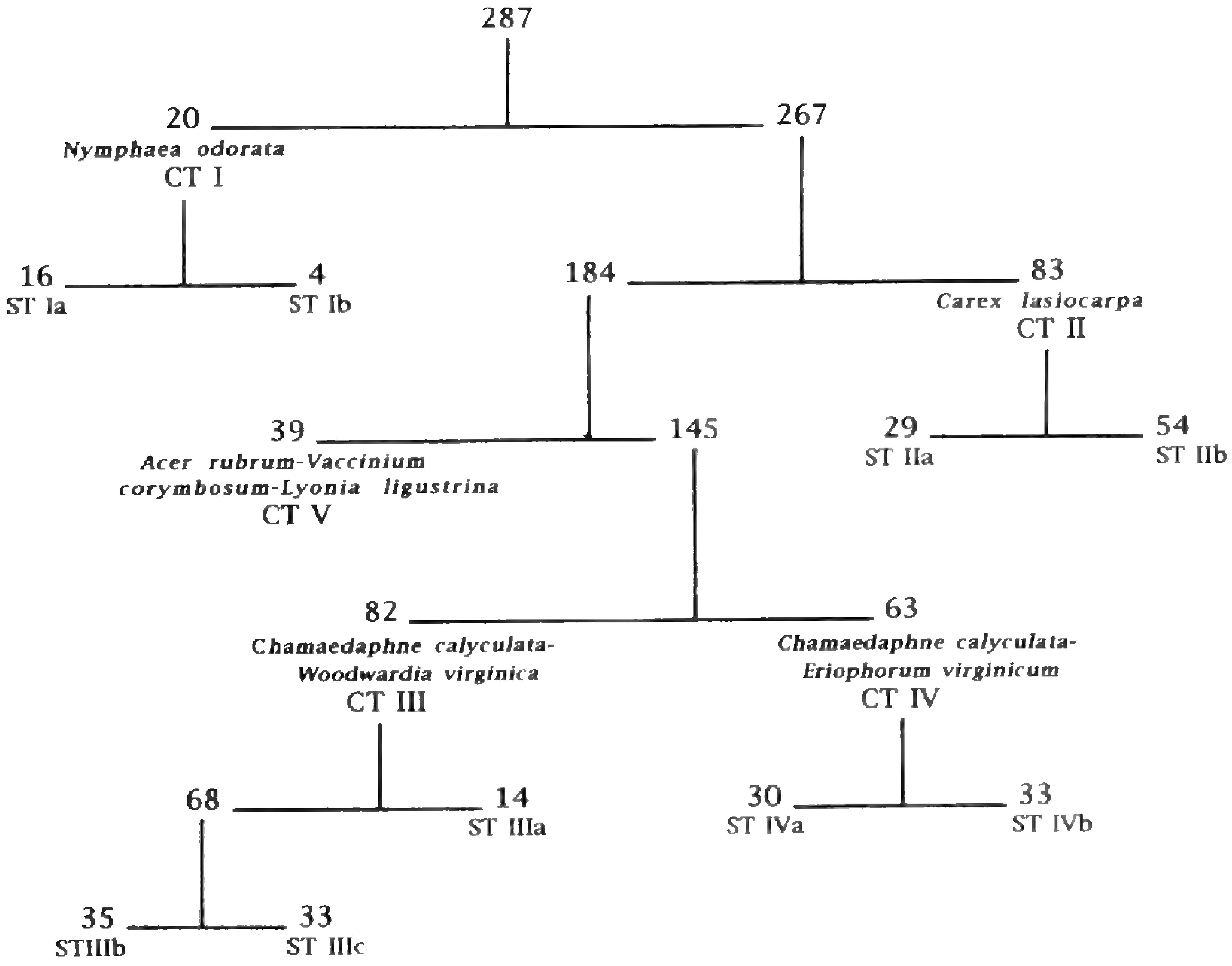

Figure 3. Summary of TWINSPAN analysis showing the separation of 287 quadrat samples into cover types (CT) and subtypes (ST) of Pequawket Bog, and indicating the number of quadrats in each group

er type (CT II) at the second level. This was also divided further into two subtypes. At the third level the remaining 184 samples clustered into *Chamaedaphne calyculata* dominated cover types and the tall shrub, *Acer-Vaccinium corymbosum-Lyonia* cover type (CT V). The *Chamaedaphne calyculata* dominated cover types are classified at the fourth level into the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III) and the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type (CT IV). These two cover types are then divided further into subtypes at the fifth and sixth levels (Figure 3).

The naming of the cover types was based primarily on the combined score of mean percent cover and percent frequently of the most dominant species (see tables 1-5). Percent cover and frequency were also tabulated for each subtype (Fahey, 1993), with subtype data presented here for selected species in the discussion.

It should be noted as well that a submerged zone dominated by *Potamogeton amplifolius* was observed in the deeper waters of the pond, particularly toward the south-central end of the pond. This area was not sampled quantitatively. However, it is worth mentioning as it may be an indication of the amount of accumulated sediments in the basin, and the depth of the water.

In the following discussion the cover types and subtypes determined by TWINSPAN for Pequawket Bog are described. Comparisons are also made with nearby Heath Pond Bog (Fahey, 1993) and other North American level peatlands described in the literature. Because this study focuses on vascular plant species, the importance of *Sphagnum* was not included in discussion, although it is understood that the various species of *Sphagnum* play a critical role in peatland ecosystems. Also, it is realized that indicator species from one geographic region may differ considerably from those of other regions.

Nymphaea odorata Cover Type (CT I)

This cover type is dominated by submerged, floating-leaf, and emergent aquatic plants and occurs around the outer pond margin in varying degrees of width. It also occurs in a pooled area at the northern edge of the peatland (Figure 4). *Nymphaea odorata*, *Utricularia purpurea*, and *Eleocharis robbinsii* are the major constituents with the highest cover and frequency values (Table 1). The TWINSPAN program used these as indicator species of this cover type. Other species recognized by TWINSPAN as preferential to this cover type are *Pontederia cordata, Utricularia intermedia*, and *Brasenia schreberi.* This is also reflected in their relatively high cover or frequency values (Table 1). Other species with more patchy distributions in the pond include *Potamogeton confervoides* and *Nuphar variegata.*

The *Nymphaea odorata* cover type of Pequawket Bog has some floristic similarities to the *Nymphaea-Brasenia* zone reported by Dunlop (1987) in Mud Pond Bog, a southern New Hampshire peatland. However, that zone at Mud Pond Bog also was apparently more depauperate than that found at Pequawket Bog, lacking many submerged and emergent species.

Aquatic zones with floristic similarities have also been reported in Michigan peatlands. Crow (1969) described two aquatic associations around a southern Michigan bog. A *Nuphar-Eleocharis* zone dominated the perimeter of the pond, and a *Decodon* zone on one side. Also present were a number of floating and submerged aquatics, including *Utricularia purpurea*, which is quite dominant at Pequawket Bog as well. *Decodon verticillata* was found in Pequawket Bog, but to a very insignificant extent toward the southwest end of the pond. Similarly, a phytosociologic zone dominated by *Nuphar variegata* and other floating-leaved macrophytes was described by Dansereau and Segadas-Vianna (1952).

Table 1. **Mean percent cover and percent frequency of dominant and subdominant species in the *Nymphaea ordorata* cover type (CT I).**

Species	Mean % Cover	% Frequency
*Nymphaea odorata**	40	95.0
*Utricularia purpurea**	20	60.0
*Eleocharis robbinsii**	14	85.0
Pontederia cordata	8	40.0
Potamogeton confervoides	6	15.0
Brasenia schreberi	2	30.0
Utricularia intermedia	2	30.0
Carex lasiocarpa	2	10.0
Nuphar variegata	1	10.0
Sphagnum spp.	1	10.0

* = indicator species for CTI

Subtype Ia

Within the *Nymphaea odorata* CT, two subtypes could be discerned. The first subtype (ST Ia) is found adjacent to the encroaching mat around the majority of the pond (Figure 4). *Utricularia purpurea* was used by TWINSPAN as the indicator species to distinguish this subtype as it shows a high frequency (75%) in the samples found around the pond as well as the second highest percent cover (25%). Additionally, *Eleocharis robbinsii* showed a high frequency of occurrence (81.3%) and the third highest percent cover (15%). *Nymphaea odorata, Brasenia schreberi, Eleocharis robbinsii*, and *Utricularia intermedia* were also found to be quite frequent in this subtype. It is this mixture of submerged, emergent, and floating-leaved aquatic species which serve as the forerunner of the encroaching mat.

Utricularia purpurea has been reported to be present primarily in bogs which possess a false bottom of muddy, organic sediments (Crum, 1988).

Keough and Pippen (1981) report *Eleocharis robbinsii* present in a southwest Michigan bog, but in an area more characteristic of a moat. There are, however, few reports of the presence of *Eleocharis robbinsii* in other peatlands. This may be due to the fact that descriptions of aquatic communities are often omitted in studies of peatland vegetation because they are not deemed unique to the peatland ecosystem, or, due to their location, are often difficult to sample.

Subtype Ib

The second subtype (ST Ib) is a smaller association found in a pooled area at the northern edge of the peatland along Pequawket Trail Road (Figure 4). This subtype appears relatively depauperate, with a total of four species. But only four sample plots fall into this division. *Pontederia cordata*, with a cover value within STIb of 4% and a 25% frequency, is the most characteristic species of this subtype, and was used by TWINSPAN as an indicator species. *Potamogeton confervoides* was also conspicuous, with a cover value of 30% and a frequency of 50%. *Eleocharis robbinsii,* a plant with a 100% frequency value, seemingly has a low cover value within the subtype (7%) due to the nature of its slender, erect growth form. *Nymphaea odorata* is also a major component of this subtype.

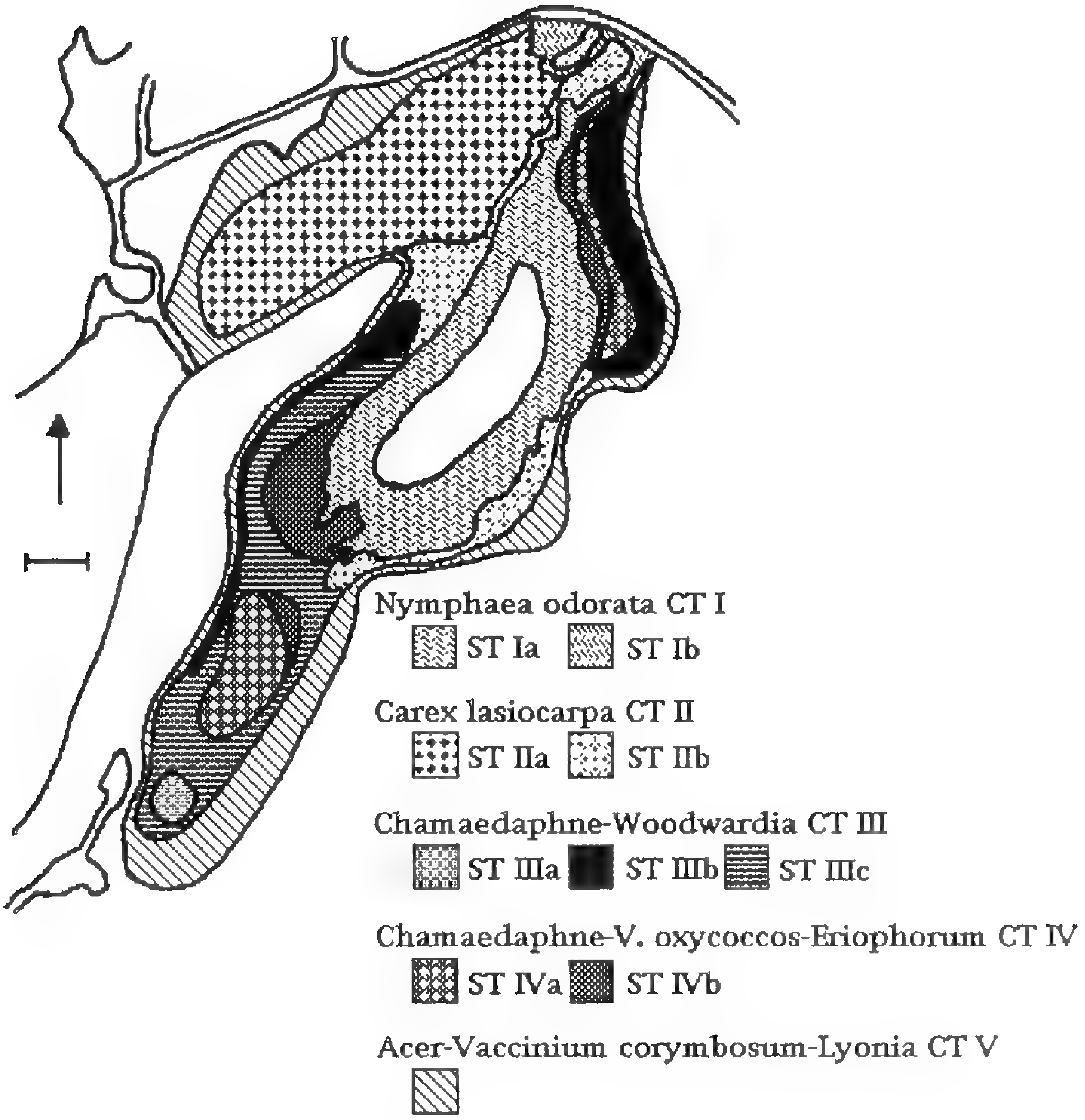

Figure 4. Vegetation map of Pequawket Bog showing five cover types(CT) and nine subtypes(ST). Scale bar equals 50 m

Potamogeton confervoides has been reported as occurring in acidic waters of New England along the coastal plain, and is often associated with *Eleocharis robbinsii* (Hellquist and Crow, 1980). It has been regarded as rare and endangered for other New England states including Connecticut, Maine, and Vermont. However, it is relatively common in New Hampshire and Massachusetts (Hellquist and Crow, 1980)

Carex lasiocarpa Cover Type (CT II)

The *Carex lasiocarpa* cover type, occupying an extensive area in the peatland particularly to the northwest of the pond, forms an open, sedgy meadow, or fen. It is also found around the pond margin in certain areas, presumably serving as the pioneer association of the floating mat (Figure 4). Compared to other areas in the peatland this portion of the mat is noticeably wetter, often with pools of standing water. The 83 samples of the total 287 plots clustered into this cover type are based primarily on the presence of *Carex lasiocarpa*. However, species such as *Vaccinium macrocarpon, Peltandra virginica, Triadenum virginicum, Carex utriculata* (=*C. rostrata* var. *utriculata*), *Sagittaria latifolia, Pogonia ophioglossoides* and *Myrica gale* are classified by TWINSPAN as preferential to this group as well. Mean percent cover and percent frequency of the dominant species in this cover type are listed in Table 2. *Carex lasiocarpa,* dominating this association with 38% cover on average, is a strongly rhizomatous, clonal species, as are the majority of the dominant species in this zone. Although *Myrica gale* and *Chamaedaphne calyculata* are quite dominant, it is largely the importance of the herbaceous species that give this cover type its character. Many of the herbaceous species show a relatively low cover value, but have a high frequency.

While *Carex lasiocarpa* and many of the associated species of this cover type are present at Pequawket Bog, this vegetation type is noticeably absent at nearby Heath Pond Bog (Fahey, 1993). No zone there resembles a sedgy meadow. Instead, the pioneer cover type invading the open water is dominated by *Chamaedaphne calyculata*. The pH of the pond water and shape of the basin probably have an important role in this difference between these two bogs. Vitt and Slack (1975) found pH of pond water to be an important factor

Table 2. Mean percent cover and percent frequency of dominant and subdominant species in the *Carex lasiocarpa* cover type (CT II).

Species	Mean % Cover	% Frequency
Sphagnum spp.	86	100.0
*Carex lasiocarpa**	39	92.8
Myrica gale	15	78.3
Chamaedaphne calyculata	15	71.1
Vaccinium macrocarpon	13	55.4
Peltandra virginica	7	39.8
Sagittaria latifolia	7	39.8
Carex utriculata	5	34.9
Aster nemoralis	3	20.5
Andromeda glaucophylla	3	15.7
Nymphaea odorata	3	12.0
Pogonia ophioglossoides	2	42.2
Triadenum virginicum	2	28.9
Rhyncospora alba	1	30.1
Juncus pelocarpus	1	16.9
Sarracenia purpurea	1	16.9
Symplocarpus foetidus	1	16.9
Utricularia intermedia	1	16.9
Drosera intermedia	1	13.3
Dulichium arundinaceum	1	13.3
Acer rubrum	1	12.0
Vaccinium oxycoccos	1	12.0
Scheuchzeria palustris	1	9.6
Carex stricta	1	8.4
Cladium mariscoides	1	8.4
Eriophorum tenellum	< 1	9.6
Sparganium americanum	< 1	6.0

*= indicator species for CT II

in influencing the species composition of the mat encroaching on the open water in northern Michigan bogs. They found *Carex lasiocarpa* to be the primary species occupying mats encroaching on the open water of bog ponds where the water was relatively alkaline, usually with a pH greater than 7.0, (the Alkaline Lake Edge Zone). In lakes with an acidic pH, usually ranging from 5.0 - 7.0, they found *Chamaedaphne calyculata*, *Andromeda glaucophylla*, and *Rhynchospora alba* showing higher importance values at the mat edge (the Acid Lake Edge Zone).

Crum (1988) reports that in Michigan, *Carex lasiocarpa* dominated cover types occur at the edge of lakes that possess false bottom sediments and that have relatively alkaline open water. The sediments in the pond accumulate over time and eventually lend themselves to colonization by aquatic macrophytes such as *Nymphaea* spp., *Nuphar* spp., and *Potamogeton* spp. *Carex lasiocarpa* rhizomes are able to invade these sediments particularly during drier years when the water level is lower. Vitt and Slack (1975) also make note of the presence of a false bottom in bogs supporting a *C. lasiocarpa* dominated pioneer zone. The accumulation of false bottom sediments is absent around the majority of Heath Pond.

Carex lasiocarpa has been described by many others as an important member of various bog and fen associations throughout the northern United States and Canada, (Gates, 1942; Conway, 1949; Crow, 1969; Heinselman, 1970; Vitt and Slack, 1975; Schwintzer, 1978; Vitt and Bayley, 1984). The presence/dominance of this sedge, as well as many of the other characteristic species of this cover type, have been well documented in other regions to be a reflection of more minerotrophic conditions (Heinselman, 1970; Jeglum, 1971;Vitt and Slack, 1975; Schwintzer, 1978; Vitt and Bayley, 1984; Crum, 1988).

Subtype IIa

Within the *Carex lasiocarpa* CT two cover subtypes could be recognized in the TWINSPAN analysis. The first of these, ST IIa, is found primarily as the association encroaching on the pond behind the aquatic cover type, and in areas that have been disturbed by beaver (Figure 4). Twenty-nine of the 83 cover type samples were classified into this group based on the indicator species identified by TWINSPAN, and reflected by the high percent frequency of these species: *Peltandra virginica* (96.6%), *Triadenum virginicum* (79.3%), *Rhynchospora alba* (65.5%), *Juncus pelocarpus* (44.8%) and *Utricularia intermedia* (44.8%). The dominant shrubs include *Chamaedaphne calyculata* (89.7% frequency) and *Myrica gale* (93.1% frequency). Several other species which have low cover values, but relatively high frequencies, and are important to the characterization of this subtype, include *Nymphaea odorata, Dulichium arundinaceum, Aster nemoralis, Cladium mariscoides, Drosera intermedia, Sarracenia purpurea, Sagittaria latifolia, and Pogonia ophioglossoides* . A relatively higher cover value (9%) for *Nymphaea odorata* in this cover subtype resulted from some plots falling on the edge of the pond or overlapping larger channels.

Two isolated patches of *Menyanthes trifoliata* were also observed in this cover subtype at the extreme ends of the pond, although transects did not intersect these sites. This species has been reported in the literature as typically having a very narrow niche within the peatland ecosystem, and is usually restricted to the lake edge (Dansereau and Segadas-Vianna, 1952) and/or to inflow/outflow channels (Vitt and Bayley, 1984). In northwest Ontario, Vitt and Bayley (1984) describe a *Sphagnum papillosum-Menyanthes trifoliata* community type which shows this pattern, and has some floristic similarities to the *Carex lasiocarpa* cover type, with the dominance of *Carex lasiocarpa* and *Myrica gale*. In northern Minnesota, Heinselman (1970) lists it as an indicator of weakly minerotrophic waters with a pH range of 4.3-5.8.

There are strong floristic similarities of this subtype to the

Alkaline Lake Edge Zone described by Vitt and Slack (1975) for northern Michigan, and to the *Carex lasiocarpa* mats described by Conway (1949) in central Minnesota. Many of the indicator species of this subtype may be reflecting the combined effect of a more minerotrophic condition, with a somewhat higher pH, and a higher water level (Jeglum, 1971). Vitt and Slack (1975) found the distribution of *Rhynchospora alba* to be apparently more influenced by moisture level and degree of shade, rather than by water chemistry.

Subtype IIb

The other subtype recognized by TWINSPAN in the *Carex lasiocarpa* CT is the most extensive of the two subtypes. It occupies a very large area to the northwest of the pond (Figure 4). Fifty-four samples clustered into this subtype, with the TWINSPAN preferential species including *Myrica gale* (70.4% frequency), *Chamaedaphne calyculata* (61.1% frequency), *Symplocarpus foetidus* (25.9% frequency), and *Pogonia ophioglossoides* (48.1% frequency). *Andromeda glaucophylla* and *Sarracenia purpurea* were also shown to have a strong preference for this subtype as well.

The floating mat on this side of the pond is weaker than portions of the mat in other areas of the peatland. In this meadow-like subtype, the dominant sedge *Carex lasiocarpa* has an average percent cover of 48% and 96.3% frequency, with its other major contributor to the mat, *Vaccinium macrocarpon*, with a 19% cover and 74.1% frequency. Other important species that add to the character of the subtype, whether through their cover values or frequencies include, *Myrica gale, Chamaedaphne calyculata, Sagittaria latifolia, Carex utriculata, Pogonia ophioglossoides,* and *Symplocarpus foetidus,* Species that are found more sparsely throughout the mat include *Aster nemoralis, Andromeda glaucophylla,* *Sarracenia purpurea, Vaccinium oxycoccos*, and small saplings of *Acer rubrum. Scheuchzeria palustris* is frequent in localized areas nearing the pond edge. *Eriophorum angustifolium,* an endangered species in New Hampshire, was also sparse, but occurred in less wet areas in this cover subtype.

The *Carex-Vaccinium macrocarpon* zone described by Crow (1969) for a southern Michigan bog has many floristic similarities to this subtype. This zone is also dominated by *Carex lasiocarpa* and *Vaccinium macrocarpon* with other similar species including *Chamaedaphne calyculata* (=*Cassandra calyculata*), *Andromeda glaucophylla, Sagittaria latifolia,* and *Sarracenia purpurea.*

A phytosociologic association dominated by *Carex utriculata* described by Dansereau and Segadas-Vianna (1952) is also similar to this subtype. They found *Carex lasiocarpa* and *C. utriculata* (=*C. rostrata* ssp. *utriculata*) to be a common association, usually in places where peat comes in contact with sand, and where there is a fluctuation in water level over the growing season. Some fluctuation of the water level was seen at Pequawket Bog, however no quantitative measurements were taken.

The *Carex lasiocarpa* CT shows up in the aerial photograph (Figure 3) as a light area; darker regions on its margin are areas where *Chamaedaphne calyculata* is more abundant. It is assumed that over time this will encroach upon the sedge meadow. This, however, will largely depend on the hydrological regime. Crow (1969) reports similar areas where *Chamaedaphne calyculata* seems to be encroaching on the *Carex lasiocarpa-Vaccinium macrocarpon* zone. Succession of this nature has been reported by Gates (1942) in peatlands of Michigan, where floating mats dominated by *Carex lasiocarpa* eventually become grounded by the accumulation of debris peat and are rapidly colonized by *Chamaedaphne* *calyculata*. This succession was not seen, however, in fens where the mat remains free floating.

***Chamaedaphne calyculata-Woodwardia virginica* Cover Type (CT III)**

This cover type, as a whole, is quite prominent in the south and southwest portions of the mat and along the west and south sides of the pond (Figure 4). It may be characterized as an extremely dense community with the vegetation usually not more than 1 meter in height. It is largely dominated by low shrubs and *Woodwardia virginica* . The other herbaceous species found here are present either as scattered individuals throughout this zone or are restricted to patchy locations that are less densely vegetated. *Chamaedaphne calyculata* is the dominant species with a mean percent cover of 36% and frequency of 100%. Codominant *Woodwardia virginiana* was recorded as having a mean percent cover of 27% and a 88.2% frequency (Table 3). TWINSPAN identified *Woodwardia virginica*, *Carex oligosperma*, *Rhododendron canadense*, and *Kalmia polifolia* as indicator species, separating this cover type from the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type (CT IV). *Myrica gale*, *Smilacina trifolia*, *Acer rubrum*, *Aronia melanocarpa* and *Alnus incana* ssp. *rugosa* also showed more of a preference to this cover type over CT IV. *Carex trisperma* is quite dominant in this cover type as well, but it did not show a preference between the two *Chamaedaphne calyculata* dominated cover types. Other woody species important to this cover type include *Kalmia angustifolia*, *Andromeda glaucophylla*, *Vaccinium corymbosum*, *Larix laricina* and *Picea mariana*. Other herbaceous species with a minor role in this zone include *Symplocarpus foetidus*, *Eriophorum virginicum*, *Sarracenia purpurea*, *Calla palustris*

Table 3. Mean percent cover and percent frequency of dominant and subdominant species of the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III).

Species	Mean % Cover	% Frequency
Sphagnum spp.	99	100.0
Chamaedaphne calyculata	38	100.0
*Woodwardia virginica**	26	85.4
*Rhododendron canadense**	11	52.4
Carex trisperma	11	45.1
*Carex oligosperma**	9	48.8
Myrica gale	8	52.4
Smilacina trifolia	5	20.7
*Kalmia polifolia**	4	50.0
Alnus incana ssp. *rugosa*	3	31.7
Acer rubrum	2	35.4
Aronia melanocarpa	2	26.8
Symplocarpus foetidus	2	20.7
Eriophorum virginicum	1	31.7
Kalmia angustifolia	1	17.1
Andromeda glaucophylla	1	13.4
Sarracenia purpurea	1	12.2
Calla palustris	1	9.8
Larix laricina	1	7.3
Vaccinium corymbosum	1	7.3
Picea mariana	1	6.1
Scheuchzeria palustris	1	2.4

*= indicators for CT III

and *Scheuchzeria palustris.*

A cover type somewhat similar is found at Heath Pond Bog (Fahey, 1993) where an extensive mat is by far dominated by ericaceous shrubs, *Eriophorum vaginatum* ssp. *spissum*, and scattered *Larix laricina* and *Picea mariana.* A similar cover type also occurs at Cedar Bog, in Kingston, New Hampshire (Crow, pers. obs.). However, there are few reports of *Woodwardia virginica* as a dominant constituent such as it is at Pequawket Bog and Heath Pond Bog. It has been been described by Damman and French (1987) in peatlands of the glaciated northeastern United States as only an occasional constituent of the *Sphagnum rubellum-Chamaedaphne calyculata* community, which is typically associated with oligotrophic quaking mats bordering lakes. They also describe it as an occasional constituent of the Cinnamon Fern-Highbush Blueberry Thicket. Keough and Pippen (1981) describe the vegetation of two adjacent bogs in southwest Michigan with strong floristic similarities to Pequawket Bog, including the dominance of *Woodwardia* in certain zones. They found it particularly dominant in the understory of a tall shrub zone dominated by *Aronia melanocarpa, Nemopanthus mucronata*, *Vaccinium corymbosum*, *Larix laricina*, and *Rhamnus frangula*. Crow (1969) reports it to be a minor constituent of the *Larix laricina* and *Acer rubrum* zones another southern Michigan bog.

Dunlop reported *Woodwardia* as occasional at Mud Pond Bog, found "on the fringe and in wooded zones particularly on the east and northeast sides of the bog" (Dunlop, 1983, p. 23), in what is described as the *Acer-Nemopanthus* Community Type (Dunlop, 1987). The *Carex trisperma-Kalmia angustifolia* subtype of the *Chamaedaphne* dominated cover type of Mud Pond Bog (Dunlop, 1987) shows some floristic similarities to Pequawket and Heath Pond Bog as well. Spatially they are comparable as well, as they are found between the quaking mat and the moat.

Subtype IIIa

Since the *Chamaedaphne calyculata-Woodwardia virginica* CT covers a rather large area of the peatland, it is not surprising that the TWINSPAN analysis reveals three subtypes. The first subtype, ST IIIa, occupies a relatively small area of the peatland toward the outer edge of the southwest mat (Figure

4). The map depicts this subtype as a circular zone surrounded by ST IIIc. This subtype has a very shrubby character and the area is substantially wetter in certain spots. The TWINSPAN program indicates that *Smilacina trifolia* (85.7% frequency) and *Symplocarpus foetidus* (71.4% frequency) show a high preference for this zone and were thus used by TWINSPAN as indicator species; *Sarracenia purpurea, Alnus incana* ssp. *rugosa*, and *Calla palustris* also show a preference to this subtype.

As in all of the subtypes of CT III, *Chamaedaphne calyculata* is dominant. Here it has a mean cover of 33% and frequency of 100% (Table 6). *Woodwardia virginica* has less cover on average (15%) in this zone compared to the other two subtypes. Other dominant woody species include *Myrica gale, Kalmia polifolia,* and *Alnus incana* ssp. *rugosa. Picea mariana, Rhododendron canadense,* and *Acer rubrum* are also present, but to a lesser degree. Other dominant herbaceous species include *Carex oligosperma* and *C. trisperma.* While *Calla palustris* and *Sarracenia purpurea*, do not appear dominant quantitatively, TWINSPAN indicates they are preferencial to the subtype. *Eriophorum virginicum* is also found occasionally in this zone.

There is no extensive zone at Heath Pond Bog that is directly comparable to this subtype, however, towards the moat running along Rte. 25 there is an area where *Smilacina trifolia, Woodwardia virginica, Chamaedaphne calyculata*, and other ericaceous shrubs are quite prominent.

While this zone is probably too narrowly defined to be directly compared to other described communities, the indicator species of this subtype may be reflecting certain ecological conditions or combinations of these conditions. Typically areas near the moat are influenced more by the mineral rich telluric water than the zones further inward on the mat. It is well documented in other geographical regions that *Alnus* *incana* ssp. *rugosa* is common in the more mineral rich areas of peatlands or in fens (Conway, 1949; Dansereau and Segadas-Vianna, 1952; Heinselman, 1970; Schwintzer, 1981, Vitt and Bayley, 1984; Crum, 1988). *Calla palustris* is often a common species associated with *Alnus* in wet moats (Crum, 1988). *Symplocarpus foetidus* is typical of more nutrient rich, wet areas as well. However, in Michigan, *Smilacina trifolia* is usually described as a subordinate in associations which are largely forested and shady, or at least in the taller shrub zones toward the moat (Gates, 1942; Crum, 1988). Worley (1981) uses the presence of *Smilacina trifolia* as one of the indicators to designate the moat in Maine peatlands.

Subtype IIIb

The second subtype (ST IIIb) is found usually in the sunniest and somewhat wetter areas of the *Chamaedaphne calyculata-Woodwardia virginica* cover type (Figure 4). In the delineation of this subtype from the others, TWINSPAN identified *Carex oligosperma* and *Chamaedaphne calyculata* as indicator species.

Chamaedaphne calyculata and *Woodwardia virginica* dominate with a mean cover of 51% and 26% respectively and both have 100% frequency. *Carex oligosperma* is quite prominent as well, with a mean cover value of 17% and frequency of 71.4%. Other dominant woody species that characterize this subtype include *Rhododendron canadense* and *Myrica gale*, and to a lesser extent *Alnus incana* ssp. *rugosa, Kalmia polifolia, Vaccinium corymbosum, Acer rubrum, Aronia melanocarpa*, and *Kalmia angustifolia*. Other herbaceous species include *Carex trisperma, Eriophorum virginicum, Symplocarpus foetidus*, and *Scheuchzeria palustris*.

Scheuchzeria palustris, interestingly, occurs in certain locations on the mat that are adjacent to the pond, particularly on the east side, but not in the southwestern portion of the bog mat. The species was, however, found on the opposite side of the pond in the *Carex lasiocarpa* CT, especially nearer the pond margin. Another species, *Eriophorum angustifolium*, occasionally found scattered within this subtype, also was found in certain locations of the *Carex lasiocarpa* CT.

Heath Pond Bog (Fahey, 1993) has scattered patches throughout the extensive mat west of the pond which are similar to this subtype, characterized as being less densely occupied by shrubs, with a relatively open and slightly wetter area of Heath Pond Bog. *Eriophorum angustifolium* is is found scattered throughout this mat. However, *Myrica gale* and *Alnus incana* ssp. *rugosa* are not present, nor is *Scheuchzeria palustris*.

Dunlop (1987) does not report any cover type at Mud Pond Bog similar to this. However, Vitt and Bayley (1984) describe an association similar to this in northwestern Ontario. It is dominated by *Chamaedaphne calyculata, Carex oligosperma*, and *Scheuchzeria palustris*, but *Woodwardia virginica* is lacking. That peatland was characterized with an average pH of 4.37 (ranging from 4.2-4.8). They found the distribution of *Scheuchzeria palustris* in the peatland apparently to be unrelated to pH. However, *Carex oligosperma* appeared to be an indicator of oligotrophic habitats with low pH values.

Schwintzer (1981) found *Carex oligosperma* and *Chamaedaphne calyculata* to be the most characteristic species of the "field layer" in northem Michigan bogs which were highly acidic (pH 3.8-4.3) and low in Ca^{++} and Mg^{++} (1.2-3.7 mg/L and 0.3-0.6 mg/L respectively). Vitt and Slack (1975) found *Carex oligosperma* occupying the Acid Lake Edge Zone, the Open Mat Zone and the Closed Mat Zone, however it was most dominant in the zones further back from the lake edge.

Subtype IIIc

The third subtype of the *Chamaedaphne calyculata-Woodwardia virginica* CT is found to be quite dominant in the southern and southwestern portions of the mat, and on the mat along the east side of the pond (Figure 4). It is characterized as being a rather dense, woody zone, and much of it difficult to walk through. TWINSPAN identified *Kalmia polifolia* (69.7% frequency), *Aronia melanocarpa* (51.5% frequency), *Acer rubrum* (54.5% frequency) and *Carex trisperma* (72.7% frequency) as species highly preferential to this subtype. *Vaccinium oxycoccos, Andromeda glaucophylla* and *Kalmia angustifolia* showed a preference here as well. One noticeable character to this subtype is the dominance of *Woodwardia virginica*, with a mean cover of 32% and a frequency of 84.8%. Compared to the other subtypes within the *Chamaedaphne calyculata-Woodwardia virginica* CT, this is the only zone where *Woodwardia virginica* has a higher mean percent cover than *Chamaedaphne calyculata*. Other dominant woody species that characterize this zone include *Chamaedaphne calyculata, Rhododendron canadense, Myrica gale, Kalmia polifolia, Acer rubrum*, and *Aronia melanocarpa*. The dominant herbaceous species include *Carex trisperma* and *Eriophorum virginicum*. Species that play a less significant role, though still important to the character of this subtype, include *Andromeda glaucophylla, Alnus incana* ssp. *rugosa, Kalmia angustifolia, Vaccinium oxycoccos, Carex oligosperma, Smilacina trifolia*, and *Sarracenia purpurea*.

A similar association is found at Heath Pond Bog (Fahey, 1993) on the portion of the mat encircling the pond, between the quaking mat and the moat, and in areas closer to the moat along the bordering highway.

The distribution of *Carex trisperma*, an indicator species, seemed to be particularly related to areas of very firm peat, and a more or less closed canopy. This observation is supported by the findings of Vitt and Slack (1975) who reported that the distribution of this sedge in northern Michigan bogs seemed to be related to shade. The sedge was found to be more abundant in areas where *Picea* and *Larix* became more important. Crum (1988) also reports its abundance enhanced by the shade created by the two conifers, on drier mounds. Vitt and Bayley (1984) describe a *Smilacina trifolia-Ledum groenlandicum-Carex trisperma* community type in Ontario which was characteristically shady as well.

Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum Cover Type (CT IV)

The *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type (CT IV) occurs in regions of the peat mat which are apparently less consolidated, as they have a noticeably more quaking feel to them. Figure 4 shows this zone on the northeast side of the pond between the aquatic cover type and the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III). On the southwest mat CT IV is found roughly in the center of that region, encircled by CT III, and also as the pioneer association encroaching on the pond at the southern and northeast sides. While *Chamaedaphne calyculata* is a dominant of this cover type, it has a much smaller stature than in the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III). It usually does not attain heights much over 30 cm. Compared to CT III this zone is strikingly more open and less shrubby. Because of its openness and low stature of the woody species, Crum (1988, p. 61) refers to similar communities such as this as the "Sphagnum Lawn Community".

The dominant species that characterize this vegetation zone include *Chamaedaphne calyculata, Vaccinium oxycoccos,* and *Eriophorum virginicum* (Table 4). It was the high degree of preference to this zone of the latter two species which TWINSPAN used to classify this cover type from CT III. *Andromeda glaucophylla* showed a preference to this zone as well. *Carex trisperma* is an integral member of this cover type also, but it does not necessarily show a preference to this zone. It is also quite dominant in the *Chamaedaphne calyculata-Woodwardia virginica* cover type, and is found most often in the transition zone between these two cover types. Other subdominant woody species of this cover type are *Myrica gale, Kalmia polifolia, Larix laricina*, and *Picea mariana.* The subordinate herbaceous species include *Drosera rotundifolia, Rhynchospora alba, Woodwardia virginica, Decodon verticillata, Eriophorum vaginatum* ssp. *spissum,* and *Peltandra virginica.* For mean percent cover and percent frequency of these species see Table 4.

Cover types of this nature are very common in peatlands, especially in kettle-hole bogs. In Michigan, Vitt and Slack (1975) describe an Open Mat Zone, adjacent to the edge zone of alkaline lakes, with strong floristic similarities. Along with *Chamaedaphne calyculata, Vaccinium oxycoccos* was the most dominant vascular plant. Its distribution within the bogs was apparently related to non-shaded habitats which were low in pH and cation concentration. These locations also had little change in microtopography, and were fairly wet. Other similarly dominant species included *Kalmia polifolia, Andromeda glaucophylla, Rhynchospora alba, Drosera rotundifolia* and *Eriophorum virginicum.* Although Vitt and Slack (1975) associated this community type with alkalinity of the lake water, the waters of Pequawket Bog's pond are not alkaline. Based on the species present, however, the pond water is probably fairly minerotrophic, and the pH is relatively high (5.69) compared to the other cover types.

Table 4. Mean percent cover and percent frequency of dominant species in the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type (CT IV).

Species	Mean % Cover	% Frequency
Sphagnum spp.	100	100.0
Chamaedaphne calyculata	43	100.0
*Vaccinium oxycoccos**	10	88.9
Carex trisperma	9	38.1
*Eriophorum virginicum**	7	88.9
Andromeda glaucophylla	5	34.9
Myrica gale	3	23.8
Drosera rotundifolia	2	19.0
Picea mariana	2	11.1
Woodwardia virginica	2	11.1
Decodon verticillata	2	9.5
Larix laricina	1	14.3
Rhynchospora alba	1	14.3
Kalmia polifolia	1	12.7
Eriophorum vaginatum ssp. *spissum*	1	7.9
Peltandra virginica	1	7.9

* = indicator species for CT IV

Subtype IVa

Two subtypes were discernable within the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* CT. The first subtype (ST IVa) occupies the center of the back south-southwest mat, and also along the mat on the northeast side of the pond (Figure 4). On the southwest mat, although it is some distance away from the open water of the pond, it still has a noticeable quaking feel to it. The basin profile data of this mat (Figure 5) indicate that this area is the center of a relatively recent closed basin. TWINSPAN found *Carex trisperma, Eriophorum virginicum* and *Chamaedaphne* *calyculata* highly preferential to this subtype over ST IVb. Although *Chamaedaphne calyculata* is dominant in both subtypes it averaged a much higher cover value (55% cover, 100% frequency) in ST IVa in contrast to ST IVb (32% cover, 100% frequency). Other species that show a preference to this subtype include *Kalmia polifolia* and *Larix laricina*.

Chamaedaphne calyculata is the clearly the dominant woody species. Other dominant woody species include *Vaccinium oxycoccos, Larix laricina, Kalmia polifolia,* and *Picea mariana* are also found here, but toward the transition into the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III). The dominant herbaceous species include *Eriophorum virginicum* and *Carex trisperma,* the latter also found more frequently toward the transition into CT III.

Platanthera blephariglottis, rare within the peatland, is found sparsely in this cover type, usually nearing the transition zone between between CT III and this cover type. Scattered individuals were found in the south-southwest mat and on the northeast side of the pond.

Subtype IVb

The second subtype is found in regions of the peatland closer to the pond on the quaking mat (Figure 4), and is often the lake edge association in locations where *Carex lasiocarpa* is not as abundant. It extends back from the edge at varying distances ranging from 0.5 to approximately 40 meters. It is less homogeneous than ST IVa. An increase in abundance and frequency of species such as *Andromeda glaucophylla* (66% frequency), *Myrica gale* (36.4% frequency), *Drosera rotundifolia* (33.3% frequency) and *Rhynchospora alba* (27.3% frequency) distinguishes this subtype from ST IVa. *Eriophorum virginicum* is also quite dominant in this subtype. Other less dominant species found here include *Decodon* *verticillata* and *Woodwardia virginica*, as well as *Peltandra virginica*, which was absent from ST IVa.

Although not represented in the sampling, small patches of a somewhat exclusive association of *Utricularia cornuta, Vaccinium oxycoccos, Drosera rotundifolia, Xyris montana,* and sometimes *Calopogon tuberosus* were present in this subtype, particularly in especially wet and mucky areas. The substrate of these mucky areas was not as consolidated as in other parts of this subtype, and may not support the weight of unsuspecting field botanists. A small localized area, close to the pond on the southsouthwest mat, possesses the same characteristics, and when probed with a peat sampler, was found to be approximately 10 meters deep. An interesting feature to this location in particular was the sizeable population of about 200 individuals of *Calopogon tuberosus*.

A comparable association was found to be quite common at Heath Pond Bog (Fahey, 1993) as well, particularly the narrow floating mat immediately adjacent to the lake-edge.

ST IVb as a whole is also floristically similar to what Dunlop (1987) reported in southern New Hampshire as a *Vaccinium oxycoccos-Rhynchospora alba* subtype, found adjacent to the lake edge of Mud Pond Bog.

The close proximity to the edge probably explains the increased abundance of *Andromeda glaucophylla* and *Myrica gale*, species that reflect, at least in other regions of North America, a weakly minerotrophic condition (Jeglum, 1971; Schwintzer, 1978). Dansereau and Segadas-Vianna (1952) found *Andromeda glaucophylla* to occur often in the wettest regions of the *Chamaedaphne calyculata* dominated association in Canada. As mentioned previously, *Rhynchospora alba* has a distribution in peatlands which seems to be governed by moisture and the intolerance of shade rather than water chemistry (Vitt and Slack, 1975).

Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina Cover Type (CT V)

This cover type is found largely around the outer periphery of the peatland. Typically it extends from the base of the upland out on to the mat in varying widths (Figure 4). Many of its constituents integrade strongly with the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III), but a high preference of *Acer rubrum, Vaccinium corymbosum,* and *Lyonia ligustrina* TWINSPAN distinguishes this cover type. It is dominated primarily by tall shrubs over 1.5 meters in height, and an understory which is quite variable. A moat of standing water is found at the immediate base of the upland, often quite deep in places. Although *Chamaedaphne calyculata* has the highest cover (18%) and frequency (79.4) value, this zone has been named after the taller shrubs based on their relative high cover and frequency in combination with their relative uniqueness to this zone (Table 5).

Other important tall, woody species (>1.5 m) that characterize this cover type include *Alnus incana* ssp. *rugosa, Nemopanthus mucronata, Ilex verticillata, Rhododendron canadense,* and *Aronia melanocarpa. Betula populifolia, Cephalanthus occidentalis* and *Viburnum cassinoides* are found less frequently. Other low growing shrubs include *Myrica gale, Kalmia angustifolia,* and *Spiraea latifolia.* The more typical herbaceous species include *Osmunda regalis, Osmunda cinnamomea, Carex stricta, Symplocarpus foetidus, Carex trisperma, Rubus hispidus, Lysimachia terrestris, Triadenum virginicum, Utricularia intermedia, Drosera rotundifolia*, and *Juncus pelocarpus.*

The moat at Heath Pond Bog (Fahey, 1993) is floristically very similar, except for the shrubby moat area which has been extensively disturbed by beavers. In another New Hampshire bog (Dunlop, 1987) the *Ilex verticillata-Acer-Carex* *canescens* community type occupying the moat shows floristic similarities, but the importance of *Vaccinium corymbosum* and *Lyonia ligustrina* are not as great.

Table 5. Mean percent cover and percent frequency of dominant species in the ***Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina*** cover type (CT V).

Species	Mean % Cover	% Frequency
Sphagnum spp.	63	97.4
Chamaedaphne calyculata	18	79.5
*Vaccinium corymbosum**	12	64.1
*Lyonia ligustrina**	12	59.0
Osmunda regalis	12	30.8
Alnus incana ssp. *rugosa*	9	53.8
*Acer rubrum**	8	74.4
Osmunda cinnamomea	8	23.1
Myrica gale	7	46.1
Nemopanthus mucronata	7	35.9
Carex stricta	7	33.3
Ilex verticillata	7	25.6
Rhododendron canadense	6	59.0
Aronia melanocarpa	4	48.7
Symplocarpus foetidus	4	43.5
Carex trisperma	4	28.2
Betula populifolia	3	20.5
Woodwardia virginica	3	17.9
Cephalanthus occidentalis	3	7.7
Rubus hispidus	2	30.8
Lysimachia terrestris	2	28.6
Kalmia angustifolia	2	25.6
Triadenum virginicum	2	25.6
Viburnum cassinoides	2	23.1
Utricularia intermedia	2	20.5
Drosera rotundifolia	1	23.1
Spiraea latifolia	1	23.1
Juncus pelocarpus	1	20.5

* = indicator species for CT V

Vitt and Slack (1975) reported a tall shrub zone (the Marginal Moat Zone) encircling bogs in northern Michigan. This community type consisted of similar species, but with different abundances. They also noted that this zone appeared to be highly variable, but was primarily dominated by *Ilex verticillata, Nemopanthus mucronata, Viburnum cassinoides*, and occasionally *Osmunda regalis*.

Floristically this cover type strongly resembles the Cinnamon Fern-Highbush Blueberry Thicket described by Damman and French (1987), with some variation. This type of tall shrub thicket occurs in locations with seasonal water-level fluctuations, and that are heavily influenced by minerotrophic water from the surrounding upland or seepage (Damman and French, 1987). The community was also characterized as having a well developed ground layer of vegetation.

Basin Profile

Probings of the peat mat at 10 meter intervals along transect 1 resulted in a profile of the bog basin (Figure 5). The profile shows an apparent basin of a former pond which has been completely blanketed by the bog mat. The basin measures approximately 11 meters at its deepest point. Figure 5 shows a vegetation map of the south and southwest portion of the peatland showing transect 1, and the vegetation types through which it runs, for comparison with the same zones shown on the basin profile. At the deepest part of the basin the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum* cover type (CT IV) occupies a relatively large area, approximately 110 m long; ST IVa occupies the majority of this area, particularly where the basin is deepest. Surrounding this zone is the *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III), an area that corresponds with a more shallow basin. Toward the pond edge the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginianum* CT is represented by ST IVb, corresponding with a basin depth of approximately 2-7 meters. At the outer edge of the mat the *Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina* cover type (CT V) is found

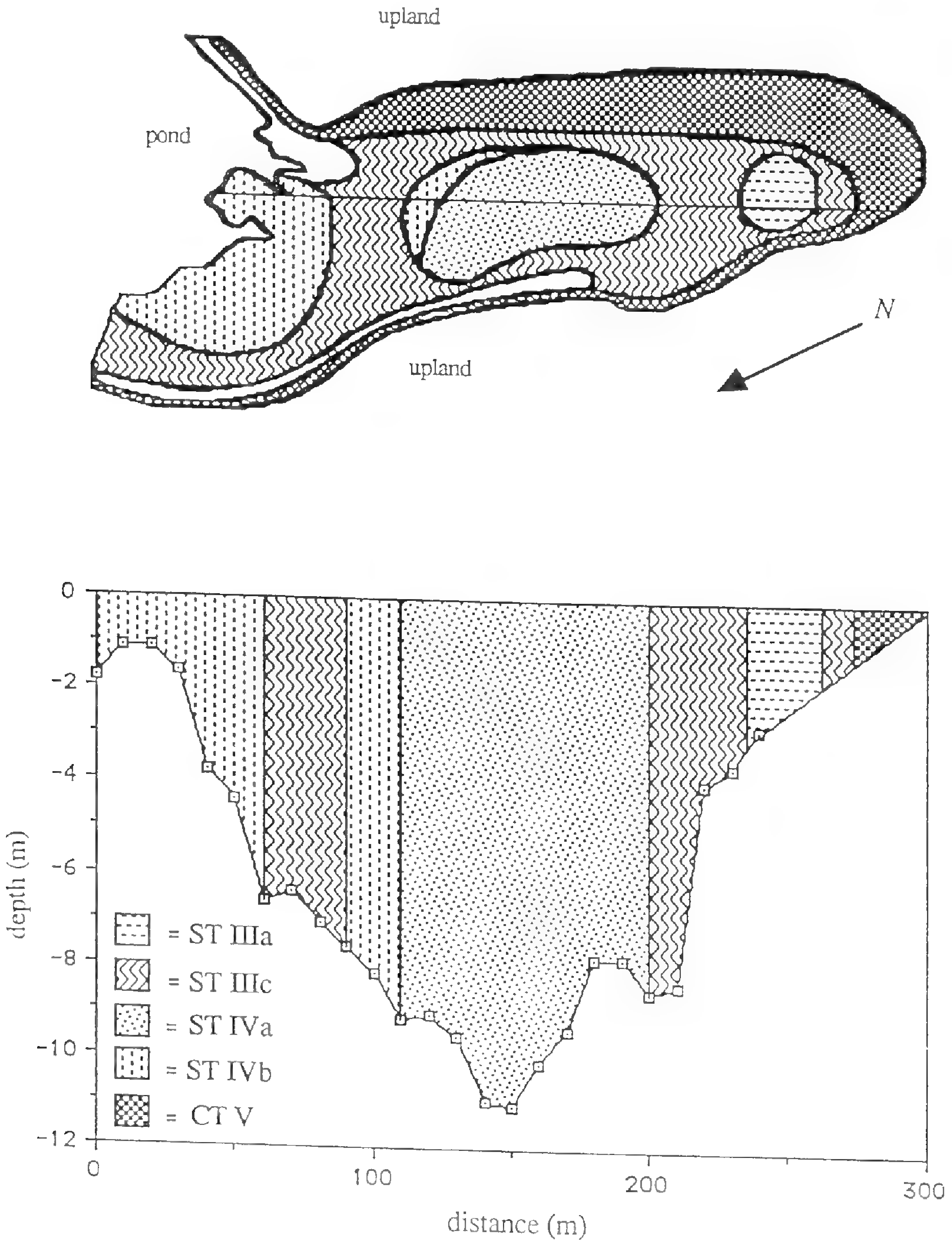

Figure 5. Basin profile (below) along transect 1 at the southwest mat in relation to the vegetation types.

in the areas that show the shallowest probings. This pattern seems to reflect the classic theory of lake-fill, or quaking bog succession.

Motzkin and Patterson (1991) recently described the vegetation patterns in Acadia Bog, a Massachusetts moat bog. They found a correlation of vegetation types to depth of sediment accumulation and distance from shore. Although the species composition of the vegetation types of the two bogs are not comparable, Pequawket Bog likewise shows a similar relationship (Figure 5) in the southernmost portion of the southwest mat.

Probings of the basin depth along transect 8 through the *Carex lasiocarpa* cover type (CT II), showed relatively shallow readings throughout. Depths ranged from 1.0 nearer the edge to 3.5 meters closer to the pond margin. In probing this section the bottom felt like very loose sand.

pH

It has been well documented that pH of the pond and mat waters play an important role in the distribution of species within a peatland (Jeglum, 1971; Vitt and Slack, 1975; Heinselman, 1970; Schwintzer, 1978, 1981; Vitt and Bayley, 1984; and others). Table 6 shows the mean pH values of each cover type.

The overall aquatic *Nymphaea odorata* cover type (CT I) has the highest pH, 5.58. The water of the open pond within ST Ia averaged 5.69. However, the pool at the northern end of the peatland, occupied by ST 1b, was more acidic, averaging 5.37.

On the outer edge of the bog the moat waters of the *Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina* cover type (CT V) are also relatively less acidic than other cover types in the peatland, averaging 5.13. Moat waters are typically less acidic and more mineral rich as a result of the influence of telluric waters entering from the upland.

The pH of the *Carex lasiocarpa* cover type (CT II) averaged 4.55, but there were considerable differences in the pH among its subtypes. ST IIa, adjacent to the open pond water, averaged 5.46, while ST IIb averaged 4.23. This may be due to the relative distance away from an influence of less acidic pond water as well as to an abundance of *Sphagnum* spp. acidifying the mat waters.

The cover types of the south-southwest mat, which appear to have covered an old pond basin (Figure 5), and along the west and northeast sides of the pond, generally show lower pH levels. The *Chamaedaphne calyculata-Woodwardia virginica* cover type (CT III) is less acidic, with a pH of 4.18, than the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginiana* cover type (CT IV) averaging 3.89.

Vitt and Slack (1975) measured pH, as well as cation concentration, along a transect from the pond edge to the base of the upland and found these to be very influential in the distribution of plant species and communities. The pH was highest in the pond water and at the alkaline mat edge. As the distance increased from the water's edge, across the mat, the pH dropped dramatically, but showed an increase again near

.and in the moat water. A similar pattern was observed for Pequawket Bog
While the pH values throughout the Pequawket peatland are very low over all, this is to be expected for regions with noncalcareous bedrock. Lakes of New Hampshire have naturally acidic conditions, as a result of surrounding acidic bedrock, such as granite.

Species Density

Some ecologists have investigated the variations in species density, or richness, within and between peatland ecosystems (Heinselman, 1970; Schwintzer, 1981), and have attempted to explain the differences observed.

At Pequawket Bog, the mean species density (number of species per m^2) was calculated for each subtype and the moat cover type (Figure 6). The *Nymphaea odorata* CT is quite depauperate with ST Ia and ST Ib averaging 4.4 (± 1.4) and 4.6 (± 1.5) species/m^2 respectively. Conversely, within the *Carex lasiocarpa* CT, ST IIa has a noticeably higher species density of 11.2 (+ 2.9), compared to all the other cover types and subtypes. Of the *Chamaedaphne calyculata* dominated subtypes the ST IIIa has the highest species density with 8.9 (± 1.9) on average, while ST IVa averaged only 4.2 (± 2.7) species/ m^2 The *Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina* CT, the tall shrub zone occupying the moat, averaged 8.4 (± 2.7) species/ m^2.

A possible explanation for the differences in species density between subtypes may be found when applying Grime's (1979) model for the control of species density in herbaceous vegetation. Although this model is for herbaceous vegetation and the validity of applying it to a woody community may have its limitations. This model proposes that vegetation in the presence of moderate levels of either stress or disturbance, or both, has an "increase in species density by reducing the vigor of potential dominants, thus allowing subsidiary species to co-exist with them" (Grime, 1979, p. 162). As these stresses or disturbances approach extremes, a decline in species density is found. Under extreme conditions only a small number of species appear to be able to survive.

Table 7 compares the vegetation types based on statistically significant differences in species density. Because many of the environmental parameters which could influence a stress or stimulus on the component species of the vegetation in the peatland were not sampled, and because levels of disturbance where not quantified, reasons for differences between vegetation types can only be speculative. However, the values measured for pH lend themselves to a possible explanation of differences between certain subtypes, as do observations of some disturbances, particularly by beavers. Grime (1979)

Table 7. A comparison of the vegetation types in Pequawket Bog showing significant differences in species density at the 95% confidence level ($p < 0.05$).

	ST Ia	ST Ib	ST IIa	ST IIb	ST IIIa	ST IIIb	ST IIIc	ST IVa	ST IVb
ST Ia									
ST Ib	---								
ST IIa	*	*							
ST IIb	---	---	*						
ST IIIa	*	*	---	---					
ST IIIb	---	---	*	---	*				
ST IIIc	*	*	*	---	---	*			
ST IVa	---	---	*	*	*	---	*		
ST IVb	---	---	*	---	---	---	*	---	
CT V	*	*	*	---	---	*	---	*	---

* significant at 95%

shows there is a relationship between the pH of different habitats and species density. Other possible influences may include fluctuations in water level, conductivity, alkalinity, and aeration.

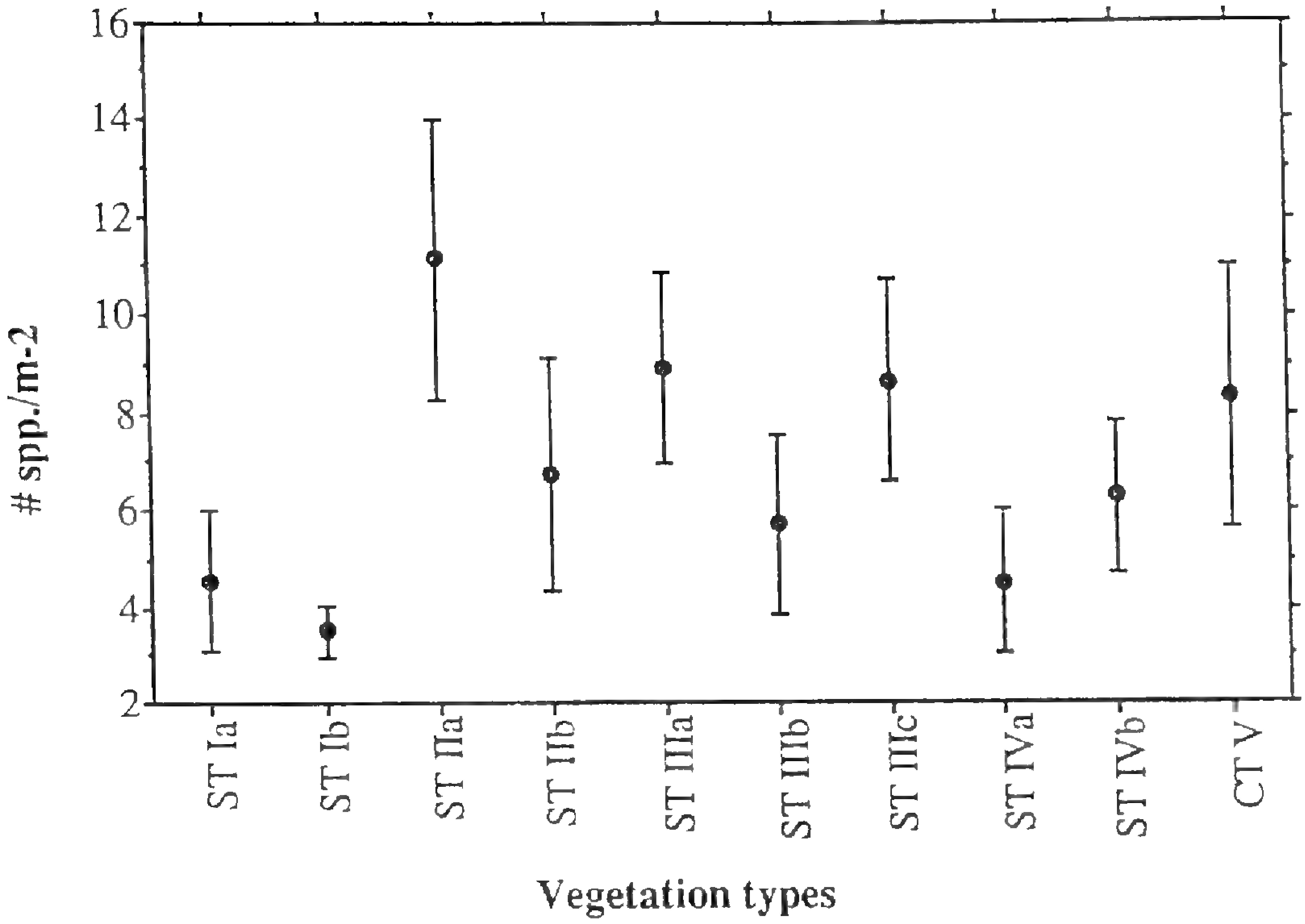

Figure 6. Average species density, expressed as number of species per square meter (for all vegetation cover types and subtypes

Within the *Carex lasiocarpa* CT, ST IIa shows a significantly higher species density than all other vegetation cover types except for ST IIIa. The areas in the peatland where ST IIa is found are on the edge of the pond, which is subjected to water level fluctuations, and in areas that show considerable disturbance by beaver (Figure 4). Likewise, the small area occupied by ST IIIa shows signs of beaver disturbance

Schwintzer (1981) found a relationship between species density of vascular plants in three northern Michigan wetland types (bogs, fens, and conifer swamps) and degree of telluric water influence. In bogs with little influence from telluric waters, a low species density was found due to the stressful, nutrient-poor environment. At Pequawket Bog, within the *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginiana* CT, ST IVa had a significantly lower richness than many other mat vegetation types, and is found in an area of the southwest mat than is furthest away from the upland. It can be assumed that this location is also relatively poor in telluric minerals as reflected by its low pH (3.72). Any inflowing telluric water from the upland probably does not reach the center of the mat; additionally, there is no export of acids out of this area. Schwintzer (1981) reports substantially higher species density in fens and conifer swamps with a moderate to strong influence of telluric water. Similarly, at Pequawket Bog higher species richness was seen in areas of the moat and on the edge of open water, where the pH is higher. Schwintzer also points out that there are other factors that influence species density, such as tree layer, water level fluctuations, and range and number of microsites provided by microrelief.

Heinselman (1970) compared the richness of seven different peatlands in northern Minnesota and found an increase in number of species as the flow-through conditions increased. The stimulus of the increase is thought to be due to the input of mineral nutrients and a reduction in anaerobic conditions.

SUMMARY

In summary, Pequawket Bog is a level peatland complex with an aquatic community, a sedge meadow, two areas with more typical bog flora, (*Sphagnum* spp. and low ericaceous shrubs

dominating), and a tall shrub or moat cover type. The five major cover types reflect general vegetational and floristic similarities with other level peatlands in northeastern North America. With a diverse flora of 109 vascular plants, the peatland complex might be best classified as a "rich fen".

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Herbarium **J. K. Morton**

Name Sonchus palustris L.

Family Compositae

Collector J.K. Morton and Joan M. Venn

No NA18427 Dried 15 Aug. 1994

Locality ON : Waterloo Region : S end of Cambridge (G) - Hwy 24 & Myers Rd. jnct.

Country Canada

Remarks Perennial (or ?biennial) herb 6-8 ft high in rank somewhat marshy ground beside abandoned railway line. Several dozen plants noted over an acre or two

Specimens in JKM WAT DAO GH

Det JKM 1994

Figure 1. Photograph of herbarium specimen of Marsh Sow-thistle x 1/3

RHODORA, Vol. 97, No. 889, pp. 93-95, 1995

THE MARSH SOW-THISTLE (SONCHUS PALUSTRIS) IN NORTH AMERICA.

J. K. MORTON AND JOAN M. VENN

ABSTRACT

The discovery of the Marsh Sow-thistle *(Sonchus palustris)* growing in the Waterloo Region of Ontario, Canada is reported.

Key Words: Marsh Sow-thistle, *Sonchus palustris* Linn., North America, Ontario.

The Marsh Sow-thistle (*Sonchus palustris* Linn.)occurs in Cambridge (Galt), Waterloo Region, Ontario, Canada, where it grows in tall, herbaceous, marshy vegetation beside an abandoned railway line on the southern outskirts of the city. This year (1994) there were many plants of the sow-thistle growing in two colonies a few hundred yards apart.

The Marsh Sow-thistle is a spectacular plant with its stout flowering stems towering over the surrounding vegetation to a height of 6 to 8 ft. (up to 2.5 m). Each stem is stiffly erect with a terminal umbel of rich yellow flower heads similar to those of the common Field Sow-thistle (*S. arvensis* L.) but only about half the size. The leaves of the Marsh Sow-thistle are distinctive, being large, narrow [c 6-8" long x 3/4-1" (15-20 cm x 2-3 cm) broad] and pointed with sharply pointed auricles at the base. The margins are straight and minutely scabrid-toothed. This type of leaf is very different from that of the Field Sow-thistle which has coarsely sinuate-lobed leaves, Broadest above the middle and conspicuously toothed.

The Marsh Sow-thistle is a native of Europe where it occurs locally in marshy ground and wet places across most of the continent except in the far north, The occurence of this species at Cambridge came to out attention when we were working through a pile of unidentified herbarium specimens recently donated to the University of Waterloo herbarium by Mr. Craig Campbell of Waterloo. The specimens included a collection of an unfamiliar *Sonchus* from the above locality made on August 10th, 1973 - *Campbell and Reznicek 73-65*. This proved to be *Sonchus palustris*. We visited the locality in late July 1994 and soon located the plant which was, however, only in bud. On a subsequent visit in mid-August it was in flower and fruit, and voucher material was collected. It is clear that the Marsh Sow-thistle is well established in this locality as it has persisted here for over 20 years. As far as we have been able to ascertain this is the first report of this European species from North America.

Voucher Collections: CANADA: **Ontario:** Cambridge (Galt), Waterloo Region, *Campbell and Reznicek 73-65* (WAT); and idem. *Morton and Venn, NA18427* (WAT, JKM, DAO, GH).

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URTICA CHAMAEDRYOIDES PURSH (URTICACEAE) REPORTED AS NEW TO CUBA

DMITRY V. GELTMAN

ABSTRACT

Urtica chamaedryoides is reported for the first time to Cuba .

Key Words: Urticaceae, Cuba, Systematics, Urtica.

While examining specimens for a taxonomic treatment of *Urtica* L. for Latin America, three Cuban collections from the Gray Herbarium of Harvard University struck me as being unusual. They were originally identified as *Urtica urens* L., a species introduced from Europe and recorded from Cuba by León and Alain (1951). On closer examination, however, they have proven to represent *Urtica chamaedryoides* Pursh, an annual species widely distributed in the southeastern United States from Southern Ohio, southern Illinois west to southeastern Kansas, south to central Florida, Texas and Louisiana, and also occurring in Mexico (Woodland et al., 1976).

Specimens examined:CUBA; Plantae Cubensis Wrightianae, *C. Wright 3681*, s.d. (GH); **Santa Clara Province**, Las Lagunas, Buenos Aires, about 2500 ft. alt., 21 April 1930, *J. G. Jack 7943* (GH); **Las Villas Province**, Trinidad Mountains, San Blas-Buenos Aires, Finca La Carida, 1 June 1942, *A. Gonzáles 485* (GH). The first specimen has no locality information (and is not cited in Grisebach's (1866) work on Wright collections), localities of the two others could not be located precisely, but it is clear that they come from the same general area in the Sierra de Trinidad, located at the junction of the present provinces of Cienfuegos, Villaclara, and Sancti Spiritus.

Urtica chamaedryoides in its North American continental range is found growing in humid, rich soils of bottom lands and flood plains, rich woods, and waste places (Woodland *et al.*, 1976). Although there is no ecological information available for the collections cited above, their occurrence in a montane habitat, typical for *Urtica* in the tropics, suggest that this species is indeed native to Cuba.

ACKNOWLEDGMENTS.

Support for my studies on the taxonomy of LatinAmerican *Urtica* species is provided by the Missouri Botanical Garden, which is gratefully acknowledged. I also grateful to GH for sending specimens on loan. Finally I thank Jim Solomon for the help in editing of the manuscript.

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RHODORA NEWS/NOTES

Lisa A. Standley

HIGHLIGHTS OF CLUB MEETINGS

April 1994 (898th Meeting). Dr, Robery Raffauf, Emeritus Professor of Northeastern University's College of Pharmacology, spoke on Rainforests and Medicinal Chemistry, the focus of his research and collaboration with Dr. Richard Schultes for the past 40 years.

Dr. Raffauf provided a whirlwind tour through the history of medical ethnobotany, from the first recorded uses of plant medicines in 4,000 BC. Ethnobotany can be traced back to Adam and Eve who noted that certain fruits had undesirable side effects. Some highlights included the Egyptian's use of moldy bread to treat wounds; the description of *Rauwolfia* as a sedative 3,000 years ago in India; Hippocrates' use of precursors of salycilic acid; and the efforts of the Spanish in the New World to record indigenous uses of medicinal plants. Some notable drugs derived from plants include digitalin (introduced in the late 1700s), scopalomine from *Brugmansia;* ergotamine, for migranes; atropine; and steroid precursors from *Dioscorea.* Despite this long history, only 11% of the drugs listed in the current US Pharmacopeia are derived from plants - and these are from a short list of 35-40 species, most of which (with the exception of *Catharanthus*) have been used for centuries. Drug companies have, mostly unsuccessfully, attempted to synthesize these plant compounds to provide more controlled and predictable dosages. New genetic engineering techniques are likely to provide the key to synthesis of plant medicinal compounds.

Dr. Raffauf examined the popular concept that there are a vast number of new natural drug-producing plants in the rainforest waiting to be discovered. Based on 40 years of reseach, his view is that there are no compelling arguments for botanical exploration of the rainforest in search of new medicines since the potential for finding new drugs is low. Of the 1500 medicinal plants used by the indigenous peoples of the Amazon, none have unique properties or commecial value. Even if some tropical tree products were found to be major drug sources, they would not be commercially viable due to the length of time needed for these trees to be grown in plantations. For example, curare plants, which are relatively fast-growing, require 30 years for a crop to reach maturity. Dr. Raffauf concluded that the real potential for new medicines,and new medical solutions to human disease, will come from the development of new vaccines and genetic engineering - not tropical forests.

MAY 1994 (899th Meeting, at Smith College). Following an historical introduction to the Smith College Botanical Garden by Dr C. John Burk, Dr. Rob Nickolson of Smith College spoke on his work collecting members of the genus *Taxus* in remote areas. As a result of his work, the Smith College Botanical Garden currently holds the worlds largest collection of wild-originated plants in the Taxaceae (*Pseudotaxus*, *Taxus*, *Cephalotaxus*, *Torreya*, and *Amentotaxus*). His talk focused on *Taxus* itself, with photos and descriptions of the various species in native habitats, including *T. baccata* in Northern Europe, *T. canadensis* in Northeastern North America, *T. globosa* in Mexico growing with Magnolia, and *T. chinensis* in Taiwan with an eight-foot basal diameter.

The taxonomy of the group appears to be based more upon geography than morphology, with few if any real morphological distinctions between species. One of Rob's and his collaborator, Melvin Shemluck's, main interests is the production of taxol. They find that taxol can be extracted from three-year old rooted cuttings, thus saving mature trees, and that it can be extracted from cloned callus cells. *Amentotaxus*, an anomaly in the family, lacks taxol. Many of his field efforts to locate or relocate populations of *Taxus* led him to areas that had recently been deforested, often illegally. The most significant message in Rob's talk was that the world's yew flora is being severely depleted for timber and bark, and that the Asian taxa in particular are likely to be lost soon unless there are significant conservation efforts.

June 1994 (900th Meeting). Former Club President Mary Walker spoke on The History of the Flora of Anguilla. The talk centered on her long-term project to photograph and document the approximately 480 species of the flora, using Dr. Richard Howard's checklist for the island. Anguilla, a small low island with a dry climate and beautiful beaches, has a long history of agricultural use. Until the introduction of electricity in 1970 and the recent rise in tourism, the islanders practiced subsistance agriculture. Cows, goats and chickens still roam free throughout the island, and pidgeon pea, peppers, yams and tomatoes are commonly grown in small gardens, while hydroponically-grown lettuce is a new cash crop.

The plant communities in the vicinity of settlements, agricultural areas and former plantations are dominated by introduced species such as aloe, indigo, tamarind, mango and calabash. Many of the island's native and introduced species are used medicinally. The dominant natural vegetation on the island is described as an evergreen bushland, dominated by sclerophyllous shrubs. Some plant groups, particularly ferns (one!) and orchids (two) are underrepresented.

Perhaps due to strong selection by goats, the majority of surviving shrub species are also protected by thorns. To the average tourist, all shrub species, including the island's only endemic, appear to have similar small, entire, leathery evergreen leaves and small red fruits. The growth habits of many species are ecologically interesting, particularly in the areas where the substrate consists of bare limestone. Plants, including the thatch palm *Thrinax* and one of the island's two orchids (*Epidendrum*), become established in small solution pits in the limestone. Other plant communities on the island include mangrove swamps and the strand vegetation along beaches, which includes sea grape and manchineel.

October 1994 (902nd Meeting). Dr. Thomas Philbrick spoke on "Flowering Plants in River Rapids - Podostemaceae in Mexico". Tom's love affair with riverweeds began when he first encountered green slime on rocks in the Lamprey River during childhood. He later discovered that these appear to present interesting evolutionary riddles, since they do not conform to the "evolutionary paradigm" of aquatic angiosperms. Aquatic flowering plants, in general, are perennial clonal plants that rely on vegetative reproduction through specialized propagules, and that have a low rate of sexual reproduction. Most families of aquatics have a low species diversity and broad distributions. Riverweeds, in contrast, are annuals that rely on a high rate of sexual reproduction and population persistence, and have a high level of taxonomic diversity with numerous endemic species with restricted distributions.

In Mexico the family consists of 5 genera and 13 species, mostly in the genus *Marathrum*. All taxa occur in rocky, clear water rivers with seasonal variations in flow, that may become completely dry during some parts of the year. Plants vary considerably in size, with shoots ranging from 2 cm to a meter in length. Members of the genus *Tristichia* are easily mistaken for bryophytes. Although many species have a disinctive bright red pigmentation, the ecological role of this color is not known. Flowers are unremarkable, and lack any perianth - radiation in the group appears to be primarily reflected in the evolution of leaves and vegetative structures. These annual plants grow vegetatively during high water. As the water level falls, the leaves die and flowering is initiated. Flowering and fruiting occurs at very high rates.Tom hypothesizes, based on the frequency of bird droppings on rocks in the river, that seed dispersal occurs when seeds adhere to bird feet. Seeds have an outer integument that hydrates and becomes mucilaginous when wet, enabling the seeds to stick to rocks. The seedling, on emergence from the seed coat, bends toward the rock and produces rhizoidal hairs that attach it to the rock.

High levels of endemism occur in the family, with over 50% of the species in Mexico occurring in a single river. Rampant endemism is also reflected in the fact that 50% of all New World species (over 80 species) occur in Brazil. Although two or three genera are often found growing together, no two members of the same genus have been reported to be sympatric. Taxonomic studies are desperately needed in this group, to determine whether the named taxa are distinct at the level of species, or if these are simply ecotypes adapted to different river conditions. Without a better understanding of patterns of taxonomic variation, it is not possible to address questions of phylogeny or understand the patterns of endemism.

The numerous endemic species also pose problems for conservation. Since many taxa occur in only one river, changes in water quality may result in extinction. The biggest threats appear to be siltation from construction and industrial pollution, since silt and petroleum distillates prevent seeds or seedlings from attaching to rocks. Eutrophication of rivers through the addition of domestic sewage increases algal growth, which also prohibits attachment.

November 1994 (903rd Meeting). William Brumback, Conservation Director of the New England Wildflower Society, spoke on the New England Plant Conservation Program. The New England Plant Conservation Program (NEPCoP) was started in 1990, assisted by a grant from the Cox foundation. The program is a voluntary organization of federal, state and private non-profit groups dedicated to the conservation of New England plants. By providing a forum for collaboration and interaction, the program increases the efficiency of state groups and more effective use of limited resources. A Regional Advisory Council sets policy and develops program priorities. State Task Forces bring together the most knowledgeable people in each state, including state and non-profit organizations as well as amateurs. The strong conservation ethic in New

England has allowed a high level of cooperation between different agencies. One of NEPCoP's major accomplishments to date was a symposium, held in 1992 and co-sponsored by the Club, that established policies for rare plant conservation. The symposium talks were published in Rhodora, and NEPCoP policies were published in "Wildflower Notes". These have been widely distributed, and are used by plant conservation groups nationwide.

Bill contrasted the problems associated with in-situ and ex-situ conservation. NEPCoP is currently concentrating on ex-situ preservation through the collection of seeds to preserve genetic variation of rare species. This is an experimental program which is intended to complement in-situ protection. Seed banking also allows researchers to explore aspects of the reproductive biology of rare species, and provides material for re-introduction. Re-introduction is a somewhat controversial issue in the conservation community, as there are concerns that it would allow habitat destruction. The New England Wildflower Society is currently developing a rare plant garden as part of an education program focused on rare flora.

NEPCoP has developed a list of regionally rare taxa called "Flora Conservanda". Four categories of rare species are listed: globally rare (D-1), regionally rare (D-2), not rare but with populations of conservation importance (D-3), and species which formerly occurred in New England but for which there are no extant populations (D-4). The Regional Task Force has been working to develop this list, and set protection priorities for the states.

State Task Forces are currently working with volunteers to collect seed of listed plants which occur on private, unprotected property This effort is intended to ensure that genetic variation of these populations is preserved. No collecting is being done from protected lands. NEPCoP staff work with the state Heritage Programs to develop lists of occurrences of target species, and to obtain permits and permission to collect seed.

NEPCoP, through the New England Wildflower Society, also sponsors Rare Plant Monitors. These lay volunteers are trained and work with Heritage Program staff to investigate and monitor known or historic occurrences of listed species. In 1994, Dr Paul Somers of the Massachusetts Natural Heritage Program used 20 volunteers to investigate over 60 sites that would not have otherwise been visited.

Bill closed the evening with slides of regionally rare plant taxa in the four categories of Flora Conservanda. Some highlights of successful seed banking and propagation included *Agalinis acuta, Hieracium robbinsii* (last seen in 1956, rediscovered by Bill in 1994), and *Potentilla robbinsiana*, successfully grown from seed. *Arethusa bulbosa* is an example of a D-3 species, of concern in Massachusetts.

December 1994 (904th Meeting). Dr. Richard Howard of the Harvard University Herbaria, reviewed "Harvard's Role in Neotropical Botany; an Historical but Partial Review". The talk consisted of a series of entertaining and enlightening anecdotes and photographs of Harvard Botanists and botanical gardens associated with work in the neotropics. The Harvard Botanical Gardens were founded in 1805, with W. D. Peck as the first director. He was succeeded by Thomas Nuttall, who resigned the post to collect plants in the western US, and sold his personal herbarium to Philadephia, apparently out of spite. The former botanical garden was, based on slides, laid out in classic Linnean order, with a Victorian glass house and palm rotunda. When the garden was abandoned in 1947, many of the tropical plants were given to Wellesley College. Few of the woody specimens remain, although the female ginkgo planted by Asa Gray survives today, and its fruits are collected by some of Boston's Chinese population. The former director's house still remains on Garden Street, and the former Herbarium building (also on Garden Street) is now the Harvard University Press. Fernald Drive and Robinson Drive commemorate directors of the Herbarium.

The flora of the neotropics, particularly Central America, the Greater Antilles, and the Lesser Antilles, has been a primary focus of the Harvard Botanical institutions over the past century and a half. Botany at Harvard has included the Botanic Garden, the Gray Herbarium, the Farlow Herbarium, the Botanical Museum, the Oakes Ames Orchid Herbarium, the Arnold Arboretum, and the Atkins Institute, a botanical garden and research center in Cuba. The Atkins was important in the training of many prominent taxonomists, whose educations included learning to drive a Model T and collect from horseback. Luckily, botanical collectors are no longer required to wear wool 3-piece suits, ties, and hats at all times in the field. The history of neotropical botany at Harvard has involved colorful personalities, incidents, and occurrences which could only be briefly mentioned in this talk. Dick recommended a book about Oakes Ames, titled "Portrait of a Harvard Botanist", to those who would like their gossip in greater detail.

January 1995 (905th Meeting). Don Hudson led the evening's parade of club members with stories to tell and slides to show. One of his highlights was a helicopter tour of a proposed extension of the Appalachian Trail from Katahdin to Mont Albert. As demonstrated by the slides, club Members ranged throughout the New World in 1994. Alaska was a popular destination. Leila Schultz visited Alaska, the Diomedes Islands and the Chukchi Peninsula of Siberia in search of arctic artemisias, and showed slides of spectacular (although minute) plants. Mark Primack showed us fall foliage in Denali National Park - more spectacular color than even New Englanders are used to. Gary VanWart went looking for conifers in the Pacific Northwest, and succeeded in finding most of the 33 native species, including the very rare Brewer's Spruce.

Moving east and south, George Newman visited the Gaspe (again), with a focus on unique ferns of Mont Albert including *Cheilanthes siliquosa, Polystichum scopulinum, Adiantum aleuticum,* and *Cystopteris montana.*

Club members also travel through time as well as space. Tonya Largy described an excavation of a late Archaic cremation burial site on the Blackstone River, with 35,000 year old seeds of *Rubus, Gaylussacia, Carya, Corylus*, and *Quercus*, as well as mystery rhizomes.

Coastal Plain ponds were also a popular destination. Mark Primack introduced us to rare white form of *Sabbatia campanulata*, and a hybrid of the two Sabbatias. Pat Swain and Paul Somers showed the New England boneset, as well as other Massachusetts rare plants. Paul reported on the sandplain gerardia's status, and experimental burns and re-introductions. NEPCoP's volunteer conservation corps posed for Paul's camera. This active group has contributed 40-50 new records of rare species a year, including the second site in the state for *Carex polymorpha.*

Ranging still further south, David Hunt shared his work on the rare Florida scrub oak, reduced to fewer than 100 populations (and most of those with For Sale signs tacked onto the oaks). These scrub communities contain the largest concentration of rare species in the eastern US, but are threatened by expansion of citrus groves and development. David showed the third bird slide of the evening (the globally endangered Florida Scrub Jay), a new record for show and tell.

Two members ventured to South America. Garrett Crow traveled through Bolivia with a graduate student, searching for aquatics from 12,000 ft to near sea level. Although high elevation aquatics include many familiar forms such as *Limosella* and *Callitriche,* lower elevaions on the Amazonian side of the Andes include the aptly-named *Equisetum giganteum.*

NEWS

Two valuable and active Club members passed away in 1994: Sib Higginbotham, who will be missed at Club meetings and field trips, and Dorothy Waleka, who mounted many of the speciments in the Club's herbarium.

NOTES

The Rhode Island Natural History Survey is a new organization with a mission to "advance scientific knowledge of Rhode Island's biota, ecological communities, and environmental resources; to facilitate and coordinate the gathering and dissemination of information on Rhode Island's biota and natural communities, and to enhance communication among Rhode Island's environmental and life scientists". The new group organized a very successful symposium in October, and is preparing a directory of Rhode Island naturalists. For information, contact the Rhode Island Natural History Survey, Inc. at the Cooperative Extension Center, E. Alumni Ave. University of Rhode Island, Kingston RI 02881.

The Conference on the Status and Management of Old Growth Forests in the Northeast was held October 29-30, 1994, in Williamstown, MA. Sponsored by the Massachusetts Audubon Society, the conference allowed scientists and old-growth enthusiasts to meet and discuss the status, characteristics, and spiritual role of old growth forests. There appears to be no clear agreement on a single definition of Old Growth - various criteria used include pre-settlement origins, multi-aged stands of significant age, as well as stands of very large trees. Some of the more interesting talks from the first day of the conference included the description of old-growth hemlock stands in Massachusetts (mostly less than 25 ha, on steep slopes); a discussion of extensive tracts of high-elevation old-growth forest in the Catskills, where areas of over 100 square miles were never logged; a description of a 130-yr old even-aged spruce stand on Mt. Graylock, regenerated after fire; a photo of the oldest spruce in Maine (450 years, 24-inch diameter); and the observation that forests of Michigan's Upper Peninsula, although never logged, are not stable in composition - these are still changing as beech continues to extend its range and dominance northward.

Biodiversity Principles and Applications, a Conference For Natural Resource Professionals, was held on January 17, 1995 in Newington NH and sponsored by the UNH Cooperative Extension Program. Speakers from academic institutions, the Nature Conservancy, and state and federal agencies addressed the definitions and levels of biological diversity, with applications to land management issues in Northern New England. The talks summarized here were of particular interest to botanists.

C. Cogbill emphasized external, abiotic factors as the major cause of change and the maintenance of diversity in forests, ranging from wind as both a cause of "fir waves" at high elevations and the major cause of change in northern hardwoods forest, to fire as a factor in the regeneration of NH pitch pine forests. A common pattern of vegetation change is that of an even-aged stand of white pine, established in an old field or following fire, catastrophically destroyed by windstorm, and replaced by northern hardwoods - emphasizing that our majestic old-growth white pine stands are temporary features of the landscape. J. Litvaitis discussed the connection between human alteration of the landscape and wildlife biodiversity. Early successional forests are critical habitat types for the New England cottontail and bobcat. This habitat type peaked in abundance in NH from 1905 through 1950, following the abandonment of agriculture. Abundances of these species and early successional birds have declined dramatically since 1950 as forests have matured. He also discussed the relationship of other landscape characteristics to small mammals. J. Kantor noted that the now-rare upland sandpiper moved into New England as agriculture expanded. Its current decline is due to habitat loss as pastures and agricultural lands revert to forest This raises some interesting questions as to the level of effort that should be expended to preserve the upland sandpiper and similar species.

BOOKS OF NOTE

One Hundred and One Botanists by Duane Isely (Iowa State Press, 272 pages, 1994). Brief biographical sketches of prominent botanists rom Aristotle onward, illustrated with photographs front the Hunt Institute collection. Highly recommended by Les Mehrhoff.

From Coastal Wilderness to Fruited Plain by Gordon G. Whitney (Cambridge University Press, 451 pages, 1994). An outstanding survey of pre-settlement vegetation types of eastern North America, the progression and effects of land cleating for agriculture and wood, the effects of farm abandonment, current anthropogenic vegetation types, changes in the fauna, and the history of the conservation movement and land protection in the northeast. Although covering an extensive geographical area, the book comprehensively treats the major topics and challenging issues of human effects on the natural vegetation and ecosystems of the northeast - and is worth buying for the 105-page bibliography alone. It is definitely academic in its tone, and some readers may not find it as easily readable or accessible as Cronon's *Changes in the Land.* The book follows the format of a scientific research paper, and the reader may want to approach it in the same way - I found the introductory chapter on methods of assessing pre-settlement vegetation types educational, but rapidly skipped ahead to the more interesting results of Whitney's investigations.

THE NEW ENGLAND BOTANICAL CLUB

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The New England Botanical Club is a non-profit organization that promotes the study of plants of North America, especially the flora of New England and adjacent areas. The Club holds regular meetings, has a large herbarium of New England plants, and a library. It publishes a quarterly journal, RHODORA, which is now in its 95th year and contains about 400 pages a volume.

Membership is open to all persons interested in systematics and field botany. Annual dues are $35.00, including a subscription to RHODORA. Members living within about 200 miles of Boston receive notices of the Club meetings.

To join, please fill out this membership application and send with enclosed dues to the above address.

Regular Member	$35.00
Family Rate	$45.00
For this calendar year	______
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SYNOPSIS OF THE GENUS *ARABIS* (BRASSICACEAE) IN CANADA, ALASKA AND GREENLAND

GERALD A. MULLIGAN

ABSTRACT

This taxonomic treatment of *Arabis* (Brassicaceae) in Canada, Alaska and Greenland recognizes 30 species. A comprehensive key is provided for these species and 8 varieties. Four new species are described: *A. boivinii* G. Mulligan, *sp. nov.*; *A. calderi* G. Mulligan, *sp. nov.*; *A. codyi* G. Mulligan, *sp. nov.*; and *A. murrayi*, G. Mulligan, *sp. nov.* In addition, many other taxa are recorded for the first time for this area. Cytological studies available for 45 North American and Greenland species of *Arabis* are summarized and discussed. Thirty-six of these species have the basic chromosome-number of $x = 7$ and some have diploid, triploid and even tetraploid chromosome races. The *Arabis* species being treated here can reproduce sexually and/or by agamospermy.

Key Words: Brassicaceae, *Arabis,* taxonomy, new species, cytology

INTRODUCTION

The first treatment of the genus *Arabis* in North America was on taxa in the Pacific Northwest (Rollins, 1936a). This was closely followed by two monographs published in *Rhodora*: *Arabis* in eastern and central North America by Hopkins (1937) and a monographic study of *Arabis* in western North America by Rollins (1941). Rollins discussed, in detail, the relationships of *Arabis* with other genera in the family Brassicaceae and among and within *Arabis* species. He continued to add to our knowledge of the taxonomy, ecology, cytology, breeding systems, hybridization and speciation in the genus in a long series of publications (Rollins, 1936a, 1936b, 1941, 1943, 1946, 1966, 1971, 1973, 1981, 1982, 1983, 1984, 1993a; Rollins and Rüdenberg, 1971, 1977, 1979). Böcher (1947, 1951, 1954, 1966, 1969) studied the cytology and embryology of some members of *Arabis* occurring in this area and Mulligan (1964) and Mulligan and Porsild (1969, 1970) published chromosome numbers for many *Arabis* taxa in Canada. Boivin (1951, 1955, 1967) also proposed a number of new taxa and rankings based on his study of Canadian *Arabis.* He summarized his taxonomic views on *Arabis* in his *Enumération des plantes du Canada* and *Flora of the Prairie Provinces* (Boivin, 1966, 1968, respectively). More recently, Sabourin (1989) presented a useful guide to the *Arabis* taxa found in eastern Canada. Rollins (1993b) published the first comprehensive taxonomic study of the genus *Arabis* in Continental North America. He included excellent keys, descriptions, habitats, distributions, and cytological data for all taxa based on material that he had seen. However, he did not have the opportunity to see the large amount of Canadian, Alaskan and Greenland *Arabis* material available to me. Consequently, many *Arabis* taxa present in Canada, Alaska and Greenland are not recorded from this area in Rollins' latest treatment. The present synopsis of *Arabis* occurring in Canada, Alaska and Greenland attempts to fill this gap.

MATERIALS AND METHODS

Herbarium specimens, including many types, were examined morphologically. They were borrowed from the following institutions: ALA, CAN, DAO, DWC, GH, K, KY, LE, MO, MT, ND, NY, ORE, OS, P, PH, QFA, RM, RSA, SASK, UBC, UC, US, WIS and WS. Herbarium acronyms are according to Holmgren et al. (1990). In addition, a very large collection of unmounted, mostly unidentified, *Arabis* specimens were studied and later deposited in the herbarium of Agriculture Canada, Ottawa (DAO). These specimens were collected in southwestern Canada and the western United States by Theodore Mosquin, with Linda Mosquin and M. H. Benn in 1962 and with G. A. Mulligan and J. M. Gillett in 1963. Many of these specimens had both herbarium labels and annotation slips containing unpublished cytological data of Theodore Mosquin. In addition, cytological studies published for all North American and Greenland species of *Arabis* were summarized. The cytological information appears in Table 1.

CYTOLOGY AND BREEDING SYSTEMS

Results from the cytological examination of 45 species of *Arabis* of North America and Greenland are presented in Table 1. Thirty-six species have the base chromosome-number of $x = 7$, eight species have $x = 8$, and one species, *A. glabra,* seems to have two base numbers, $x = 6$ and 8.

Nineteen of the species with the base number of $x = 7$ are known only as diploids, five species only as triploids, one species only as a tetraploid, nine species as both diploids and triploids, and two species as diploids, triploids and tetraploids. Seventeen of these thirty-six species, with the base number of $x = 7$, contain plants that are triploid and/or have an irregular meiosis. Since these plants have almost a complete seed set, it seems likely that they produce seed by apomixis. Eight species (*A. columbiana, A. divaricarpa, A. drummondii, A. exilis, A. holboellii, A. laevigata, A. puberula* and *A. sparsiflora*), also with a very high seed set, have plants with a regular pairing at meiosis and thus may very well be sexual. However, all of these eight species also have plants that are triploid and/or have an irregular meiosis and thus are almost certainly also apomictic. A number of species, with the base number of $x = 7$, include aneuploids and plants with B-chromosomes.

Böcher (1947, 1951, 1954, 1966, 1969) first reported apomixis in North American and Greenland *Arabis* with the base number of $x = 7$. According to Böcher (1969), some diploids with a completely normal meiosis seem to be sexual whereas others with meiotic abnormalities are probably apomictic or amphi-apomictic. He also stated that triploids may easily be formed by the fusion of reduced and unreduced cells in diploids and that this process may be reversible. The most common base number for North American and Greenland *Arabis* is $x = 7$, and these species may be sexual, apomictic or amphi-apomictic or any combination thereof. It appears that plants with the base number $x = 7$, some possibly propagating apomictally, do occur occasionally on other continents. For example, Berkutenko and Gurzenkov (1976) reported $2n = 14$ for *Arabis falcata* (Turcz.) Berkut. and $2n = 21$ for *Arabis pendula* L. from the south Magadan region in the former U.S.S.R. and Galland (1969) $2n = 14$ for plants of *Arabis auriculata* Lam. and *Arabis conringioides* Ball. from Morocco. *Arabis pauciflora* (Grimm.) Garcke has the chromosome number of $2n$

Table 1. Reported chromosome-numbers for *Arabis* of Canada, the United States and Greenland. Chromosome counts and other cytological information attributed to voucher specimens under the collection numbers of Theodore Mosquin (T.M.) were observed by him and were attached to specimens that are now deposited in the Agriculture Canada herbarium at Ottawa (DAO). The references given in Table 1 refer to published reports. The chromosome numbers listed as n = 15/2, 21/2, and 22/2 indicate that Mosquin observed very irregular configurations totalling 15, 21 and 22 chromosomes, respectively, at meiosis.

Taxon	n	$2n$	Sources of materials, vouchers or references, and special cytological information
A. aculeolata Greene		32	OREGON (Rollins & Rüdenberg 1977).
A. alpina L.	8	16	GREENLAND (Jörgensen *et al.* 1958; Dalgaard 1988, 8II). QUEBEC (Rollins 1941; Mulligan 1964). MANITOBA (Löve & Löve 1982).
A. arenicola (Richardson) Gelert	8	16	GREENLAND (Böcher 1966). QUEBEC (Hedberg 1967; *Lepage 39394* by T.M.).
A. boivinii G. Mulligan	21/2		MONTANA (*T.M. & L. Mosquin 5219*). SOUTH DAKOTA (*T.M. & G.A. Mulligan 5157*).
A. breweri S. Wats.		14	CALIFORNIA (Rollins & Rüdenberg 1971).
A. canadensis L.		14	ONTARIO (Mulligan 1964).
A. caucasica Willd.	8		ONTARIO (Mulligan 1964, 8II).
A. cobrensis M.E. Jones	7		WYOMING (Rollins 1941).
A. columbiana Macoun	7		BRITISH COLUMBIA (*T.M. & G.A.M. 4930 & 4937*, meiosis irregular). CALIFORNIA (*T.M. 4548*). IDAHO (*T.M. & G.A.M. 4966, 4982 & 4994*, meiosis irregular; *T.M. & G.A.M. 4998*, 7II). OREGON (*T.M. & G.A.M. 4953*, 7II).
	21/2	*ca.* 21	CALIFORNIA (*T.M. 4531 & 4535*). WASHINGTON (*T.M. & G.A.M. 4944*, n = 21/2).

Table 1. Continued.

Taxon	n	$2n$	Sources of materials, vouchers or references, and special cytological information
	22/2		WASHINGTON (*T.M. & G.A.M. 4946*).
A. constancei Rollins		14	CALIFORNIA (Rollins & Rüdenberg 1971).
A. crandallii Robinson	7	14	COLORADO (Rollins 1941, 1966).
A. demissa var. *russeola* Rollins		21	WYOMING (Rollins 1966).
A. depauperata Nelson & Kennedy	7		MONTANA (*T.M. & J.M. Gillett 5253*).
A. divaricarpa A. Nels. var. *divaricarpa* or *dacotica* (Greene) Boivin	7	14	MANITOBA (Löve & Löve 1975a, 1982). COLORADO (Rollins 1966). MONTANA (Rollins 1966, 1983).
		22	CALIFORNIA (Rollins 1966). WYOMING (Böcher 1969, apomictic, EMCs, PMCs, and pollen grains had 22 chromosomes and dyads and uniform pollen were formed). The $n = 8$ and $n = 15$ chromosome-number reports by L.O. Gaiser in Rollins (1941) are probably erroneous (Rollins, pers. comm.).
A. divaricarpa var. *divaricarpa*	7	14	SASKATCHEWAN (Taylor & Brockman 1966). ALBERTA (*T.M., L.M. & M.H. Benn 4751 & T.M. & L.M. 4703,* 7II). BRITISH COLUMBIA (Mulligan 1964, $2n = 13 + 2B$ & 14). COLORADO (*T.M. & L.M. 4575*).
	15/2		MONTANA (*T.M. & J.M.G. 5258*).
	21/2	21	ALBERTA (*T.M. & M.H.B. 5183,* $n = 21/2$). BRITISH COLUMBIA (Mulligan 1964). CALIFORNIA (*T.M. 4529*).
A. divaricarpa var. *dacotica*	*ca.* 7		COLORADO (*T.M. & L.M. 4575*)
	21/2	21	BRITISH COLUMBIA (Mulligan 1964). COLORADO (T.M. & G.A.M. 5066 & 5073, $n = 21/2$).

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
	14	28	MACKENZIE DISTRICT (Mulligan 1964, $2n = 28$ & 28 + 1B). MANITOBA (*T.M. & L.M. 4904 & 4910,* $n = 14$ with irregular meiosis).
A. drummondii Gray	7	14	YUKON (Mulligan 1964). MANITOBA (Löve & Löve 1982). ALBERTA (*T.M. & L.M. 4706 & T.M., L.M. & M.H.B. 4737,* both 7II). CALIFORNIA (Rollins & Rüdenberg 1977). COLORADO (Rollins 1941, 1966; Rodman & Bhargava 1976; *T.M. & L.M. 4580, 4616 & 4630,* all 7II; *T.M. & G.A.M. 5068, 5093 & 5101,* all 7II). IDAHO (*T.M. & G.A.M. 4999*). MONTANA (Rollins 1966, 1983; *T.M. & J.M.G. 5232, 5232a & 5260,* all 7II). UTAH (*T.M. & G.A.M. 5120,* 7II). WYOMING (Rollins 1966, 1983; *T.M. & L.M. 4658, 4663 & 4668,* all 7II; *T.M. & J.M.G. 5246 & 5247,* both 7II).
		20	BRITISH COLUMBIA (Mulligan 1964).
	21/2	21	ALBERTA (*T.M. & L.M. 4755,* 7II + 7I; *T.M. & M.H.B. 4738*).
	14	28	MASSACHUSETTS (Böcher 1969).
A. eschscholtziana Andrz.	32		BRITISH COLUMBIA (Taylor & Mulligan 1968, 32II).
A. exilis A. Nels.	7	14	YUKON (Böcher 1969). BRITISH COLUMBIA (Mulligan 1964; Taylor & Taylor 1977, 7II). MONTANA (Böcher 1969). WYOMING (Rollins 1966; Böcher 1969).
		ca. 21	UTAH (*T.M. & G.A.M. 5122*).

Table 1. Continued.

Taxon	n	$2n$	Sources of materials, vouchers or references, and special cytological information
A. fendleri (S. Wats.) Greene	7	14	CALIFORNIA (Rollins & Rüdenberg 1979). COLORADO (Rollins 1941, 1966). The $n = 14$ report for Colorado material in Rollins (1941) may be erroneous (Rollins, pers. corr.).
		21	NEVADA (Rollins & Rüdenberg 1979). The $n = 21$ report for Colorado material in Rollins (1941) is almost certainly erroneous.
A. glabra (L.) Bernh.	6	12	QUEBEC (*Gillett 10569,* $2n = 12$ by T.M.). ONTARIO (*Bowden,* $2n = 12$ by G.A.M.). ALBERTA (*T.M. & L.M. 4687*). CALIFORNIA (*T.M. 4542, 4515B & 4815,* all 6II; *Breedlove,* 6II by T.M.). COLORADO (Rodman & Bhargava 1976; *T.M. & G.A.M. 5104,* 6II). IDAHO (*T.M. 4795*). MONTANA (*T.M. & J.M.G. 5218,* meiosis regular). OREGON (*T.M. & L.M. 4359 & 4484,* 6II). WYOMING (*T.M. & L.M. 4669* 6II).
	8		VIRGINIA (Hill 1982).
A. glaucovalvula M.E. Jones	7		CALIFORNIA (Rollins & Rüdenberg 1979).
A. gunnisoniana Rollins	7		COLORADO (Rollins 1941).
A. hirsuta (L.) Scop. var. *hirsuta*	16		CALIFORNIA (*T.M. 4525,* 16II). COLORADO (*T.M. & J.M.G. 5347,* 16II).
A. hirsuta var. *pycnocarpa* (Hopkins) Rollins	16	32	MACKENZIE DISTRICT (Mulligan 1964). MANITOBA (Taylor & Brockman 1966). ALBERTA (*T.M. & L.M. 4688 & 4701,* 16II; *T.M. & M.H.B. 5184,* 16II). BRIT-

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
			ISH COLUMBIA (*T.M. & G.A.M. 4933,* 16II). CONNECTICUT (Rollins 1941). COLORADO (Rollins 1941). SOUTH DAKOTA (*T.M. & G.A.M. 5154 & 5155,* 16II). WISCONSIN (Smith 1938, 16II). The *n* = 32 chromosome-number by L.O. Gaiser in Rollins (1941) should be discounted until it is confirmed.
A. holboellii Hornem. var. *holboellii*	7	14	GREENLAND (Böcher 1954; Böcher 1969, some have completely normal meiosis and seem to be sexual whereas others probably are amphiapomictic or apomictic; Dalgaard 1988, 7II).
		21	GREENLAND (Böcher 1954; Böcher 1969, metaphases correspond to those of second division, PMCs have asyndetic metaphase plates with the somatic number; *Hansen et al. 2304,* 2*n* = *ca.* 21 by T.M.).
A. holboellii var. *consanguinea* (Greene) G. Mulligan	7		NEVADA (*T.M. & L.M. 4335 & 4337,* 7II).
	21/2	21	ALBERTA (*T.M. & L.M. 4696 & 4705*; *T.M. 5201,* *n* = *ca.* 21/2, meiosis irregular; *T.M. & M.H.B. 5212,* *n* = *ca.* 21/2). CALIFORNIA (*T.M. & P. Raven 4419*; *T.M. & L.M. 4440 & 4441,* *n* = 21/2). COLORADO (*T.M. & L.M. 4623*; *T.M. & G.A.M. 5094*). OREGON (*T.M. & L.M. 4485*; *T.M. & J.M.G. 5276*).

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
A. holboellii var. *retrofracta* (Graham) Rydb.	7	14	MANITOBA (Mulligan 1964; Löve & Löve 1982; *T.M. & L.M. 4911,* 7II). SASKATCHEWAN (Mulligan 1964; *T.M. & L.M. 4914 & 4915,* both 7II). ALBERTA (Mulligan 1964; *T.M. & L.M. 4683 & 4686,* both 7II; *T.M. & G.A.M. 4924,* 7II). BRITISH COLUMBIA (Mulligan 1964; *T.M. & L.M. 4454 & 4460,* both 7II; *J.A. Calder & J.M.G. 26537,* 7II by T.M.; *T.M. & G.A.M. 4935 & 4938,* both 7II; *T.M. & G.A.M. 4929, n* = 7, meiosis irregular). CALIFORNIA (Rollins 1941, 1966; Rollins & Rüdenberg 1977; *T.M. & P. Raven 4427,* 7II; *T.M., 4532*; *T.M. 4530, n* = 7 meiosis irregular). COLORADO (Rollins 1941; *T.M. & L.M. 4628,* 7II). IDAHO (Böcher 1969, meiosis regular with 7 bivalents, hundreds of anaphase I were normal, only tetrads were formed and pollen was uniform; *T.M. & G.A.M. 4967, 4970, 4972, 4997 & 4998,* all 7II). MONTANA (Rollins 1966, 1983). NEVADA (*T.M. & G.A.M. 5001 & 5008,* both 7II; *T.M. & G.A.M. 5013, n* = 7, irregular meiosis). OREGON (*T.M. & G.A.M. 4962,* 7II). SOUTH DAKOTA (*T.M. & G.A.M. 5151, n* = 7, irregular meiosis). WASHINGTON (Böcher 1969). WYOMING Rollins 1941, 1983; Böcher 1969; *T.M. & L.M. 4665,* 7II).
		14 + 1B	ALBERTA (Packer 1964). BRITISH COLUMBIA (Mulligan 1964).

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
	15/2		ALBERTA (*T.M., L.M. & M.H.B. 4735,* 7II +1I). BRITISH COLUMBIA (*T.M. & G.A.M. 4932*). COLORADO (*T.M. & G.A.M. 5097,* irregular meiosis).
	ca. 21/2	21	ALBERTA (*T.M. & G.A.M. 4922, n = ca.* 21/2). BRITISH COLUMBIA (*T.M. & L.M. 4452, n = ca.*21/2, meiosis irregular). IDAHO (*T.M. & L.M. 4156, n = ca.* 21/2, PMCs form dyads not tetrads). OREGON (*T.M. & L.M. 4353*). WYOMING (*T.M. & L.M. 4164, n* = 21/2). The *n* = 14 chromosome-number given in Rollins (1941) may be erroneous.
A. holboellii var. *secunda* (Howell) Jepson	7	14	QUEBEC (Böcher 1954). IDAHO (*T.M. & G.A.M. 4983,* 7II).
		21	BRITISH COLUMBIA (Mulligan 1964).
			UTAH (*T.M. & G.A.M. 5119*).
	ca. 22/2		UTAH (*T.M. & G.A.M. 4988*).
A. inyoensis Rollins		21	NEVADA (Rollins & Rüdenberg 1971).
		23	NEVADA (Rollins & Rüdenberg 1971).
A. kamtschatica (Fisch.) Ledeb.		32	ALASKA (Dawe & Murray 1979, 2*n* = 32 as on voucher in ALA not 2*n* = 16 as in paper; Rollins 1966, under *A. lyrata*). YUKON (Mulligan 1964, under *A. lyrata*). BRITISH COLUMBIA (Taylor & Mulligan 1968, Mulligan 1964, under *A. lyrata*). The GH voucher for *A. lyrata* ssp. *kamtschatica* of Johnson & Packer 1968 is *A. media.*

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
A. laevigata (Mühl) Poir.		7	CONNECTICUT (Rollins 1941). MARYLAND (Kovanda 1978). OHIO (Easterly 1963, 7II). WISCONSIN (Smith 1938, 7II).
A. lemmonii S. Wats.		14	ALBERTA (Mulligan 1964). BRITISH COLUMBIA (Mulligan 1964). WYOMING (Rollins 1966).
	ca. 21/2		MONTANA (*T.M. & J.M.G. 5229 & 5252*).
A. lignifera A. Nels.	7	14	COLORADO (Rollins 1941). WYOMING (Rollins 1941).
A. lyallii S. Wats.	21/2	21	ALBERTA (Mulligan 1964). BRITISH COLUMBIA (Mulligan 1964). UTAH (*T.M. & J.M.G. 5322, n* = 21/2).
A. lyrata L.	8	16	ONTARIO (Böcher 1969; *Garton 6191,* 8II by T.M.).
A. media N. Busch		16	ALASKA (Rollins 1966 under *A. lyrata* but voucher in GH is *A. media*); Johnson & Packer 1968 under *A. lyrata* subsp. *kamtschatica* but voucher in GH is *A. media*).
A. microphylla Nuttall	7	14	BRITISH COLUMBIA (Mulligan 1964). OREGON (Rollins 1941).
	15/2	15	WYOMING (Böcher 1969, PMCs form dyads and anaphases initiating dyads were all regular with 15 chromosomes). The *n* = 14 chromosome-number in Rollins (1941) may be erroneous.
A. parishii S. Wats.	7		CALIFORNIA (Rollins & Rüdenberg 1979).

Table 1. Continued.

Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
A. pendulina Greene	7	14	UTAH (Böcher 1969, pollen was uniform).
A. perennans S. Wats.	7	14	COLORADO (Rollins 1941). ARIZONA (Rollins & Rüdenberg 1971).
A. perstellata Braun	7		TENNESSEE (Rollins 1966).
A. petiolaris (Gray) Gray	14	*ca.* 28	TEXAS (Rollins & Rüdenberg 1977).
A. pinetorum Tidestrom	7	14	ALASKA (Dawe & Murray 1979 under *A. holboellii* but voucher in ALA is *A. pinetorum*). CALIFORNIA (*T.M. 4547*, $n = 7$, meiosis irregular).
		13 + 2B	MANITOBA (Mulligan 1964 under *A. holboellii*).
	21/2	21	CALIFORNIA (*T.M. & L.M. 4439*; Rollins & Rüdenberg 1971). NEVADA (*T.M. 4536*). WYOMING (Rollins 1966).
A. puberula A. Nels.	7		NEVADA (*T.M. & L.M. 4337*, 7II).
	21/2		OREGON (*T.M. & L.M. 4347 & 4349*).
A. pulchra M.E. Jones	7	14	NEVADA (Rollins & Rüdenberg 1979).
			UTAH (Rollins & Rüdenberg 1971).
		21	NEVADA (Rollins & Rüdenberg 1979).
			UTAH (Rollins & Rüdenberg 1971).
A. repanda S. Wats.	7		CALIFORNIA (Rollins 1941).
A. schistacea Rydb.		14	UTAH (Böcher 1969, pollen is uniform).
A. selbyi Rydb.		*ca.* 21	COLORADO (Rollins & Rüdenberg 1977).

Table 1. Continued.

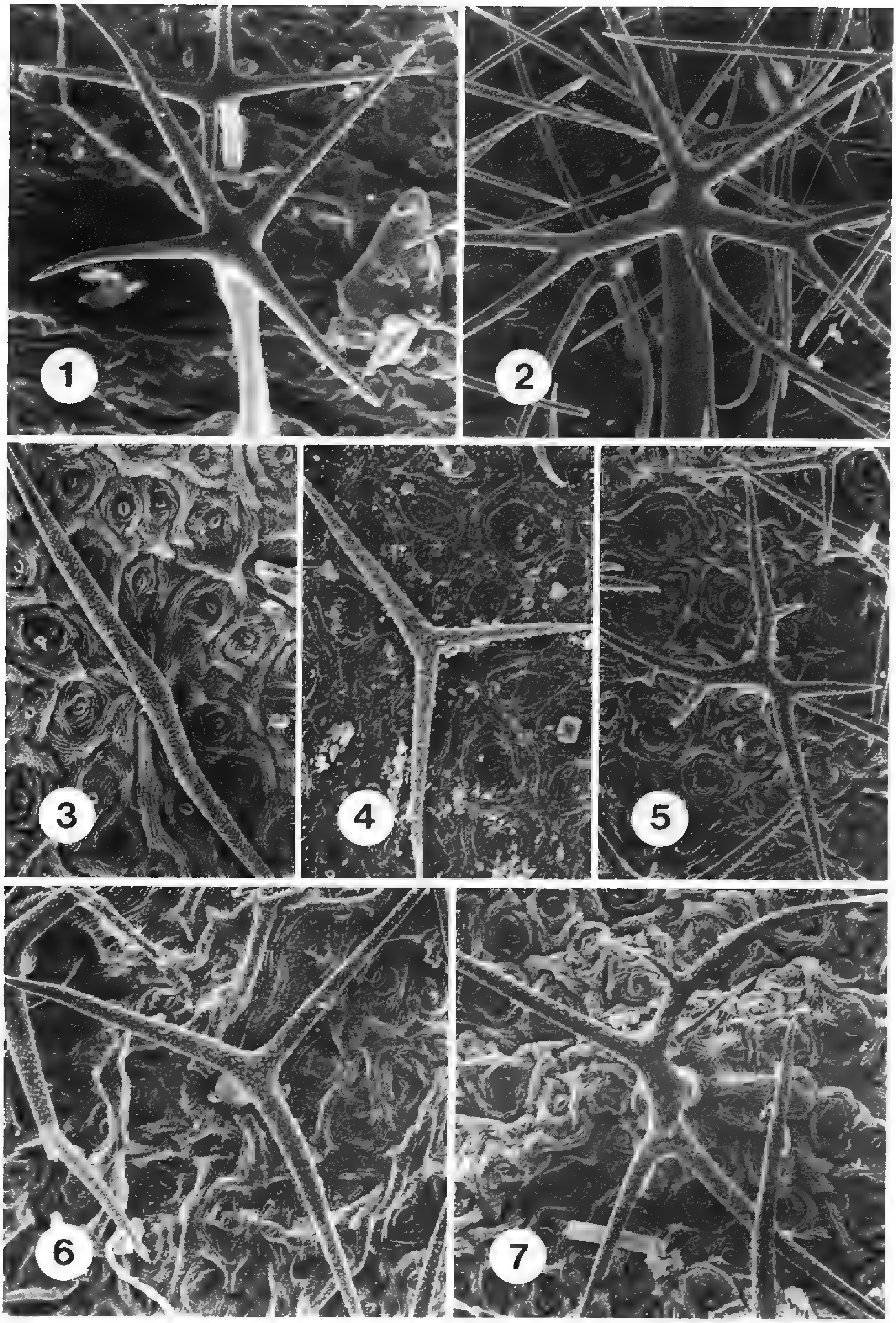
Taxon	*n*	2*n*	Sources of materials, vouchers or references, and special cytological information
A. serotina Steele		14	VIRGINIA (Wieboldt 1987).
A. sparsiflora Nuttall	7		ARIZONA (*T.M. & L.M. 4245,* meiosis irregular). IDAHO (*T.M. & L.M. 4338 & 4352,* both 7II).
	22/2	22	CALIFORNIA (Raven *et al.* 1965; Böcher 1969, 7II + 8I at metaphase I).
A. subpinnatifida S. Wats.		7	OREGON (Rollins & Rüdenberg 1977).

= 14 in Austria, Sweden, France and Germany (Burdet, 1967). However, he does not think that it is related to North American *Arabis* with the base number $x = 7$. He points out that this species has baffled European taxonomists, who have placed it at various times in the genera *Turritis, Brassica, Conringia* and even *Erysimum.*

The eight North American species of *Arabis* with the base number of $x = 8$, and *A. glabra,* with $x = 6$ and 8, all appear to produce seed sexually. All of the material, with these base numbers, examined by the author and by other workers on North American material and plants from continents, had a regular meiosis and/or lacked triploids, and, with the exception of *A. caucasica,* had a very high seed set when found growing in isolation. They are, therefore, almost certainly sexual and self-compatible. Burdet (1967) considers $x = 8$ to be the common basic chromosome-number of European and Asiatic *Arabis.* He does suggest that the base number may even be $x = 4$ because of chromosome-counts of $2n = 8$ for plants of *A. hirsuta* from Switzerland and France. Burdet (1967) states that the somatic chromosomes of *A. glabra* are quite different from those of other *Arabis,* supporting other evidence that it perhaps could be placed in another genus.

TRICHOMES IN *ARABIS*

The trichomes on the undersurfaces of the caudex leaves, when present, often differ from taxon to taxon. They vary from simple or once-forked to dendritic or stellate and the more complex ones are from sessile to long-stalked. Scanning electron microscope (SEM) photographs of the more complex trichomes are shown in Figures 1 to 20. Where the trichomes are similar, a close relationship may be indicated. This seems to be the case for *A. drummondii, A. calderi, A. lyallii, A. divaricarpa* var. *divaricarpa* and *A. divaricarpa* var. *dacotica* (Figures 3 to 7, respectively). In most cases, the trichomes are very different in form and/or size; for example *A. caucasica* (Figure 2), *A. microphylla* (Figure 13), *A. sparsiflora* (Figure 18) and *A. pinetorum* (Figure 20). These differences in the morphology and size of trichomes on the undersurfaces of the caudex leaves have been used extensively in the key to separate taxa.



Figures 1–7. SEM photographs of *Arabis* trichomes; all ×150. Figure 1, *A. alpina.* Figure 2, *A. caucasica.* Figure 3, *A. drummondii.* Figure 4, *A. calderi.* Figure 5, *A. lyallii.* Figure 6, *A. divaricarpa* var. *divaricarpa.* Figure 7, *A. divaricarpa* var. *dacotica.*

TAXONOMIC TREATMENT

KEY TO TAXA OF *ARABIS* OF CANADA, ALASKA AND GREENLAND

1. Bases of middle cauline leaves all attenuate, cuneate, obtuse, to truncate, never clasping stems 2

2. Siliques strongly descending to pendulous 3

3. Stems 3 to 9 dm high; biennials, usually lacking caudex leaves as plants mature; caudex leaves, if present, glabrous or with simple to once-branched trichomes to 0.5 mm long; siliques 2.0 to 3.25 mm wide; seeds prominently winged; sw Que., s Ont., and southward . . . . **11.** *A. canadensis*

3. Stems usually less than 3 dm high; perennials with persistent caudex leaves; surfaces of caudex leaves with short-stalked (less than 0.063 mm long) semistellate trichomes mostly 0.125 mm wide; siliques 1.5 to 2.0 mm wide; seeds only slightly winged; Yukon, Sask. (Cypress Hills), sw Alta., B.C., and southward . . . . **22.** *A. exilis*

2. Siliques ascending to erect 4

4. Siliques strongly ascending to erect; surfaces of caudex leaves glabrous or with short-stalked (less than 0.063 mm long) semidendritic to dendritic trichomes mostly 0.125 mm wide; sw Yukon, s B.C., and southward . . . . **21.** *A. murrayi*

4. Siliques ascending; surfaces of caudex leaves with simple or medium- to long-stalked (0.063 mm long or longer) 1- to 2-branched, -forked or -rayed trichomes from 0.25 to 1.5 mm long or wide 5

5. Some caudex leaf blades with a larger terminal segment and two to many much smaller lateral segments or prominent lobes 6

6. Petals 6.0 to 8.0 mm long; siliques 0.75 to 1.0 mm wide; beaks of siliques 0.5 to 1.0 mm long, much longer than wide; surfaces of caudex leaves with few to many simple trichomes 0.75 to 1.25 mm long; larger terminal segments of caudex leaves usually ovate; Ont., Man., Sask., Alta., and southward . . . . **4.** *A. lyrata*

6. Petals (4.0) 5.0 to 5.5 mm long; siliques 1.25 to 1.5 mm wide; beaks of siliques usually less than 0.5 mm long, shorter to slightly longer than wide; surfaces of caudex leaves usually glabrous, rarely with few to scattered 2-forked or -rayed trichomes to 0.75 mm long; larger terminal segments of caudex leaves usually broadly ovate to orbicular; Alaska, westward into Russia, Yukon, Mack. Dist., n Sask., sw Alta., B.C., and Wash. . . . . **5.** *A. kamtschatica*

5. All caudex leaf blades entire, sparingly toothed or with one to few pairs of shallow to deep lobes; none of leaf blades with a larger terminal segment and smaller lateral segments or prominent lobes 7

7. Petals (4.5) 7.0 to 8.0 mm long; outer sepals prominently saccate at base; surfaces of caudex leaves mostly with simple trichomes 0.75 to 1.5 mm long; Yukon (rare), sw Alta., se B.C., and southward . . . . **10.** *A. nuttallii*

7. Petals 4.0 to 5.5 mm long; outer sepals weakly saccate; surfaces of caudex leaves glabrous or mostly with branched or rayed trichomes less than 0.75 mm long or wide 8

8. Siliques subterete with prominent midvein from base to apex, 0.75 to 1.0 (1.25) mm wide; surfaces of caudex leaves mostly with medium-stalked (0.063 to 0.125 mm long) 2- to 3-rayed trichomes; n Alaska, westward into Russia, and n Yukon . . . . **2.** *A. media*

8. Siliques flattened, prominent midvein absent towards apex, 1.5 to 2.5 (3.0) mm wide; surfaces of caudex leaves glabrous or with simple and long-stalked (over 0.125 mm long) branched or rayed trichomes 9

9. Plants glabrous, except for occasional simple trichomes on leaf margins; Mack. Dist., Keew. Dist., Frank. Dist., Greenland, Labrador, n Que., n Ont., and n Sask. . . . . **3a.** *A. arenicola* var. *arenicola*

9. Plants with copious simple, 1- to 2-branched and long-stalked 2-rayed trichomes on stem and leaf surfaces; Keew. Dist., n Que., n Ont., n Man., and n Sask. . . . . **3b.** *A. arenicola* var. *pubescens*

1\. Bases of middle cauline leaves always auriculate-, hastate-, to sagittate-clasping stems 10

  10\. Caudex leaves glabrous, or absent when plants mature 11

    11\. Siliques erect-appressed to rachis 12

      12\. Siliques subterete; petals yellow, about as long as sepals; biennials with basal leaves few or absent as plants mature; bases of stems with spreading trichomes; Alaska, Yukon, Mack. Dist., Que., Ont., Man., Sask., Alta., B.C., southward, Europe, and Asia .... *A. glabra*

      12\. Siliques strongly flattened; petals whitish to purplish, about twice as long as sepals; short- to long-lived perennials with caudex leaves persisting as plants mature; bases of stems glabrous or with malpighiaceous trichomes; Alaska, Yukon, Mack. Dist., Nfld., N.S., N.B., Que., Ont., Man., Sask., Alta., B.C., and southward .... **14.** *A. drummondii*

    11\. Siliques descending, spreading, ascending to strongly ascending 13

      13\. Inflorescences secund; Yukon (rare), w Alta., B.C., and southward .... **18.** *A. lemmonii*

      13\. Inflorescences symmetrical 14

        14\. Siliques strongly ascending, (2.0) 2.25 to 3.5 mm wide; stems 1.0 to 2.5 (4.0) dm high; persistent perennials with much branched, many-stemmed, caudexes; sw Alta., s B.C., and southward .... **16.** *A. lyallii*

        14\. Siliques descending, spreading to ascending, 0.75 to 2.0 mm wide; stems (2) 3 to 10 dm high; biennials or short-lived perennials with basal leaves often absent as plants mature; single to few stemmed 15

          15\. Siliques up to 25 mm long and 0.75 mm wide, with a scattered simple to once-forked puberulence; petals up to 2.0 mm long; Essex Co. Ont., and southward .... **13.** *A. shortii*

          15\. Siliques more than 25 mm long and 0.75 mm wide, glabrous, petals longer than 2.0 mm 16

16. Cauline leaves more than 10 mm wide; basal leaves usually absent; siliques spreading and strongly downwardly arcuate; sw Que., s Ont., and southward . . . . **12.** *A. laevigata*

16. Cauline leaves mostly less than 10 mm wide; basal leaves mostly persisting; siliques descending, spreading to ascending, straight to slightly arcuate; Alaska (rare), Yukon, Mack. Dist., Que., N.B. (rare), Ont., Man., Sask., Alta., B.C., and southward . . . . **17a.** *A. divaricarpa* var. *divaricarpa*

10. Caudex leaves present and hairy 17

17. Surfaces of caudex leaves with simple trichomes only; siliques spreading and strongly downwardly arcuate; sw Que., s Ont., and southward . . . . **12.** *A. laevigata*

17. Surfaces of caudex leaves with some forked or rayed trichomes; if siliques are spreading and strongly downwardly arcuate, the trichomes on surfaces of caudex leaves are all forked or rayed 18

18. Siliques all strongly descending, pendulous to downwardly-appressed to rachis 19

19. At least one-half of fruiting pedicels semigeniculate to geniculate at their bases 20

20. All fruiting pedicels strongly geniculate at their bases; siliques 1.0 to 1.5 mm wide; middle and upper cauline leaves revolute at edges; Alaska, Yukon, Mack. Dist., Que. (rare), Ont. (rare), Man., Sask., Alta., B.C., and southward . . . . **25c.** *A. holboellii* var. *retrofracta*

20. About one-half of fruiting pedicels semigeniculate to geniculate at their bases; siliques 1.25 to 2.5 mm wide; middle and upper cauline leaves flat at edges 21

21. Siliques 1.75 to 2.5 mm broad; Greenland . . . . . . **25a.** *A. holboellii* var. *holboellii*

21. Siliques 1.25 to 1.5 mm broad; Alaska, Yukon, Mack. Dist., Que., (rare, but common in Gaspé), Ont. (rare), Sask., Alta., B.C., and southward . . . . **25d.** *A. holboellii* var. *secunda*

19. Fruiting pedicels gradually to abruptly reflexed near their bases, never semigeniculate or geniculate 22
    22. Undersurfaces of caudex leaves mostly with short-stalked (less than 0.063 mm long), semidendritic to dendritic, unbranched to few-branched, 2- to 3-forked trichomes 0.25 to 0.35 mm long; these trichomes often semi-appressed to leaf surfaces and pointing towards apexes; Alaska, Yukon, Mack. Dist., Man., Sask., Alta., B.C., and southward .... **30.** *A. pinetorum*
    22. Undersurfaces of caudex leaves with sessile to medium-stalked (to 0.125 mm long), semistellate to stellate, unbranched to many-branched, 3- and 4-rayed trichomes from 0.125 to 0.35 mm wide 23
        23. Middle cauline leaves weakly auriculate-, hastate- to sagittate-clasping stems; undersurfaces of caudex leaves with short-stalked (less than 0.063 mm long) semistellate trichomes, mostly 0.125 mm wide; Yukon, Sask. (Cypress Hills), sw Alta., and southward .... **22.** *A. exilis*
        23. Middle cauline leaves strongly auriculate-, hastate- to sagittate-clasping stems; undersurfaces of caudex leaves with nearly sessile stellate trichomes, mostly 0.25 to 0.35 mm wide; Sask., Alta, B.C., and southward .... **25b.** *A. holboelli* var. *consanguinea*
18. Siliques slightly descending, spreading, strongly ascending to erect-appressed to rachis 24
    24. Undersurfaces of caudex leaves mostly with medium- to long-stalked (over 0.063 mm long) rayed or forked trichomes; simple trichomes on surfaces of caudex leaves present or absent 25
    25. Siliques arcuate-spreading to arcuate-descending 26
        26. Undersurfaces of caudex leaves mostly with 2- and 3-forked trichomes; fruiting

plants usually have sterile rosettes with strongly ascending leaves; s B.C. (Penticton area) and southward . . . . **28.** *A. sparsiflora*

26. Undersurfaces of caudex leaves mostly with 3- and 4-rayed trichomes; fruiting plants lacking sterile rosettes; Yukon, sw Alta., B.C., and southward . . . . **29.** *A. columbiana*

25. Siliques mostly straight and ascending, strongly ascending to erect-appressed to rachis 27

27. Cauline and caudex leaves with similar dentate to subdentate margins; flowering stems spreading to ascending 28

28. Petals less than 10 mm long and 3.5 mm wide; plants self-compatible, forming well-developed siliques; undersurfaces of caudex leaves mostly with unbranched cruciform trichomes 0.25 mm wide; Frank. Dist., Keew. Dist., Greenland, Nfld., and Que. . . . . **8.** *A. alpina*

28. Petals more than 10 mm long and 3.5 mm wide; self incompatible; isolated plants with aborted siliques; undersurfaces of caudex leaves mostly with short-branched cruciform to 5-or-more-rayed trichomes; rare garden escape in Que., Ont., and B.C. . . . . **9.** *A. caucasica*

27. Cauline and caudex leaves not similarly dentate to subdentate; flowering stems erect 29

29. Siliques ascending; caudex leaves with unbranched to few-branched, 2- and 3-rayed, medium-stalked (0.063 to 0.125 mm long) trichomes; siliques 1.5 to 1.75 mm wide; Yukon (rare), and B.C. (rare) . . . . **20.** *A. codyi*

29. Siliques strongly ascending to erect-appressed to rachis; caudex leaves with simple to medium- (0.063 to 0.125 mm) and long- (over 0.125 mm) stalked 2- to 3-forked trichomes; siliques 1.0 to 1.75 mm wide 30

30. Biennials; petals yellow; outer sepals not saccate at bases; siliques subterete; middle and upper cauline leaves glabrous and glaucous; Alaska, Yukon, Mack. Dist., Que., Ont., Man., Sask., Alta., B.C., southward, Europe, and Asia . . . . **1.** *A. glabra*

30. Biennials to short-lived perennials; petals white to purple; outer sepals saccate at bases; siliques strongly flattened; middle and upper cauline leaves pubescent, at least at bases, not glaucous 31

31. Petals small, 3 to 5 mm long; siliques 1.1 mm wide or narrower, erect-appressed to rachis; outer sepals moderately saccate at bases; cauline leaves approximate to remote 32

32. Mostly perennials; siliques beakless or nearly so; B.C. (rare); Calif., Col. and Nevada and probably more widespread south of our range; Europe . . . . **6a.** *A. hirsuta* var. *hirsuta*

32. Biennials to short-lived perennials; beaks of siliques mostly 0.5 to 1.25 mm long; Alaska, Yukon, Mack. Dist., N.S., N.B., Que., Ont., Man., Sask., Alta, B.C., and southward . . . . **6b.** *A. hirsuta* var. *pycnocarpa*

31. Petals larger, (6) 7 to 9 (9.5) mm long; siliques 1.25 to 1.75 mm wide, somewhat divergent; outer sepals prominently saccate at bases; cauline leaves remote; Alaska and westward, Yukon, B.C. and southward . . . . **7.** *A. eschscholtziana*

24. Undersurfaces of caudex leaves mostly with sessile to short-stalked (less than 0.063 mm long) rayed or forked trichomes; simple trichomes on surfaces of caudex leaves absent 33

33. Undersurfaces of caudex leaves with unbranched to few short-branched 2- to 3-rayed or forked trichomes 34

34. Siliques erect, often appressed to rachis 35

    35. Undersurfaces of rosette or caudex leaves with malpighiaceous trichomes only; Alaska, Yukon, Mack. Dist., Nfld., N.S., N.B., Que., Ont., Man., Sask., Alta., B.C., and southward . . . . **14.** *A. drummondii*

    35. Undersurfaces of caudex leaves mostly with sessile 3-rayed trichomes or short-stalked 2- and 3-rayed trichomes 36

        36. Undersurfaces of caudex leaves mostly with unbranched, sessile, 3-rayed trichomes 0.25 to 0.35 mm wide; rays of trichomes appressed to leaf surfaces; bases of middle cauline leaves strongly clasping stems; sw Yukon, Mack. Dist. (rare), sw Alta., B.C., and probably southward . . . . **15.** *A. calderi*

        36. Undersurfaces of caudex leaves glabrous or with mostly unbranched to few-branched, short-stalked 2- and 3-rayed trichomes 0.125 mm wide; rays and branches of trichomes elevated from leaf surfaces; bases of middle cauline leaves cuneate, truncate to very weakly auriculate; sw Yukon, s B.C., and southward . . . . **21.** *A. murrayi*

34. Siliques strongly descending, descending to ascending 37

    37. Siliques to 25 mm long and 0.75 mm wide with a scattered, simple to bifurcate puberulence; petals up to 2.0 mm long; Essex Co., Ont., and southward . . . . **13.** *A. shortii*

    37. Siliques more than 25 mm long and 0.75 mm wide, glabrous; petals longer than 2.0 mm 38

        38. Stems 0.7 to 2.5 (4.0) dm high; perennials with persistent, often branched, caudexes 39

39. Siliques 2.0 to 3.5 mm wide; undersurfaces of caudex leaves with sessile to short-stalked (less than 0.063 mm long) unbranched to 2-branched, 3-rayed trichomes from 0.25 to 0.35 mm wide; siliques spreading to ascending or strongly ascending; inflorescences symmetrical to secund 40
    40. Undersurfaces of caudex leaves with short-stalked, semistellate 1- to 2-branched, 3-rayed trichomes; siliques spreading to ascending; inflorescences secund; sw Yukon, sw Alta., B.C., and southward . . . . **19.** *A. drepanoloba*
    40. Undersurfaces of caudex leaves with sessile to short-stalked, unbranched, 3-rayed trichomes; siliques strongly ascending; inflorescences symmetrical; sw Alta., s B.C., and southward . . . . **16.** *A. lyallii*
39. Siliques 1.5 to 1.75 mm wide; undersurfaces of caudex leaves with medium-stalked (0.063 to 0.125 mm long), unbranched to few-branched, 2- and 3-forked trichomes from 0.125 to 0.25 mm long; siliques ascending; inflorescences symmetrical; sw Yukon, and nw B.C. . . . . **20.** *A. codyi*

38. Stems (2) 3 to 10 dm high; biennials or short-lived perennials with compact caudexes that tend to become reduced in size as plants mature 41
41. Undersurfaces of caudex leaves with unbranched to many prominently branched, sessile to short-stalked, 3-rayed trichomes, mostly less than 0.35 mm wide 42
    42. Undersurfaces of caudex leaves with unbranched, sessile or nearly

sessile, 3-rayed trichomes with rays appressed to leaf surfaces; inflorescences symmetrical; siliques descending, spreading to ascending; Alaska (rare), Yukon, Mack. Dist., N.B. (rare), Que., Ont., Man., Sask., Alta., B.C., and southward .... **17a.** *A. divaricarpa* var. *divaricarpa*

42. Undersurfaces of caudex leaves with short-stalked, 3-rayed trichomes; the rays elevated above the leaf surfaces with numerous prominent branches; inflorescences semisecund to secund; siliques slightly to strongly descending; Sask., southward into U.S.A., and disjunct to Que. (rare in Gaspé) . **26.** *A. boivinii*

41. Undersurfaces of caudex leaves with unbranched to few weakly branched, short-stalked, 3-rayed trichomes, mostly more than 0.35 mm wide; se Alaska, Yukon, Mack. Dist., Que. (rare), n Ont., Man., Sask., Alta., B.C., and southward .... **17b.** *A. divaricarpa* var. *dacotica*

33. Undersurfaces of caudex leaves with unbranched to many-branched 3- and 4-rayed trichomes 43

43. Trichomes on undersurfaces of caudex leaves mostly less than 0.25 mm wide; siliques 1.25 to 2.0 mm wide 44

44. Trichomes on undersurfaces of caudex leaves mostly between 0.125 and 0.25 mm wide; inflorescences secund; siliques mostly spreading; Yukon (rare), Alta., B.C., and southward .... **18.** *A. lemmonii*

44. Trichomes on undersurfaces of caudex leaves mostly 0.125 mm wide; inflorescences symmetrical; siliques mostly ascending; s B.C., and southward .. .. **23.** *A. microphylla*

43. Trichomes on undersurfaces of caudex leaves mostly 0.25 or more mm wide; siliques 1.5 to 3.0 mm wide 45
  45. Inflorescences secund; siliques 2.25 to 3.0 mm wide; sw Yukon, sw Alta., B.C., and southward . . . . **19.** *A. drepanoloba*
  45. Inflorescences symmetrical to slightly secund; siliques 1.5 to 2.0 mm wide 46
    46. Siliques strongly ascending to erect; trichomes on undersurfaces of basal leaves short-stalked, semidendritic; stems 5 to 20 (40) cm high; s B.C., and southward . . . . **24.** *A. depauperata*
    46. Siliques spreading to descending; trichomes on undersurfaces of caudex leaves nearly sessile, semistellate to stellate; stems 30 to 60 cm high 47
      47. Inflorescences symmetrical; trichomes on undersurfaces of caudex leaves mostly 0.25 mm wide; strongly perennial; frequently many stemmed; s B.C., and southward . . . . **27.** *A. lignifera*
      47. Inflorescences slightly secund; trichomes on undersurfaces of caudex leaves more than 0.25 mm wide; biennial or shortlived perennials; usually one to few stemmed; Sask., southward into U.S.A., and Que. (rare in Gaspé) . . . . **26.** *A. boivinii*

1. **Arabis glabra** (L.) Bernh., Syst. Verg. erf. 195. 1800. Based on *Turritis glabra* L., Sp. Pl. 2: 666. 1753; Habitat in Europae, Hort. Cliff. 339. See Hopkins (1937) pp. 106 & 107 for summary of synonymy.

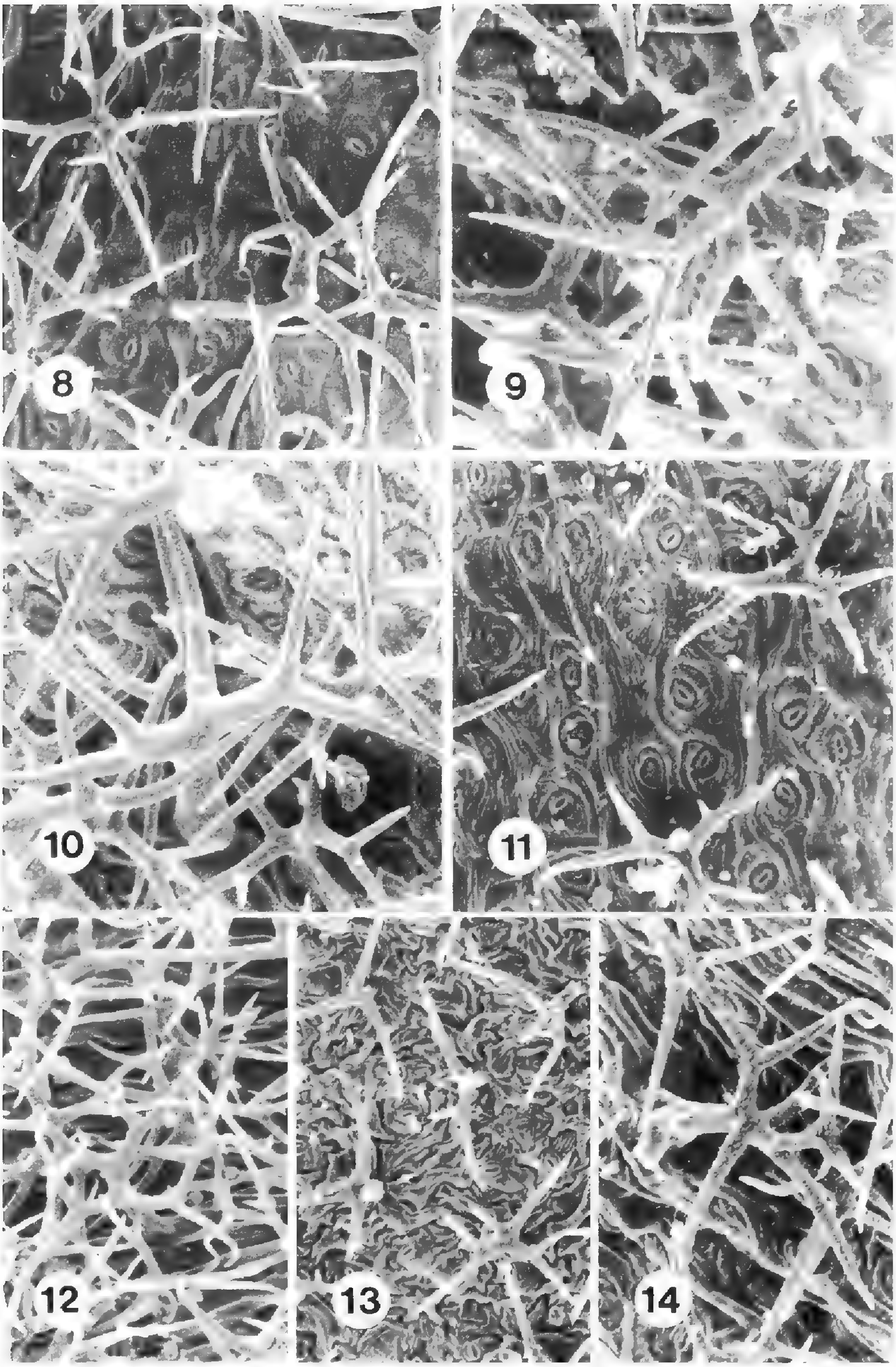
Arabis macrocarpa (Nutt.) Torr., Bot. Mex. Boundary pt. 1: 32. 1838. Based on *Turritis macrocarpa* Nutt. in T.&G., Fl. N. Am. 1: 78. 1838; Rocky situations in woods of Oregon (HOLOTYPE PH!)

Arabis glabra var. *furcatipilis* Hopkins, Rhodora 39: 109. 1937; Logan City Camp, Logan Canyon, Utah, *B. Maguire 3437* (HOLOTYPE GH!).

DISTRIBUTION. It is a native of Europe and western Asia, except in the extreme north and south, and, according to Hultén (1971) has been introduced into Africa and Australia. In North America, it is distributed widely in temperate areas of Alaska, Yukon, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia and, from Hopkins (1937), southward from Maine to North Carolina and westward to Washington, Oregon and California. It is obviously introduced at a few weedy sites in Alaska and Yukon, but occurs both in weedy and native habitats further south, particularly on sandy and sandy-loam soils of roadsides, railway embankments, open fields, riverbeds, outcrops, ledges, cliffs and openings in thickets and woods.

BIOLOGICAL NOTES. This species is sometimes removed from *Arabis* and placed in the genus *Turritis,* mostly because of its subterete siliques. I prefer to follow the treatment of Rollins (1941, p. 316) and include it in *Arabis.*

The chromosome-number $n = 6$, $2n = 12$ was obtained on North American material of *A. glabra* from Quebec, Ontario, Alberta, California, Colorado, Idaho, Montana, Oregon and Wyoming (Table 1). Pollen mother cells had 6 pairs at meiosis. Burdet (1967), combining his cytological observations and those of previous workers, reported only $2n = 12$ for plants of Canada, Austria, Bulgaria, Czechoslovakia, England, France, Germany, Hungary, Sweden and Switzerland. The $n = 8$ count of Hill (1982) on material from Virginia, therefore, needs clarification. Burdet (1967) states that the somatic chromosomes of this species are quite different from those of other *Arabis,* and uses this as a further argument that it should be placed in the genus *Turritis.* There is every indication that *A. glabra* reproduces sexually and that abundant viable seed is normally produced by selfing.



Figures 8–14. SEM photographs of *Arabis* trichomes; all ×150. Figure 8, *A. lemmonii.* Figure 9, *A. drepanoloba.* Figure 10, *A. codyi.* Figure 11, *A. murrayi.* Figure 12, *A. exilis.* Figure 13, *A. microphylla.* Figure 14, *A. depauperata.*

2. **Arabis media** N. Busch, Fl. Sib. Orient. Extrem. 1: 465. 1926; figure p. 464. *Cardaminopsis media* (N. Busch) O. E. Schulz in Engler & Prantl, Nat. Pflanzenf. 17b: 541. 1936.

Arabis media DC. var. *glabra* (DC.) Busch, Fl. Sib. Orient. Est. 4: 465. 1926. Based on part of *Arabis ambigua* DC. var. *glabra* DC., Syst. 2: 121. 1821; Unalaska.

Arabis media var. *intermedia* (DC.) Busch, Fl. Sib. Orient. Est. 4: 465. 1926. Based on part of *Arabis ambigua* DC. var. *intermedia* DC., Syst. 2: 121. 1821: Unalaska.

DISTRIBUTION. It is native to sand dunes, sand bars, tundra tussocks, disturbed gravel, river terraces and volcanic ash in arctic regions of northern Yukon, northern Alaska and adjacent northeastern Siberia. According to the distribution in the map of *Arabis arenicola* in Hultén (1968) the map should be that of *A. media.*

BIOLOGICAL NOTES. This taxon has subterete siliques, with a prominent midvein from base to apex, rather than the flattened siliques, with prominent midvein absent towards the apex, that is characteristic of most of our *Arabis* species. *Arabis media* has accumbent cotyledons. I do not consider the siliques of this species sufficiently different from our *Arabis* to warrant placing it in another genus. In fact, many workers have erroneously included specimens of *A. media* in *A. arenicola.*

Arabis media plants from two locations in Alaska had 16 somatic chromosomes (Table 1). Its basic number of $x = 8$ is the common one in Eurasiatic species of *Arabis.* It seems likely that *A. media* is a sexual species that produces seed primarily by selfing.

3a. **Arabis arenicola** (Richardson) Gelert var. **arenicola.** *Arabis arenicola* (Richardson) Gelert, Bot. Tidsk. 21: 289, 290. 1898. Based on *Eutrema arenicola* Richardson in Hooker, Fl. Bor.-Am. 1: 67. 1830; Deep sand upon shores of Arctic America, between long 107° and 150°, *Dr. Richardson* (ISOTYPE, CAN!).

Arabis humifusa (J. Vahl) S. Wats., Proc. Am. Acad. 25: 124. 1889. Based on *Sisymbrium humifusum* J. Vahl, Fl. Dan. t. 2297. 1840.

An excellent discussion of the systematics and nomenclature of *A. arenicola* var. *arenicola* and var. *pubescens* is presented on pages 77 to 80 of Hopkins (1937).

Distribution. It is a native on sandy beaches, river banks and dunes, and on rocky shores along the north coast of Canada from the Mackenzie District to Labrador, on Southampton Island, on Baffin Island, along shores and on islands in Hudson Bay, Kenora District in northern Ontario, south shore of Lake Athabasca in northern Saskatchewan and in Greenland.

Biological Notes. The chromosome number $n = 8$, $2n = 16$ has been obtained for plants of this species from Greenland and Quebec (Table 1). It has the same basic number, $x = 8$, as *A. media.* Both var. *arenicola* and var. *pubescens* are probably sexual taxa producing seed primarily by selfing.

3b. **Arabis arenicola** var. **pubescens** (S. Wats.) Gelert, Bot. Tidsk. 21: 290. 1898. Based on *A. humifusa* (J. Vahl) S. Wats. var. *pubescens* S. Wats. in Gray, Synop, Fl. N. Am. 1: 160. 1895.

Distribution. It is native on sandy and gravel beaches and river banks along the east and west coasts of Hudson Bay and on adjacent islands in the Keewatin District, Quebec, Ontario and Manitoba, Kenora District in northern Ontario and on the south shore of Lake Athabasca in northern Saskatchewan.

4. **Arabis lyrata** L., Sp. Pl. 2: 665. 1753; Habitat in Canada, D. Kalm, Gron. virg. 76.

See Hopkins (1937), page 89 for synonomy.

Distribution. It is native on ledges and cliffs in thickets and woods and on sandy or rocky shores of streams, rivers and lakes in the southern half of Ontario, Manitoba (rare), Saskatchewan, Alberta (localized) and in British Columbia (rare). It occurs as a rare introduction in the Mackenzie District and in Alaska. It is found in Vermont, to New Jersey and Georgia, west to Missouri, and north to Wisconsin (Rollins, 1993b).

Biological Notes. *Arabis lyrata* material from two locations in Ontario had 16 somatic chromosomes (Table 1). Pollen mother cells had 8 pairs at meiosis. It is a diploid with the basic chromosome-number of $x = 8$, the same base number as *A. kamtschatica,* a tetraploid species that is frequently considered a variety or subspecies of *A. lyrata.* Other closely related taxa, are *A.*

media and *A. arenicola,* both diploids based on $x = 8$. *Arabis lyrata* is likely a sexual species producing seed by selfing.

5. **Arabis kamtschatica** (Fisch.) Ledeb., Fl. Ross. 1: 121. 1842; Kamtschatka, *ex* herb. Fisch. & labelled *Arabis kamtschatika* Fisch. (LECTOTYPE chosen LE!) *Arabis lyrata* var. *kamtschatica* Fisch. *ex* DC. Syst. 2: 231. 1821. *Arabis lyrata* subsp. *kamtschatica* (Fisch.) Hultén, Fl. Aleut. Is. 202: 1937.

Arabis kamtschatica var. *glabra* (DC.) N. Busch, Fl. Sib. Orient. Est. 4: 468. 1926. *Arabis lyrata* var. *glabra* (DC.) Hopkins, Rhodora 39: 93. 1937. Based on part of *Arabis ambigua* DC. var. *glabra* DC., Syst. 2: 121. 1821; Unalaska.

Arabis kamtschatica var. *intermedia* (DC.) N. Busch, Fl. Sib. Orient. Est. 4: 468. 1926; *Arabis lyrata* var. *intermedia* (DC.) Farwell, Mich. Acad. Sci. Rep. 256. 1917. Based on part of *Arabis ambigua* DC. var. *intermedia* DC., Syst. 2: 121. 1821; Unalaska.

Arabis occidentalis (Wats.) Nelson, Univ. Wyoming Pub. 3: 111. 1937. Based on *Arabis lyrata* var. *occidentalis* S. Wats. in Gray Syn. Fl. N. Am. 1: 159. 1895; Unalaska.

DISTRIBUTION. Moist and spring-flooded habitats in Alaska, Aleutian Islands eastern Asia, Yukon, Mackenzie District, British Columbia, Washington and south shore of Lake Athabaska in northern Saskatchewan.

BIOLOGICAL NOTES. The chromosome number $2n = 32$ has been obtained on plants growing in Alaska, Yukon and British Columbia (Table 1). It is a tetraploid with the base number of $x = 8$. It is likely a sexual species producing seed by selfing.

6a. **Arabis hirsuta** (L.) Scop. var. **hirsuta.** *Arabis hirsuta* (L.) Scop., Fl. Carn. 2: 30. 1772. Based on *Turritis hirsuta* L., Sp. Pl. 2: 666. 1753; Hort cliff. 339, habitat in Sueciae, Germaniae and Angliae.

DISTRIBUTION. Known from only one location in Canada (Mountain Creek campground and roadside, 51°26′N 117°30′W, Glacier National Park, British Columbia, elev. 2850 ft., *Haber & Shchepanek 1685,* CAN). I have seen specimens in DAO from California, Colorado and Nevada. It is probably more widespread south of Canada. It also occurs in temperate areas of Europe and Asia (Hultén, 1971).

Biological Notes. Plants from Mono Co., California and Custer Co., Colorado, had the chromosome-number $n = 16$ (Table 1). Pollen mother cells had 16 pairs at meiosis. Burdet (1967) records the chromosome-number $2n = 8$ for plants of *A. hirsuta* from one location in Switzerland and one in France, $2n = 16$ for plants from Switzerland, France, Sweden, Bulgaria and Germany and $2n = 32$ for plants from England and Norway. He suggests that $x = 4$ has to be considered as the base number for at least part of the genus *Arabis*. *Arabis hirsuta* is probably a sexual species producing seed by selfing.

6b. **Arabis hirsuta** var. **pycnocarpa** (Hopkins) Rollins, Rhodora 43: 318. 1941. Based on *Arabis pycnocarpa* Hopkins, Rhodora 39: 117. 1937; Quebec, dry ledges, St. Jean l'Evangéliste, Nouvelle Bonaventure Co., *J. F. Collins & M. L. Fernald, July 19 & 20, 1904* (Holotype GH!). *Arabis hirsuta* subsp. *pycnocarpa* (Hopkins) Hultén, Arssk. Lunds Univ. N.F. Avd. 41: 873. 1945.

Arabis rupestris Nuttall in T.&G., Fl. N. Am. 1: 81. 1838; Wahlalmet R. (Oregon), *Nuttall* (Isotype GH!).

Arabis pycnocarpa var. *reducta* Hopkins, Rhodora 39: 117. 1937; Gravelly Beach, Carlton, Tracadigash Point, Quebec, *Collins & Pease 4312* (Holotype GH!).

Arabis hirsuta var. *adpressipilis* (Hopkins) Rollins, Rhodora 43: 319. 1941. Based on *Arabis pycnocarpa* var. *adpressipilis* Hopkins, Rhodora 39: 117. 1937; Montier, Missouri, *Bush 32* (Holotype GH!).

Arabis hirsuta var. *minshallii* B. Boivin, Can. Field-Nat. 65: 16. 1951; Lemieux Island, Ottawa, Ont., *W. H. Minshall, June 26 1934* (Holotype DAO!)

Distribution. The information given by Hopkins (1937) for *A. pycnocarpa* covers my concept of *A. hirsuta* var. *pycnocarpa*: basic ledges, cliffs, bluffs, dry and rocky or moist banks and gravelly alluvium, eastern Quebec to Yukon, south to Georgia, Indiana, Illinois, Missouri, Kansas, New Mexico, Arizona and California. Workers should look for var. *hirsuta,* particularly south of the Canadian border. I have seen specimens of var. *pycnocarpa* from Alaska, Mackenzie District, Yukon, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia.

Biological Notes. Plants from Mackenzie District, Manitoba, Alberta, British Columbia, Connecticut, Colorado, South Dakota and Wisconsin had the chromosome number $n = 16$, $2n$

= 32 (Table 1). Pollen mother cells had 16 pairs at meiosis. Both var. *hirsuta* and var. *pycnocarpa* plants of North America are either tetraploid based on $x = 8$ or octoploid based on $x = 4$. Burdet (1967) has suggested that the base number for *A. hirsuta* may be $x = 4$, not $x = 8$.

7. **Arabis eschscholtziana** Andrz. in Ledeb. Fl. Alt. 3: 25. 1831; *ex* insula Unalaschka, Cham. & Schtechtd. (Type not seen). *Arabis hirsuta* var. *eschscholtziana* (Andrz.) Rollins, Rhodora 43: 320. 1941. *Arabis hirsuta* subsp. *eschscholtziana* (Andrz.) Hultén, Arssk. Lunds Univ. N.F. Avd. 41: 872. 1945.

Distribution. It occurs in moist habitats towards the Pacific coast in the Aleutian Islands, Alaska, Yukon, British Columbia, western Idaho, Washington and Oregon.

Biological Notes. The chromosome-number $n = 32$ was obtained from plants growing in the Queen Charlotte Islands of British Columbia (Table 1). Pollen mother cells had 32 pairs at meiosis. *Arabis escholtziana* has twice the chromosome-number of North American plants of *A. hirsuta,* a species to which it is obviously closely related. They possibly also have the same basic chromosome-number, either $x = 4$ or $x = 8$. *Arabis eschscholtziana* is probably a sexual species. Although it has rather large flowers for our *Arabis* taxa, some plants growing in isolation set much seed. It is, therefore, probably a selfer.

8. **Arabis alpina** L., Sp. Pl. 2: 664. 1753; Habitat in Alpibus Helveticus, Lapponicus, Hort. cliff. 335.

Arabis incana Moench., *Arabis alpina* var. *minor* Lange, *Arabis alpina* var. *ruderalis* Wormskj., *Arabis alpina* var. *glabrata* Blytt. (see Hopkins, 1937).

Distribution. Cliffs, ledges, rock and gravel shorelines, and alpine meadows along the west coast of Hudson Bay in Manitoba and Ontario, islands of Hudson Bay, southern shore of Baffin Island, northern shores of Quebec and Labrador, Gaspé Quebec and adjacent north shore of St. Lawrence River, Newfoundland and Greenland.

Biological Notes. Plants from Greenland, Quebec and Manitoba had the chromosome number $n = 8$, $2n = 16$. Pollen mother cells had 8 pairs at meiosis (Table 1). *Arabis alpina* is probably a sexual species producing seed by selfing.

9. **Arabis caucasica** Willd., Enum. Pl. Hort. Berol. suppl. 45. 1813.

DISTRIBUTION. It is found south of the range of *A. alpina* in Europe and Asia (Hultén, 1958). It persists as a rare garden escape in Quebec, Ontario and British Columbia.

BIOLOGICAL NOTES. Plants growing as a garden escape in Ontario had 8 pairs of chromosomes at meiosis (Table 1). Since isolated plants produce little or no seed, it is likely that *A. caucasica* is a sexual outcrosser. It is closely related to *A. alpina* and is considered a variety or subspecies of *A. alpina* by some workers.

10. **Arabis nuttallii** Robinson in Gray, Syn. Fl. N. Am. 1: 160. 1895; R. Mts, *Nuttall* (HOLOTYPE PH!; ISOTYPE GH!).

Arabis bridgeri M. E. Jones, Contrib. West. Bot. 14: 38. 1912; Mt. Bridger, Gallatin Co., Montana, *M. E. Jones, Aug. 10, 1905* (HOLOTYPE PH, not seen).
Arabis macella Piper, Proc. Biol. Soc. Wash. 33: 103. 1920. Ritzville, Adams Co., Washington, *Sandberg & Leiberg 202* (HOLOTYPE US, not seen).

DISTRIBUTION. Grassy slopes and benches, prairie hillsides, open thickets and woods, and roadsides in Yukon (very rare), southwest Alberta, southeast British Columbia, Montana, Wyoming, Utah, Idaho, Washington and Nevada.

BIOLOGICAL NOTES. I have seen no information on the chromosome number of *A. nuttallii.* Since isolated plants have some aborted siliques and plants growing in dense colonies have all well-formed siliques, it is possible that this relatively large flowered *Arabis* is a sexual outcrosser.

11. **Arabis canadensis** L., Sp. Pl. 2: 665. 1753; *Eruca virginiana* Pluk. alm. 136.

Arabis falcata Michx., Fl. Bor. Am. 1: 31. 1803 and *Arabis mollis* Rafinesque, Am. Month. Mag. 2: 43. 1817 *non* Steven, Bull. Soc. Nat. Mosc. 2: 270. 1812 (see Hopkins, 1937, p. 178).

DISTRIBUTION. Rich woods, thickets and rocky banks, southwestern Quebec, southern Ontario. It also occurs from Maine to Florida, and westward to Texas, Nebraska and Minnesota (Rollins, 1993b).

BIOLOGICAL NOTES. The chromosome-number of $2n = 14$ has been reported for plants growing in southern Ontario (Table 1). It has the basic number, $x = 7$, that is very common for North American species of *Arabis.*

12. **Arabis laevigata** (Mühl.) Poir., Encyl. Suppl. 1: 411. 1810. Based on *Turritis laevigata* Mühl., Index Fl. Lancastr. in Trans. Am. Phil. Soc. 3: 1793.

Arabis lyraefolia DC., Syst. 2: 244. 1821; *Arabis heterophylla* Nutt. *ex* T.&G., Fl. N. Am. 1: 81. 1838; *Arabis hastata* Eaton, Man. Bot. ed. 2: 141. 1818 (all after Hopkins, 1937).

Arabis missouriensis Greene, in Feddes Repertorium 5: 244. 1908; Montier, Missouri, *B. F. Bush 31* (HOLOTYPE ND!).

DISTRIBUTION. Rich rocky woods, rocky hillsides and ledges, southwestern Quebec, southern Ontario. It is also found from New Jersey to Georgia, west to Oklahoma and Kansas, and north to Minnesota (Rollins, 1993b).

BIOLOGICAL NOTES. The chromosome-number $n = 7$ was obtained for plants from Connecticut, Maryland and Wisconsin (Table 1). Pollen mother cells had 7 pairs of chromosomes at meiosis. *Arabis laevigata* is probably a sexual species producing seed by selfing.

13. **Arabis shortii** (Fern.) Gleason, Phytologia 4: 23. 1952; *Arabis perstellata* E. L. Braun var. *shortii* Fernald, Rhodora 48: 208. 1946. Based on *Sisymbrium dentatum* Torrey in Short, 3rd Suppl. Cat. Pl. Kentucky, 338. 1833; On the sandy banks of the Ohio river, Fl. April, *C. W. Short* (LECTOTYPE DWC!).

Arabis shortii (Fern.) Gleason var. *phalacrocarpa* (Hopkins) Steyerm., Rhodora 62: 130. 1960. Based on *Arabis dentata* var. *phalacrocarpa* Hopkins, Rhodora 39: 169. 1937; Along shaded limestone bluffs of Osage River, near Osceola, St. Clair County, Missouri, *E. J. Palmer 35650* (HOLOTYPE GH!).

DISTRIBUTION. Shady banks and bottomlands and on limestone bluffs and ledges in rich woods, Essex County in Ontario. It also occurs from New York to Virginia, Tennessee and Alabama, west to Kansas, and Nebraska, and north to Minnesota (Rollins, 1993b).

BIOLOGICAL NOTES. The chromosome number of $n = 7$ reported for *Arabis perstellata* (Table 1), probably does not apply to *A. shortii*. The holotype of *A. perstellata* in GH has cauline leaves cuneate at bases not sagittate-clasping as in *A. shortii*.

14. **Arabis drummondii** Gray, Proc. Am. Acad. 6: 187. 1863. Based on *Turritis stricta* Graham, Edinburg New Phil. Jour. 350, 1879; plant grown from seeds collected by Drummond in Rocky Mts. (see Hopkins, 1937, p. 146).

Arabis albertina Greene, in Pittonia 4: 196. 1900; Alberta, Elbow River, Rocky Mountains, *J. Macoun 18101* (Holotype nd!).

Arabis drummondii var. *oxyphylla* (Greene) Hopkins, Rhodora 39: 143. 1937. Based on *Arabis oxyphylla* Greene, in Pittonia 4: 197. 1900; Near Pagosa Peak, Colorado, *C. F. Baker 747* (Holotype nd!).

Arabis drummondii var. *connexa* (Greene) Fernald, Rhodora 5: 231. 1903. Based on *Arabis connexa* Greene, in Pittonia 4: 197. 1900; Near Pagosa Peak, Colorado, *C. F. Baker 341* (Holotype & 3 Isotypes nd!).

Distribution. Open, often calcareous, habitats in Alaska, Yukon, Mackenzie District, Newfoundland, Labrador, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia. It is widespread from New Jersey, west to northern Arizona and the Sierra Nevada of California, and north to Washington (Rollins, 1993b).

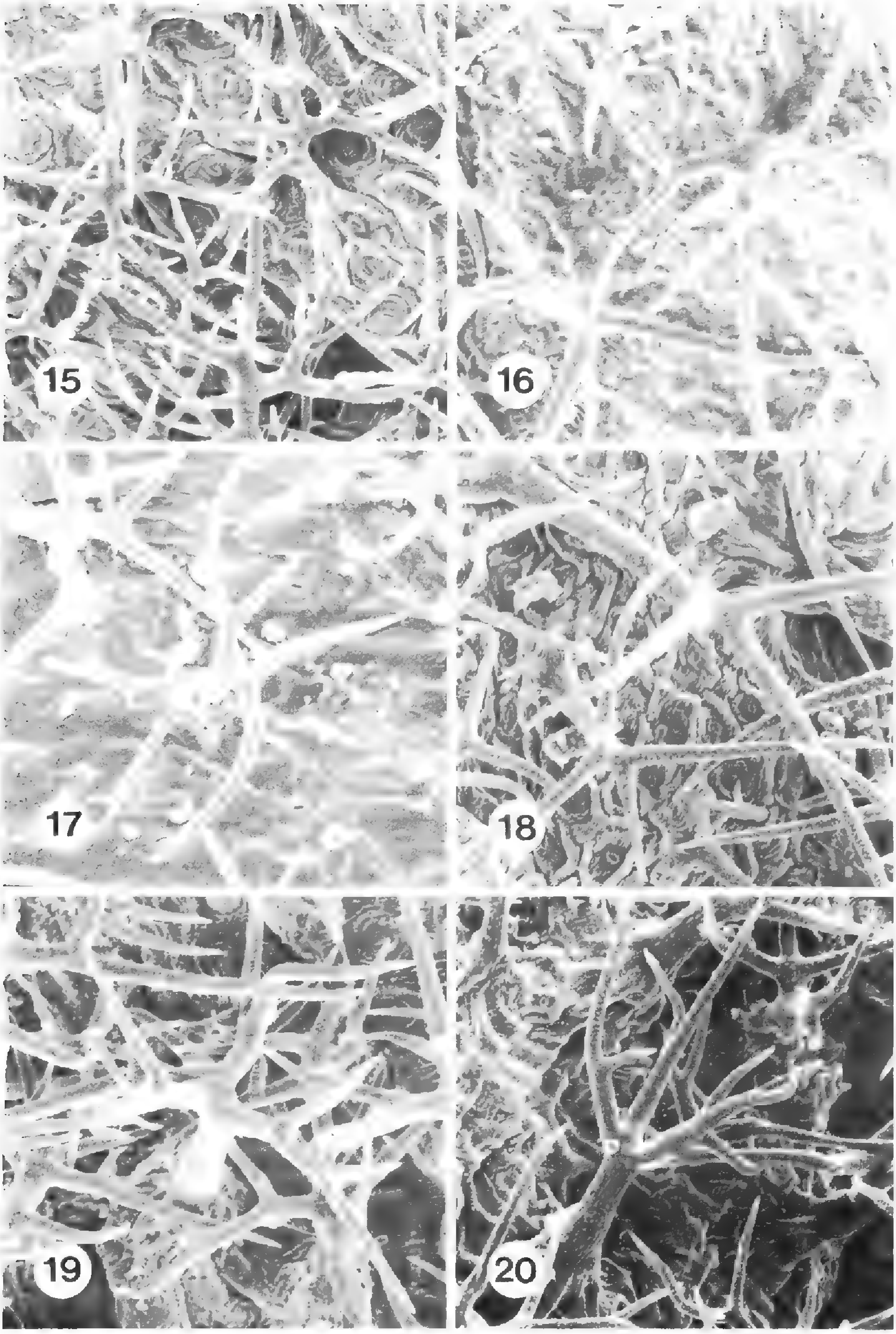
Biological Notes. *Arabis drummondii* is one of our most widespread species. Siliques tend to be narrower and the basal or caudex leaves glabrous or nearly so in the eastern part of its range. This species seems to be most closely related to *A. calderi* and through *A. lyallii* to *A. divaricarpa. Arabis drummondii* contains diploid, triploid and tetraploid chromosome races based on $x = 7$ (Table 1). Most diploids from Yukon, Alberta, California, Colorado, Montana, Utah and Wyoming had 7 pairs at meiosis. These plants were probably sexual, producing seed by selfing. The triploids from Alberta and British Columbia almost certainly produce seed by apomixis. According to Böcher (1969) the tetraploid plants from Massachusetts were probably sexual as their pollen had the reduced number of 14.

15. **Arabis calderi** G. Mulligan, *sp. nov.*

Arabis calderi ab A. drummondia 3-radiatis trichomatibus et siliquis angustioribus differt et ab A. lyallii et ab A. divaricarpa siliquis erectis et rachidi adpressis differt.

Arabis calderii differs from *Arabis drummondii* by its 3-rayed trichomes and narrower siliques and from *Arabis lyallii* and *Arabis dicaricarpa* by its siliques being erect and appressed to the rachis.

The holotype specimen, in the herbarium of Agriculture Canada, Ottawa (dao), is named after James Alexander Calder, 1915–1990 (*see* tribute to Calder by Cody & Cayouette, 1991). British Columbia, Indian River at Mile 34 from Alaska Highway on Atlin Road, approx. 59°54′N, 133°48′W, common on open grassy flats



Figures 15–20. SEM photographs of *Arabis* trichomes; all ×150. Figure 15, *A. holboelli* var. *retrofracta*. Figure 16, *A. boivinii*. Figure 17, *A. lignifera*. Figure 18, *A. sparsiflora*. Figure 19, *A. columbiana*. Figure 20, *A. pinetorum*.

on bench above river, *J. A. Calder & J. M. Gillett 25180,* June 9, 1960 (HOLOTYPE DAO!).

Perennial with a simple or branched caudex; stems erect, one to several, simple to once-branched, 7.5 to 40.0 cm high; cauline leaves entire, glabrous, sessile, mostly strongly sagittate-clasping stems, narrowly lanceolate, 1 to 4 cm long, 1 to 4 mm wide; caudex leaves entire, numerous and rosulate, 1 to 3 cm long, 2 to 6 mm wide, the blades narrowly oblanceolate, slender petiolate; lower surfaces of caudex leaves with sparse to scattered sessile, unbranched 3-rayed trichomes 0.25 to 0.35 mm wide; inflorescences symmetrical, usually congested; sepals purplish, oblong to narrowly oblong, saccate at bases, 3 to 4 mm long, 0.75 to 1.0 mm wide; petals purplish, narrowly cuneate, 7.0 to 7.5 mm long, 0.75 to 1.5 to 1.75 mm wide; style rudimentary; seeds mostly in 2 rows, brownish, oval, 1.75 mm long, 1.25 mm wide, prominently winged on sides and apex, cotyledons accumbent.

DISTRIBUTION. Grassy clearings, meadows and openings in thickets in subalpine and alpine areas of southwestern Yukon, Great Bear Lake of Mackenzie District, southwest corner of Alberta and in British Columbia. It is probably commoner than the number of herbarium collections indicate. No specimens were seen from the adjacent United States, but it almost certainly occurs there.

BIOLOGICAL NOTES. It is most closely related to *A. drummondii* and *A. lyallii.* All of the specimens of *A. calderi* seen in herbaria were previously identified mostly as *A. drummondii* and occasionally as *A. lyallii* or *A. divaricarpa.* Although no chromosome numbers have been determined from plants of *A. calderi,* I would predict a base number of $x = 7$.

REPRESENTATIVE SPECIMENS. CANADA. **Yukon:** Vicinity of Mackintosh (mile 1022, Alaska Highway), roadside, flowers purplish tinged, slightly glaucous, *Schofield & Crum 7348* (CAN, UBC); Vicinity of Pine Creek, Alaska Highway near mi. 1019, app. 60°47′N, 137°35′W, prairie, *Raup et al. 13033* (ALA, CAN, UBC); Canol Rd., Mile 132, Lower Lapie R. Crossing, slopes near timberline, 5000′, *Porsild & Breitung 9722* (CAN); Mile 25 from Alaska Highway on road to Dawson, 61°08′N, 135°20′W, occasional in openings in dwarf birch-willow thickets on flats at 2600′, flowers dark mauve, *Calder & Gillett 25788* (ALA, DAO); Champagne at Mile 974, Alaska Highway, 60°47′N, 136°29′W, in slightly saline grassy clearing between spruce-Aspen . . . , flowers mauve, alt. 2300′, *Calder & Gillett 25142* (DAO). **Mackenzie District:** Great Bear Lake, north shore of Smith ARM, Olmstead Bay, about 66°32′N, 122°35′W, calcareous soil *Porsild & Porsild 5080* (CAN); Great Bear Lake, Etacho Point (Big Point), elevation about 1500 feet, 66°N, 121°30′W, *Porsild & Porsild 3494B,* sheet is mixture of 2 plants of *A. calderi* and 1 plant of *A. drummondii* (CAN). **Alberta:** Lake Agnes above Lake Louise, Banff National Park, occasional on dry, gravelly-rocky slopes at treeline, alt. 7000′, *Calder 24021* (DAO); Crandell Trail and Akamena Hwy., 49°05′N, 113°58′W, partly exposed on steep SE hill, 5200′, Waterton Lakes National Park, *Blais 1996* (CAN). **British Columbia:** Blustry Mountain, 50°36′N, 121°42′W, 2256 m, *Johns 584* (DAO, UBC); old Jackson Mine Road, south of New Denver-Kaslo Road, 50°01′N, 117°09′W, ca. 6000′, *Beamish et al. 750328* (DAO, UBC); Cornwall Mtn., Lookout Rd., southwest of Ashcroft, ca. 6000 ft., *Beamish 630166* (DAO); Cairn Peak, Upper Hat Creek, 7600 ft., *Brink 49-514* (UBC).

16. **Arabis lyallii** S. Watson, Proc. Am. Acad. 11: 122. 1875. Based on *Arabis drummondii* var. *alpina* S. Watson in King, Geol. Expl. Fortieth Parallel 5: 18. 1871; Clover Mts., N. Nevada, 10,000 ft. alt., *S. Watson 75* (HOLOTYPE GH!).

Arabis oreophila Rydb., Bull. Torr. Bot. Club 3: 437. 1907; Divide between Big Cottonwood Canyon and Heber Valley, *P. A. Rydberg & E. C. Carlton 6678* (HOLOTYPE NY!).

Arabis amerifolia Greene, Leaflets Bot. Obs. Crit. 2: 75. 1910; On a firm pumice slope, Crater Lake National Park, Oregon, *F. V. Coville 1504* (HOLOTYPE US!)

Arabis multiceps Greene, Leaflets Bot. Obs. Crit. 2: 76. 1910; On open rocky slope, Mount Thielson, Cascade Mts., Oregon, *F. V. Coville & E. I. Applegate 435* (HOLOTYPE US!).

Arabis densa Greene, Leaflets Bot. Obs., Crit. 2: 76. 1910; Eagle Cap, Imnaha National Forest, Oregon, 9500 feet, *A. W. Sampson & G. A. Pearson 206* (HOLOTYPE US!).

Arabis davidsonii Greene, Leaflets Bot. Obs. Crit. 2: 159. 1911; Bishop Creek, Inyo Co., Cal., *A. Davidson 2728* (LECTOTYPE RSA!). *Arabis lyallii* var. *davidsonii* (Greene) Smiley, Univ. Calif. Pub. Bot. 9: 205. 1921.

DISTRIBUTION. Occurs in alpine and subalpine areas in shale and rock crevices and in meadows in southwestern Alberta and southern British Columbia. It also occurs southward into Montana, Idaho, Washington, Wyoming, Utah, Nevada, Oregon and California (Rollins, 1941).

BIOLOGICAL NOTES. *Arabis lyallii* seems to be the alpine and subalpine phase of the more widespread *A. divaricarpa.* It also resembles the latter species in that some plants have glabrous caudex leaves. *Arabis lyallii,* at least in our range, is more uniform morphologically than *A. divaricarpa.* Plants of *Arabis lyallii* from Alberta and Utah were triploid, based on $x = 7$. These must therefore produce seed by apomixis.

17a. **Arabis divaricarpa** A. Nelson var. **divaricarpa.** *Arabis divaricarpa* A. Nelson, Bot. Gaz. 30: 193. 1900; Yellowstone Lake, on the stony and sandy banks of the lake, Yellowstone National Park, *A. & E. Nelson 6622* (LECTOTYPE chosen by Hopkins, 1937, RM!; ISOLECTOTYPE GH!).

Arabis brachycarpa (T.&G.) Britton, Mem. Torre. Bot. Club. 5: 174. 1894. *Non* Ruprecht, Fl. Cauc. 73. 1869. Based on *Turritis brachycarpa* T.&G., Fl. N. Am. 1: 79. 1838; Fort Gratiot, Michigan and shore of Lake Superior, *Dr. Pitcher* (HOLOTYPE NY!).

Arabis nemophila Greene, Leaflets Bot. Obs. & Crit. 2: 78. 1910; Sequoia National Forest, California, *A. Davidson 1847* (HOLOTYPE US!).

Arabis brevisiliqua Rydberg, Bull. Torr. Bot. Club 39: 326. 1912; Skagit Valley, B.C., *J. M. Macoun 70825* (HOLOTYPE NY!; ISOTYPE CAN!).

Arabis drummondii var. *pratincola* (Greene) Hopkins, Rhodora 39: 142. 1937. Based on *Arabis pratincola* Greene, in Feddes Repertorum 5: 244. 1908; Spooner, Douglas County, Nevada, *C. F. Baker 1149* (ISOTYPES GH!, MO!).

Arabis patula (Graham) Torrey var. *stenocarpa* (Hopkins) Farwell, Papers Mich. Acad. Sci. 26: 14. 1941. Based on *Arabis divaricarpa* var. *stenocarpa* Hopkins, Rhodora 39: 133. 1937; Quebec, slaty ridges east of Bic, Rimouski Co., *M. L. Fernald & J. F. Collins 1057* (HOLOTYPE GH!; ISOTYPE CAN!).

DISTRIBUTION. Open disturbed areas on cliffs and rock outcrops, in woods on shorelines and along roadsides in Alaska (rare), southern Yukon, Mackenzie District, New Brunswick (rare), Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and southward into the United States, particularly in the east.

17b. **Arabis divaricarpa** var. **dacotica** (Greene) B. Boivin, Am. Midl. Nat. 54: 510. 1955. Based on *Arabis dacotica* Greene, Leaflets Bot. Obs. & Crit. 2: 80. 1910; Fort Meade, South Dakota, *W. H. Forwood 28* (HOLOTYPE US!).

Arabis oblanceolata Rydb., Bull. Torr. Bot. Club 31: 557, 1904, Valley Spur, Colorado, *L. M. Underwood & A. D. Selby 454* (HOLOTYPE NY!).

Arabis divaricarpa var. *hemicylindrica* B. Boivin, Am. Midl. Nat. 54: 510. 1955; Maple Creek, Sask., 10 milles au sud Carmichael, monts Cyprès, écorre de la coulée du ruisseau Bone, *B. Boivin & J. Alex 9738* (HOLOTYPE DAO!). A specimen with the identical label data, in SASK, is *Arabis pinetorum.*

DISTRIBUTION. Open, dry, often sandy, disturbed areas of prairie, grasslands, hillsides and shorelines in southeast Alaska, central and southern Yukon, Mackenzie District, Quebec (rare, Co. Témiscamingue), northern Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and southward into the United States, particularly from Minnesota westward.

BIOLOGICAL NOTES. It is morphologically the most variable of our *Arabis* species. The siliques range from ascending to descending, surfaces of rosette or caudex leaves may be glabrous to densely covered with sessile to short-stalked 3-rayed trichomes. The 3-rayed trichomes are from less than 0.25 mm in diameter to more than twice that wide and rays are appressed to leaf surfaces to divergent. It is often difficult to distinguish some western plants of *A. divaricarpa* from *Arabis lyallii,* particularly fragmentary material. However, complete and mature plants of *A. lyallii,* a more montane plant, can be reliably separated from *A. divaricarpa.* Although there is some morphological overlap between var. *divaricarpa* and var. *dacotica,* they seem to have slightly different habitats and distributions. Plants of var. *divaricarpa* from Saskatchewan, Alberta, British Columbia, Montana and California were diploid or tetraploid, based on $x = 7$, whereas plants of var. *dacotica* from the Mackenzie District, Manitoba, British Columbia and Colorado were diploid, triploid or tetraploid, with the same base number (Table 1). One of the diploids formed 7 pairs of chromosomes at meiosis. Böcher (1969) reported that EMCs, PMCs and pollen grains of *A. divaricarpa* plants from California had the aneuploid number of $2n = 22$ and dyads and uniform pollen grains were formed. Mosquin (Table 1) found that tetraploid plants from Manitoba had an irregular meiosis. In addition, some plants have supplementary chromosomes ($2n = 13 + 2B$). It, therefore, appears that *A. divaricarpa* has diploids, triploids and tetraploids, that some of the diploids are probably sexual selfers, that triploids are apomictic, and that at least some of the tetraploids are also apomictic. The reproductive system of *A. divaricarpa* is obviously very complex. Rollins (1983) suggested that *A. divaricarpa* can either: **a.** be considered a natural hybrid taxon that includes stable populations of ancient hybrid origin, less stable more recently produced hybrids, and many hybrid populations produced under intermediate conditions; or **b.** be considered a polytypic species of ancient hybrid origin. I have observed no morphological evidence of any recent interspecific hybridization in our *Arabis* species.

18. **Arabis lemmonii** S. Watson, Proc. Am. Acad. 22: 467. 1887; Lassen's Peak, *Lemmon 23* (LECTOTYPE GH!).

Arabis latifolia (S. Wats.) Piper, Contrib. U.S. Nat. Herb. 295. 1906. Based on *Arabis canescens* Nutt. var. *latifolia* Watson in King, Geol. Expl. Fortieth Parallel 5: 17. 1871; Clover Mts., Nevada, 11,000 ft., *S. Watson* 71 (HOLOTYPE GH!).

Arabis kennedyi Greene, Leaflets Bot. Obs. & Crit. 2: 71. 1910; Galena Creek, Washoe Co., Nevada, *P. B. Kennedy 1248* (HOLOTYPE US!; ISOTYPE NY!).

Arabis oreocallis Greene, Leaflets Bot. Obs. & Crit. 2: 73. 1910; Beaverfoot Mts., Selkirk & Rky. Mts., British Columbia, *C. H. Shaw 315* (HOLOTYPS US!).

Arabis semisepulta Greene, Leaflets Bot. Obs. & Crit. 2: 74. 1910; Near summit in loose lava gravel, Mount Thielson, Cascade Mountains, Oregon, *F. V. Coville & E. I. Applegate 454* (HOLOTYPE US!; ISOTYPE RM!).

Arabis polyclada Greene, Leaflets Bot. Obs. & Crit. 2: 75. 1910; Farwell Gap, California, *C. A. Purpus 5229* (HOLOTYPE US!; ISOTYPES GH!, UC!).

Arabis egglestonii Rydb., Fl. Rocky Mts., 316. 1918; Clover Mountain, above Garfield, Colorado, *W. W. Eggleston 6013* (HOLOTYPE NY!).

DISTRIBUTION. Rock and gravel alpine slopes in Yukon (rare, Mt. Archibald), southwestern Alberta and southern British Columbia. Occurs southward in Montana, Idaho, Washington, Wyoming, Colorado, Utah, Nevada, Oregon and California (Rollins, 1941).

BIOLOGICAL NOTES. *Arabis lemmonii* plants from Alberta, British Columbia and Wyoming were reported to be diploid, based on $x = 7$, and from Montana were found to be triploid, with the same base number. The latter plants, producing large amounts of seed, were obviously apomictic.

19. **Arabis drepanoloba** Greene, Pittonia 3: 306. 1898; Devil's Head Lake, Banff National Park, Alberta, *Macoun 1719a* (HOLOTYPE ND!; ISOTYPE US!).

DISTRIBUTION. Alpine meadows and ridges in Colorado, Wyoming, Montana, southwest Alberta, southeast British Columbia and disjunct to southwest Yukon.

BIOLOGICAL NOTES. Although there are no chromosome counts for this species, I suspect that it belongs to *Arabis* species with the base number $x = 7$. It is most similar to *A. lemmonii* but I think that the two entities should be treated as separate species because of the much larger trichomes and siliques in *A. drepanoloba.*

20. **Arabis codyi** G. Mulligan, *sp. nov.*

Arabis codyi ab A. drepanoloba et ab A. lyallii differt siliquis angustioribus 1.5–1.75 mm latis et trichomatibus furcatis potius quam radiatis.

Arabis codyi differs from *A. drepanoloba* and *A. lyallii* by its narrower, 1.5 to 1.75 mm wide, siliques and forked, rather than rayed trichomes.

The holotype specimen in the herbarium of Agriculture Canada, Ottawa, is named after William James Cody (1922–). Yukon, Kaskawulsh nunatak, jct. N and central arms Kaskawulsh Glacier, W of Kluane Lake, 6000 ft., unstable slopes, *D. F. & D. B. Murray 72,* 1 July–1 August, 1965 (HOLOTYPE DAO!).

Perennial with a simple or branched caudex; stems erect to ascending, one to several, simple, 7 to 14 cm high; cauline leaves entire, rarely few toothed, glabrous or with scattered short-stalked, unbranched to few branched, 2- and 3-forked trichomes from 0.125 to 0.25 mm long, leaves sessile, mostly sagittate clasping stems, narrowly lanceolate to lanceolate, 0.5 to 1.5 cm long, 1.5 to 3.0 mm wide; caudex leaves entire to rarely with 1 to 2 shallow lobes towards apex, numerous and rosulate, 0.75 to 1.5 cm long, 1.5 to 3.0 mm wide, the blades narrowly oblanceolate to oblanceolate, slender petiolate; lower surfaces of caudex leaves densely pubescent with short stalked, unbranched to few-branched, 2- and 3-forked trichomes from 0.125 to 0.25 mm long; inflorescences symmetrical, open; sepals purplish, oblong, saccate at bases, 2.5 to 3.0 mm long, 1.5 to 1.75 mm wide; petals purplish, cuneate, 6.5 mm long, 2.0 mm wide; fruiting pedicels ascending, straight, 3 to 5 mm long; siliques ascending, straight to slightly curved, 2.0 to 3.75 cm long, 1.5 to 1.75 mm wide, abruptly tapering at apex to a rudimentary style.

The only other specimen seen was collected in British Columbia: Perow, B.C., 54°30′N, 126°26′W, growing on sandy beach, 700 m, *Taylor & Levis 468* (UBC).

21. **Arabis murrayi** G. Mulligan, *sp. nov.*

Arabis murrayi a ceteris Arabibibus praeditis foliis mediis caulinis basi cuneatis vel raro infirme auriculatis, siliquis erectis rachidi adpressis differt. A. murrayi *plerumque A. lyallii confusa est, specie praedita foliis caulinis valde sagittao-amplexicaulibus.*

Arabis murrayi differs from other *Arabis* that have the bases of middle cauline leaves cuneate to rarely weakly auriculate, by its erect siliques which are appressed to the rachis. It is usually misidentified as *A. lyalli,* a species with strongly sagittate-clasping cauline leaves.

The holotype specimen in the herbarium of Agriculture Canada, Ottawa, is named after David F. Murray, University of Alaska, College. Yukon, Kaskawulsh nunatak, jct. N. and central arms Kaskawulsh Glacier, W of Kluane Lake, 6000 ft., *D. F. & B. M. Murray 91b,* 1 July–1 August, 1965 (HOLOTYPE DAO!; ISOTYPE ALA!).

Perennial with a simple or branched caudex; stems erect, one to several, simple, 2.5 to 15.0 cm high; cauline leaves entire, glabrous or with scattered short-stalked, unbranched to few branched 2- and 3-rayed trichomes mostly 0.125 mm wide, leaves sessile, cuneate to rarely weakly auriculate at bases, lanceolate, 0.3 to 1.0 cm long, 1 to 3 mm wide; caudex leaves numerous and stiffly ascending, 0.5 to 1.75 cm long, 0.75 to 1.5 mm wide, the blades narrowly oblanceolate, slender petiolate; lower surfaces of caudex leaves with scattered to dense short-stalked, unbranched to few branches, 2- and 3-rayed trichomes mostly 0.125 mm wide; inflorescences symmetrical, short, few-fruited, congested; sepals slightly purplish, oblong to narrowly oblong, nonsaccate at bases, 3 mm long, 1 mm wide; petals whitish, linear-oblong, 6.5 mm, 0.5 mm wide; fruiting pedicels erect, straight to slightly curved, 3 to 4 mm long; siliques erect, appressed to rachis, straight, 2.0 to 4.5 cm long, 1.5 to 2 mm wide, style *ca.* 0.125 mm long; seeds oval, in 2 rows, brownish, 1.0 mm long, 0.75 mm wide, prominently winged only at apex, cotyledons accumbent.

DISTRIBUTION. Alpine slopes in southwestern Alberta, southern British Columbia, Washington and probably Idaho and western Montana. It apparently has a disjunct distribution to the southwestern corner of Yukon.

BIOLOGICAL NOTES. Nearly all of the *A. murrayi* material that I have examined in herbaria were misidentified as *A. lyallii* and many sheets were mixtures of the two taxa. *Arabis murrayi* has cauline leaves that are cuneate to rarely weakly auriculate; trichomes on undersurfaces of caudex leaves, if present, are unbranched to few branched, 2- and 3-rayed, and mostly 0.125 mm wide; and siliques are erect and appressed to the rachis. *Arabis lyallii* has cauline leaves that are strongly sagittate-clasping the stems, trichomes on undersurfaces of caudex leaves, if present, are unbranched, 3-rayed, and mostly 0.25 mm wide; and siliques are strongly ascending. The surfaces of the caudex leaves of both species are often glabrous.

REPRESENTATIVE SPECIMENS. CANADA. **Yukon:** Kaskawush nunatak, jct. N. and central arms Kaskawush Glacier, W. of Kluane Lake, unstable slopes, 6000 ft., *Murray & Murray 41A,* also contains plants of *A. drepanoloba* labelled *41B* (ALA, CAN). **Alberta:** Crypt Lake, Waterton Park, open slope, 6600′, *Scotter 9881B,* also contains plants of *A. lyallii* labelled *9881A* (DAO). **British Columbia:** Akamina Ridge on B.C.-Alberta border, 49°01′N, 114°04′W–114°07′W, occasional on rocky shade exposed summit ridge between 8000′ & 8400′, *Taylor et al. 3547* (DAO); Cathedral Lakes, Ashnola Dist., 49°N, 120°15W, rock slide on shoulder of Pyramid Mt., 7000′, cor. purple, *Taylor 1370* (UBC); Finlayson Peak overlooking Maselpanik Creek, 7200 feet, purple flowers, *Pinder-Moss & Hamlyn 1157* (UBC); Blackwell Peak, north of ranger station along Hope-Princeton Highway, occasional on rocky, east-facing slope, alt. 6300′, flowers purplish-blue; *Calder & Saville 10551A,* also contains plants of *A. lyallii* labelled *10551B* (DAO). UNITED STATES. **Washington:** Yakima Co., alpine slopes of Mt. Aix, Snoqualmie Nat. Forest, 7000 feet, *Thompson 15045a* (DAO); Chelan Co., ridge ½ mi. W of Hoodo Pass and ca. 16 mi. SSW of Twisp, in dry herbfield, alpine zone, aspect S20W, slope 20%, 6830′, *Douglas & Douglas 4143* (DAO).

22. **Arabis exilis** A. Nelson, Bull. Torrey Bot. Club. 26: 123. 1899; Evanston, Wyoming, *A. Nelson 4523* (LECTOTYPE RM!, centre specimen (A) best fits description of *A. exilis,* outer two specimens (B) are *Arabis holboellii* var. *retrofracta*; ISOLECTOTYPE GH!).

Arabis pendulocarpa A. Nelson, Bot. Gaz. 30: 192. 1900; On cliffs and rocky ridges, Madison River, Yellowstone National Park, *A. & E. Nelson 5504* (LECTOTYPE RM! by Rollins 1941; ISOLECTOTYPES GH!, NY!, RM!, US!). *Arabis holboellii* var. *pendulocarpa* (A. Nels.) Rollins, Rhodora 43: 446. 1941.

DISTRIBUTION. On rocky and grassy subalpine slopes and prairie in southcentral Yukon, Cypress Hills Saskatchewan, Cypress Hills Alberta, southwest Alberta and British Columbia. Herbarium specimens were also seen from Montana, Washington, Utah, Colorado and Nevada. It undoubtedly occurs elsewhere in the western United States.

BIOLOGICAL NOTES. Plants from Yukon, British Columbia and Montana were diploid, based on $x = 7$, whereas those from Utah were triploid (Table 1). One of the diploids from British Columbia formed 7 pairs of chromosomes at meiosis (Taylor and Taylor, 1977). This species probably contains sexual and apomictic plants. Böcher (1969, p. 146) grew material of this species in experimental plots alongside plants of *A. holboellii* and concluded that it should no longer be included in the *A. holboellii* complex.

23. **Arabis microphylla** Nuttall in T.&G., Fl. N. Am. 1: 82. 1838; Rocky Mountains, *Nuttall* (HOLOTYPE PH!).

Arabis macounii Watson, Proc. Am. Acad. 26: 124. 1891; Gravelly banks, Eagle Pass, W of Revelstoke B.C., *J. Macoun, May 13th, 1890* (HOLOTYPE GH!; ISOTYPES CAN!, MO!, PH!, US!). *Arabis microphylla* var. *macounii* (Watson) Rollins, Rhodora 43: 428. 1941.

Arabis paupercula Greene, Leaflets Bot. Obs. & Crit. 2: 77. 1910; Farwell Gap, southeastern California, 10,600, *C. A. Purpus 5229½* (HOLOTYPE US!; ISOTYPES MO!, UC!).

Arabis tenuicula Greene, Leaflets Bot. Obs. & Crit. 2: 82. 1910; Crevices of cliffs, Union Co., Oregon, *W. C. Cusick 1124* (HOLOTYPE US!; ISOTYPE GH!).

Arabis microphylla var. *saximontana* Rollins, Rhodora 43: 429. 1941; Granitic hillsides, Porcupine Creek, near Medicine Mountain, Big Horn County, Wyoming, alt. 8500 ft., *L. O. & R. Williams 3264* (HOLOTYPE GH!).

Arabis lemmonii var. *paddoensis* Rollins, Rhodora 43: 384. 1941; Rocks, Mount Paddo, Washington, 6 or 7000 ft. alt., *W. N. Suksdorf 509* (HOLOTYPE GH!).

DISTRIBUTION. In crevices on rock cliffs and large boulders in southcentral British Columbia and, according to Rollins (1941), from Montana and Wyoming to Nevada and Washington.

BIOLOGICAL NOTES. This species has the chromosome number $n = 7$ and 15/2 and $2n = 14$ and 15 (Table 1). Böcher (1969) stated that plants from Wyoming had PMCs forming dyads, and anaphases initiating dyads were all regular with 15 chromosomes. *Arabis microphylla* obviously contains apomictic diploid plants with the base number $x = 7$, some of which have an aneuploid number of $2n = 15$. This species seems most closely related to *Arabis depauperata*.

24. **Arabis depauperata** Nelson & Kennedy, Proc. Biol. Soc. Wash. 14: 35. 1906; Summit Mt. Rose, Washoe Co., Nevada, *P. B. Kennedy 1167* (ISOTYPE UC!). *Arabis lemmonii* var. *depauperata* (Nelson & Kennedy) Rollins, Rhodora 43: 384. 1941.

Arabis interposita Greene, Leaflets Bot. Obs. & Crit. 2: 78, 79. 1910; Ashland Butte, Siskiyou Mts., and Crater lake, Cascade Mts., southern Oregon, *Wm. C. Cusick 2970* (LECTOTYPE US!, plant second from left; ISOLECTOTYPE GH!, plant on left). *Arabis divaricarpa* var. *interposita* (Greene) Rollins, Rhodora 43; 378. 1941.

Arabis acutina Greene, Leaflets Bot. Obs. & Crit. 2: 82. 1910; On an open rocky slope, Mount Thielson, Cascade Mts., Oregon, *F. V. Coville & E. I. Applegate 434* (LECTOTYPE US!; ISOLECTOTYPES RM!, US!).

Arabis bracteolata Greene Leaflets Bot. Obs. & Crit. 2: 73. 1910; Northwestern Wyoming, *J. N. Rose 1893* (HOLOTYPE US!).

Arabis nubigena Macbr. & Payson, Contrib. Gray Herb 49: 62. 1917; Gravelly flat, alt. 9000 ft., Smoky Mts., Blaine Co., Idaho, *J. F. Macbride & E. B. Payson 3772* (HOLOTYPE GH!; ISOTYPES UC!, US!, RM!). *Arabis microphylla* var. *nubigena* (Macbr. & Payson) Rollins, Res., St., State Coll. Wash. 4: 40. 1936.

Arabis microphylla var. *thompsonii* Rollins, Rhodora 43: 429. 1941. Kittitas Co., Washington, alpine meadows of Table Mt., 5000 ft., *J. W. Thompson 9266* (HOLOTYPE GH!; ISOTYPES NY!, US!).

DISTRIBUTION. On rocky alpine slopes in southern British Columbia. I have seen specimens from Montana, Nevada and California. It almost certainly also occurs in Idaho, Washington and Oregon.

BIOLOGICAL NOTES. *Arabis depauperata* contains diploid plants based on $x = 7$ (Table 1). It seems most closely related to *A. microphylla.*

25a. **Arabis holboellii** Hornem. var. **holboellii,** *Arabis holboellii* Hornem., Fl. Dan. 2: 5. 1827; plate 1879.

Arabis holboellii var. *tenuis* Böcher, Svensk Bot. Tidskrift 48: 38. 1954; ex Ilwdlinguaq sinus Søndre Strømfjord, Greenland, *T. Böcher, 22, 5, 1951* (HOLOTYPE C, not seen).

DISTRIBUTION. Open habitats in Greenland.

25b. **Arabis holboellii** var. **consanguinea** (Greene) G. Mulligan, *comb. nov.* Based on *Arabis consanguinea* Greene, Pittonia 4: 190. 1900; Los Pinos, southern Colorado, 7000 ft., *C. F. Baker 342* (HOLOTYPE ND!; ISOTYPES ND!, RM!, US!).

DISTRIBUTION. Open grassland and scrub in Alaska (rare), Yukon (rare), Saskatchewan (rare), Alberta, British Columbia, Washington, Oregon, California, Nevada, Colorado and Utah.

25c. **Arabis holboellii** var. **retrofracta** (Graham) Rydberg, Contrib. U.S. Nat. Herb. 3: 484. 1896. Based on *Arabis retrofracta* Graham, Edinb. Phil. Journ. 345. 1829; Rocky Mountains, Palliser's Brit. N. Am. Expl. Expedition, *E. Bourgeau, 1858* (PROVISIONAL LECTOTYPE GH!, chosen by Hopkins, 1937 and confirmed by Rollins, 1941; no specimen referred to in Graham's original description and there is no suitable material in the Royal Botanic Garden in Edinburgh).

Arabis rhodantha Greene, Pittonia 3: 155. 1897; Above Empire, Colorado, *E. L. Greene, 1875* (HOLOTYPE ND!, sheet 6327; ISOTYPE ND!, left specimen on sheet 6328).

Arabis tenuis Greene, Pittonia 4; 189. 1900. On mountains, 2000 ft. alt., W. Klickitat, Washington, *W. N. Suksdorf 15* (HOLOTYPE ND!; ISOTYPE GH!).

Arabis lignipes A. Nelson, Bot. Gaz. 30: 191. 1900; Madison River, Yellowstone National Park, *A. & E. Nelson 5505* (LECTOTYPE RM! by Rollins, 1941; ISOLECTOTYPE RM!).

Arabis caduca A. Nelson in Coulter & Nelson, New Man. Bot. Rky. Mts. 229. 1909; Woods Creek, Wyoming, *A. Nelson 2584* (HOLOTYPE RM!).

Arabis polyantha Greene, Leaflets Bot. Obs. & Crit. 2: 80. 1910; Along R.R. track at Rock Island, Washington, *K. Whited 1043* (HOLOTYPE US!).

Arabis macdougalii Rydberg, Bull. Torr. Bot. Club 3: 326. 1912; Old Sentinel, near Missoula, Montana, *MacDougal 191* (HOLOTYPE NY!; ISOTYPES NY!, US!).

Arabis retrofracta var. *multicaulis* B. Boivin, Can. Field-Nat. 65: 17. 1951; left bank of Malique R. at Fish Hatchery, Jasper National Park, *G. H. Turner 5086* (HOLOTYPE DAO!).

DISTRIBUTION. Grass slopes, talus, benches, roadsides, hillsides and many other open habitats in Alaska, Yukon, Mackenzie District, Quebec (rare), Ontario (rare), Manitoba, Saskatchewan, Alberta, British Columbia and southward. United States specimens were seen from Michigan, North Dakota, South Dakota, Montana, Wyoming, Colorado, Utah, Idaho, Washington, Oregon, Nevada and California.

25d. **Arabis holboellii** var. **secunda** (Howell) Jepson, Man. Fl. Pl. Calif. 430. 1925. Based on *Arabis secunda* Howell, Erythea 3: 33. 1895; Mount Adams, Washington, *T. Howell 1487* (HOLOTYPE ORE!; ISOTYPES NY!, US!).

Arabis collinsii Fernald, Rhodora 7: 32. 1905; Limestone—conglomerate cliffs and ledges, island—headland east of Baptiste Michaud's, Bic, Rimouski Country, Quebec, *J. F. Collins & M. L. Fernald July 16 & 18, 1904* (HOLOTYPE GH!; ISOTYPES CAN!, DAO!, GH!, MT!). *Arabis holboelii* var. *collinsii* (Fernald) Rollins, Rhodora 43: 445. 1941. *Arabis retrofracta* var. *collinsii* (Fernald) B. Boivin, Can. Field-Nat. 65; 17. 1951.

DISTRIBUTION. Prairie, grasslands, sand, and rocky areas in Alaska, Yukon, Mackenzie District, Quebec (rare, but common in Gaspé), Ontario (rare), Saskatchewan, Alberta, British Columbia and southward. Specimens were seen from Washington, Idaho, Montana and Utah. It probably occurs elsewhere in the western United States.

BIOLOGICAL NOTES. *Arabis holboellii* is nearly as widespread as *A. divaricarpa* and is certainly more abundant within its range. I have recognized four taxa of *A. holboellii* at the varietal level, all of these appearing to contain sexual and apomictic diploids and apomictic triploids, based on $x = 7$ (Table 1). I suspect that the sexual diploids are self-compatible.

26. **Arabis boivinii** G. Mulligan, *sp. nov.*

Arabis divaricarpa var. *dechamplainii* B. Boivin, Naturaliste Can. 94: 645. 1967; Cap au Cobeau, Bic, rochers maritimes calcaires, *A. A. De Champlain 1577* (HOLOTYPE DAO!; ISOTYPE MT!).

Arabis boivinii ab A. lignifera different inflorescentia leviter secunda, trichomatibus in foliorum radicalium paginis inferioribus plus quam 0.25 mm latis et habitu bienni vel breviter perenni.

Arabis boivinii differs from *Arabis lignifera* by its slightly secund inflorescence, its wider trichomes on undersurfaces of caudex leaves (i.e., more than 0.25 mm wide), and its biennial or short-lived perennial growth habit.

The holotype specimen in the herbarium of Agriculture Canada, Ottawa, is named after Bernard Boivin, 1916–1985 (see tribute to Boivin by Cody and Cayouette, 1986). Saskatchewan, District de Maple Creek, Carmichael, 10 milles au sud, Monts Cyprès écorre de la coulèe du ruisseau Bone, inflorescence seconde ou parfois distique, *B. Boivin & J. Alex 9738,* 8 juillet, 1952 (HOLOTYPE DAO!; ISOTYPE MT!). *Arabis divaricarpa* A. Nels. var. *hemicylindrica* B. Boivin, Amer., Midl. Nat. 54: 510. 1955 (same type as *A. boivinii*).

Biennial or short-lived perennial with a simple, compact caudex; stems erect, usually single, simple to few branched, 30 to 60 cm high; cauline leaves entire to rarely few toothed, glabrous to pubescent, sessile, mostly strongly sagittate-clasping stems, narrowly lanceolate, 1.0 to 2.5 cm long, 3 to 5 mm wide; caudex leaves entire to few toothed, compact, 1.5 to 2.0 cm long, 3 to 6 mm wide, blades lanceolate, slender petiolate; lower surfaces of caudex leaves with sparse to dense sessile to short-stalked, branched, 3- to 4-parted trichomes mostly 0.35 mm wide; inflorescences semisecund, open; fruiting pedicels arcuate-spreading to arcuate-descending, 3 to 9 mm long; siliques slightly descending to strongly descending, straight to slightly arcuate, 4.0 to 6.5 cm long, 1.5 to 2.0 mm wide, style rudimentary; seeds mostly in 1 row, brownish, oval, 1.75 mm long, 1.25 to 1.5 mm wide, narrowly winged at apex, cotyledons accumbent.

DISTRIBUTION. Dry prairie and hills of southern Saskatchewan, Montana and South Dakota and probably elsewhere on the plains of the United States; disjunct eastwards to limestone cliffs and ridges of Cap aux Corbeaux, Rimouski County, Quebec.

BIOLOGICAL NOTES. *Arabis boivinii* is a triploid based on $x = 7$ (Table 1). Morphologically it seems somewhat intermediate between *Arabis holboellii* and *Arabis divaricarpa.* Although both of these taxa occur within the range of *A. boivinii,* there is no evidence that it has resulted from recent hybridizations. I am treating it as a species resulting from the ancient hybridization of *A. holboellii* and *A. divaricarpa.* Rollins (1983) has suggested that *A. divaricarpa* itself is probably of ancient hybrid origin.

REPRESENTATIVE SPECIMENS. CANADA. **Quebec:** Cap aux Corbeaux, Comtè de Rimouski, sur le conglomerat nu, *Rousseau 26440* (DAO, MT); Point aux Corbeaux to Cap Caribou, Bic, limestone and limestone-conglomerate ridges, *Fernald & Collins 1061* (CAN). **Saskatchewan:** Cypress Hills, side hill on Bald Butte, *Budd 2005* (SASK); Cypress Hills Park, open plateau, occasional, *Breitung 4401* (MT); 12 miles south of Indian Head, dry south-facing knoll, *Jones 784* (SASK). UNITED STATES. **Montana:** Cascade Co., 3.8 miles south of Neihart, fresh road cut, clay-gravel soil, *Mosquin & Gillett 5219* (DAO). South Dakota: Lawrence Co., 2 miles north and ½ mile west of Savoy, steep south facing eroding slopes, *Mosquin & Mulligan 5157* (DAO).

27. **Arabis lignifera** A. Nelson, Bull. Torr. Bot. Club. 24: 123. 1899; Green River, Sweetwater Co., Wyoming, *A. Nelson 4711* (HOLOTYPE RM!; ISOTYPES GH!, MO!).

Arabis densicaulis A. Nelson, Bot. Gaz. 30: 190. 1900. In rocky exposed places on an abrupt slope, Undine Falls, Yellowstone National Park, *A. & E. Nelson 5680* was designated as the type for both *A. densicaulis* and *Arabis elegans* A. Nelson (Bot. Gaz. 30: 191. 1900). However, the specimens in RM and MO fit the description of *A. densicaulis* not *A. elegans.* A note on the isotype of *A. densicaulis* in RM, written by C. L. Porter '51, states that "also cited as a type of *A. elegans* A. Nels., Bot. Gaz. 30: 192, 1900 but this was an error for No. 6939."

Arabis subserrata Greene, Leaflets Bot. Obs. & Crit. 2: 79. 1910; Ellensburg, Washington, *K. Whited 321* (HOLOTYPE US!; ISOTYPE WS!).

DISTRIBUTION. Open rocky areas in northwest corner and in southern British Columbia and southward. It also grows in Idaho and Wyoming to Colorado and west to Nevada (Rollins, 1993b).

BIOLOGICAL NOTES. *Arabis lignifera* contains diploid plants with the base number $x = 7$ (Table 1).

28. **Arabis sparsiflora** Nuttall in T.&G., Fl. N. Am. 1: 81. 1838; Forests of Rocky Mountains, towards sources of Oregon (LECTOTYPE PH!, specimen on extreme right of herbarium sheet).

Arabis sparsiflora var. *arcuata* (Nuttall) Rollins, Res. Studies State Coll. Wash. 5: 26. 1936. Based on *Streptanthus arcuatus* Nuttall in T.&G., Fl. N. Am. 1: 77. 1836; Santa Barbara, *Nuttall* (HOLOTYPE PH!; ISOTYPE GH!).

Arabis sparsiflora var. *peramoena* (Greene) Rollins, Res. Studies State Coll. Wash. 5: 26. 1936. Based on *Arabis peramoena* Greene, Feddes Repertorium 5: 242. 1908; Dry sandy soil of Willow Creek, Malheur Co., Oregon, purple showy flowers, *W. C. Cusick 2309* (ISOTYPES NY!, RM!, US!).

Arabis campyloba Greene, Pittonia 4: 192. 1900; Near Yreka, California, *E. L. Greene, April & May 1876* (HOLOTYPE ND!).

Arabis polystricha Greene, Leaflets Bot. Obs. & Crit. 2: 72. 1910; Dry hill near near Yreka, Siskiyou Co., California, *Butler 723* (HOLOTYPE ND!; ISOTYPES ND!, P!, RSA-POM!, UC!).

Arabis arcoidea A. Nelson, Bot. Gaz. 53: 220. 1912; Loamy creek banks among hills, altitude 2200, near Plymouth, Canyon County, Idaho, *J. F. Macbride 87* (HOLOTYPE RM!; ISOTYPES GH!, RM!).

Arabis sparsiflora var. *californica* Rollins, Rhodora 43: 402. 1941; California, on dry hills, near Campo, San Diego County, *L. Abrams 3563* (HOLOTYPE GH!).

DISTRIBUTION. Occurs in sagebrush and on dry benches in southern British Columbia (only near Penticton), Idaho, Oregon, Arizona, Nevada, California and Washington.

BIOLOGICAL NOTES. One diploid population, with the base number $x = 7$, growing in Arizona was apparently sexual, whereas another was probably apomictic (Table 1). Raven et al. (1965)

and Böcher (1969) reported $2n = 22$ for plants from California. Böcher observed the configuration of 7II + 8I at metaphase I. It appears that sexual diploids and apomictic diploids and deviant triploids, based on $x = 7$, occur in this species.

29. **Arabis columbiana** Macoun, Mac. Cat. 5: 304. 1890; Gravel, Yale, B.C., *Macoun, May 17th, 1889* (LECTOTYPE CAN!; ISOLECTOTYPE GH!). *Arabis sparsiflora* var. *columbiana* (Macoun) Rollins, Rhodora 43: 405. 1941.

Arabis sparsiflora var. *subvillosa* Rollins, Rhodora 43: 403. 1941. Based on *Arabis arcuata* Gray var. *subvillosa* Watson in Gray, Syn. Fl. N. Am. 1: 164. 1895; Pulman, Washington, *C. V. Piper, May 20, 1894* (HOLOTYPE GH!).

Arabis elegans Nelson, Bot. Gaz. 30: 192. 1900; Undine Falls, Yellowstone National Park, *A. & E. Nelson 6939* (LECTOTYPE RM!).

Arabis stokesiae Rydb., Fl. Rocky Mts. 361. 1918; Parley's canyon, Wahsatch Mts., alt. 5000 ft., *S. G. Stokes, June 8, 1901* (HOLOTYPE US!; ISOTYPE GH!, NY!).

DISTRIBUTION. Grasslands, sagebrush, rock outcrops, talus slopes, and open woods in Yukon, British Columbia, Washington, Idaho, Oregon, California, Nevada and Utah.

BIOLOGICAL NOTES. It appears that sexual and apomictic diploids and apomictic triploids, based on $x = 7$, occur in *A. columbiana* (Table 1).

30. **Arabis pinetorum** Tidestrom, Proc. Biol. Soc. Wash. 36: 182. 1923; In coniferous forest north of Glenbrook, along Lake Tahoe, Nevada, elev. 1890 meters, *I. Tidestrom 10387* (HOLOTYPE GH!). *Arabis holboellii* var. *pinetorum* (Tidestrom) Rollins, Rhodora 43: 447. 1941. *Arabis divaricarpa* var. *pinetorum* (Tidestrom) B. Boivin, Can. Field-Nat. 65: 16. 1951.

DISTRIBUTION. Open slopes, dunes and prairie in Alaska, Yukon, Mackenzie District, Manitoba, Saskatchewan, Alberta and British Columbia. Specimens were seen from North Dakota, Utah, Wyoming, Nevada and California. It undoubtedly occurs elsewhere in the western United States.

BIOLOGICAL NOTES. Plants with the somatic chromosome numbers of 14, 13 + 2B and 21 occur in *A. pinetorum* (Table 1). One of the sites, in California, had diploid plants with an irregular meiosis. It, therefore, seems likely that apomicts, based on $x = 7$, occur both at the diploid and triploid level.

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A NATURAL HYBRID OF *DROSERA ANGLICA* HUDS. AND *DROSERA LINEARIS* GOLDIE IN MICHIGAN

Donald E. Schnell

ABSTRACT

Plants of the natural hybrid of *Drosera anglica* Huds. and *Drosera linearis* Goldie were discovered in a fen in Chippewa County, Michigan and are herein reported for the first time. Leaf aspects of the hybrid are intermediate between the parents and are best expressed as a leaf blade length/width ratio. Multiple measurements of the ratio in the parents and putative hybrid indicate an intermediate state. Chromosome evaluation indicates $2n = 30$ (*D. anglica* $2n = 40$, *D. linearis* $2n = 20$ in the literature). Pollen viability is very low and no seeds are produced in the plants. The corolla is slightly larger in the hybrid than in either parent. In the field, the hybrid appears very vigorous and grows on two low mossy hummocks in a calcareous fen. In culture in the greenhouse, the hybrid plants show heterosis and leaf out and flower earlier in the season than the putative parents.

Key Words: *Drosera anglica, Drosera linearis, Drosera anglica* × *D. linearis,* hybrids

INTRODUCTION

While botanizing in a typical calcareous Great Lakes fen along the Lake Huron shoreline in the eastern tip of Michigan's upper peninsula, I noted two stands of Drosera which at first glance appeared to be particularly vigorous plants of *Drosera anglica* Huds. As I prepared to photograph the plants, reexamination indicated that the plants might be *Drosera linearis* Goldie. Since the plants seemed to have leaf characteristics of both species, I then conjectured that they might be hybrids of *D. anglica* and *D. linearis.*

A search of the literature indicated that a natural hybrid of these two species had not yet been characterized, although postulated by Wood (1955). Kusakabe (1979) submitted a list of artificial *Drosera* hybrids which he had prepared in his greenhouse. Among these was "*D* × *linglica*" (Sic; quotes mine), produced in 1976 using *D. linearis* from Ontario and *D. anglica* from Munich Botanical Gardens. There is no record of "*D.* × *linglica*" having been published horticulturally or botanically.

HABITAT DESCRIPTION

The location is near the shore of Lake Huron in Chippewa County, Michigan. First seen in June 1987, the plants are in a typical Great Lakes calcareous or marl fen of rich type. Such fens are described in detail elsewhere (e.g., Cruise and Catling, 1974; Schnell, 1982; Crum, 1988).

This rather large fen is nearly a hectare in extent and consists of marly sand and peat overlaid by a 1–3 cm layer of very slowly flowing water originating from springs at the fen margins. Scattered across this flat are variably sized and spaced hummocks of *Sphagnum* spp. and other non-sphagnous mosses. The edge of the fen is marked by deep stands of similar mosses extending into a rather dense surrounding woods of predominantly *Picea mariana* (P. Mill.) B.S.P., *Thuja occidentalis* L., *Larix laricina* (Du Roi) K. Koch and *Betula* spp.

Droseras in the fen included *D. anglica, D. linearis* and *D. rotundifolia* L. *D. linearis* typically occurs scattered over the marly flat in water, less commonly on hummocks. *D. rotundifolia* usually occurs in sphagnum on the hummocks. *D. anglica* grows preferentially around the bases of hummocks but may appear in the moss.

The plants in question were occupying the entirety of two hummocks approximately 0.5 meter across and located 5 meters apart. They crowded the entire surface of each hummock to the exclusion of other Droseras and numbered between 100–200 plants each (Figure 1).

Specimens were collected and pressed 21 June 1987 for my personal herbarium, then submitted to US as my specimen number *870621-1* at the conclusion of studies on 30 July 1994. A few plants were also collected to be grown and observed in cultivation. The area was also revisited and observed over the intervening years.

MATERIALS AND METHODS

Vernier calipers were used to measure corolla diameters as well as leaf blade length (petiole excluded) and maximum width. The numbers of leaves from as many plants are indicated by *n* in the Table. Means, medians and standard deviations (SD) were calculated.

Figure 1. Putative *Drosera anglica* Huds. × *D. linearis* Goldie in flower in Chippewa County Michigan.

Root squashes for chromosome counts were attempted but were unsuccessful due to a peculiar crystalline material within cells that interfered. Tissue sections of roots disclosed few mitoses. Young flower buds (2–3 mm) were fixed in alcohol:acetic acid (3:1), dehydrated using standard histologic technique and then imbedded in paraffin. Ten micron sections were made and stained with

Table 1. Leaf blade length/width ratios of putative hybrid and parents. ***n***—number of leaves from as many plants, **mean**—average of L/W's, **SD**—standard deviation of ratios, **range**—one SD around mean, **lowest and highest L/W's**—lowest and highest ratios in the series, **median**—from list of lowest to highest L/W's in each category.

	D. linearis	*D. anglica* × *linearis*	*D. anglica*
n	40	47	41
Mean	16.3	9.0	5.4
SD	3.6	1.5	1.5
Range-1 SD	12.7–19.9	7.5–10.5	2.4–8.4
Lowest L/W	10.6	5.6	3.1
Highest L/W	26.6	12.0	9.7
Median	15.85	9.0	5.1

hematoxylin and eosin. There was no ovule or PMC mitotic activity, but many somatic mitoses were noted in the carpels. Those cut at the best angle for counting were selected and amounted to 24 figures in buds of seven flowers from seven different plants.

Surrogate pollen viability was determined by staining with lactol phenol cotton blue. Pollen was placed on a glass microslide, stain added, the pollen mixed with the stain, the whole coverslipped and set aside for three hours.

Plants were successfully cultivated in the greenhouse in southwestern Virginia in a wet medium of equal parts coarse sand and peat. Minimum greenhouse temperature was 7–8°C. Samples of *D. anglica* and *D. linearis* were kept in similar cultural conditions beside the putative hybrid plants.

RESULTS AND DISCUSSION

Basic morphometric studies were undertaken to find the simplest and most useful demonstration of whether the study plants were hybrids of the putative parent species. Flowers were found to have corollas 1.5 to 2.0 mm larger on the average than either *D. linearis* or *D. anglica* (both of which measure 6–7 mm across). Leaves of the putative hybrids were on the whole 5–6 mm longer than leaves of *D. linearis.* Neither of these features were helpful in precise differentiation for study purposes.

Noting that the leaves of *D. linearis* are linear in character while those of *D. anglica* are obovate to elongate-spatulate, I required measurements to take into account leaf blade width and length in one term. The simplest measurement term in my opinion was leaf blade length divided by width (L/W) in order to obtain an index of minimum complexity.

The resulting ratios, means, medians and SD's are listed in the Table, and means and SD ranges compared in Figure 2, with "average" leaves shown in Figure 3. The study plants fall into an intermediate position between the two putative parent species with minimum overlap. The medians are close to the means indicating a closely Gaussian distribution of samples about the means. I would expect a hybrid of the two species to have these intermediate leaf characters. The larger flower and generally but insignificantly longer leaf of the hybrid will be mentioned later.

Chromosome counts on carpel sections were $2n = 30$. All North American Droseras are $2n = 20$ except *D. anglica* which is $2n =$

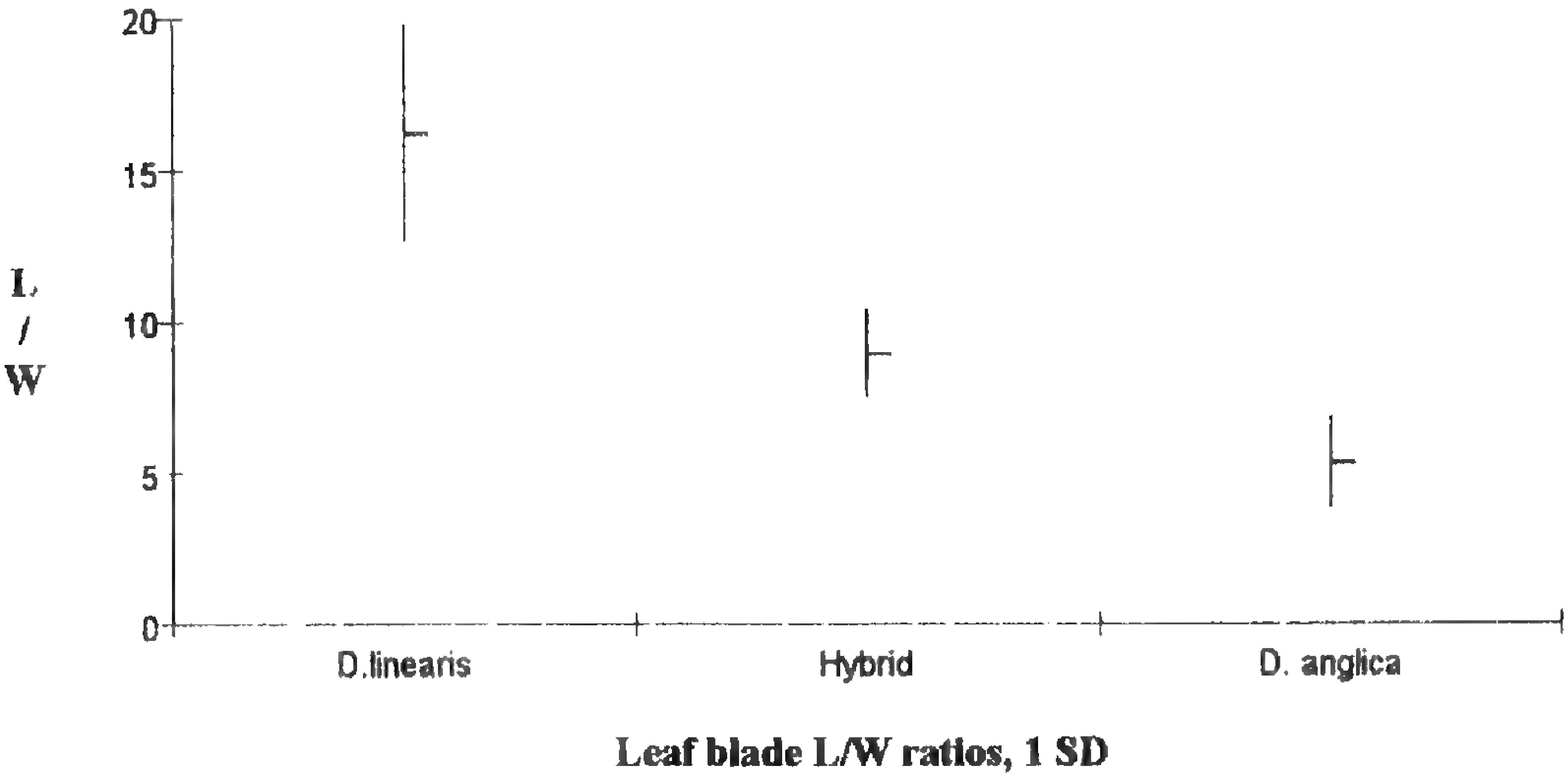

Figure 2. Comparison of leaf blade length/width (L/W) ratios with highest and lowest in each category, and mean indicated by tick in center of each bar.

40 due to its amphiploid hybrid origin (Wood, 1955). These counts are also consistent with a hybrid between the two putative parent species.

Usually, North American *Drosera* spp. self pollinate when the flower closes at the end of one to two days if pollination has not been effected by another agent. *Drosera* hybrids are typically sterile (pers. obs.; Wood, 1955). The study plants, examined at the conclusion of each of five growing seasons, were never seen to set seed in nature or in cultivation while both putative parent species readily did so. Pollen staining indicated that less than 10% of the grains in several different preparations from different study plants stained minimally. Pollen samples from the two species had greater than 95% intense staining. Examination of withered flowers of the study plants at the conclusion of anthesis disclosed a few empty testae with no seeds present. These findings support the hybrid origin of the plants in this setting.

In cultivation, the study plants began spring growth from winter hibernacula three to four weeks prior to either putative parental species. Growth was vigorous and similar to those plants in nature. The hibernaculae frequently budded so that the plants reproduced vegetatively. This activity along with minimally increased corolla diameter and leaf length is attributed to heterosis. I have observed similar hybrid vigor in other North American *Drosera* hybrids.

I conclude that the leaf blade L/W ratios, chromosome counts,

Figure 3. Photo comparison of typical leaves of *D. anglica* (top), putative hybrid *D. anglica* × *D. linearis* (middle), and *D. linearis* (bottom).

flower sterility, and evidence of heterosis all indicate that the study plants are of hybrid origin involving *D. anglica* and *D. linearis* as the parents.

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THE CHROMOSOME NUMBER OF *SAXIFRAGA GASPENSIS* FERNALD

CAMILLE GERVAIS, NORMAN DIGNARD, AND ROSAIRE TRAHAN

ABSTRACT

The chromosome number of *Saxifraga gaspensis* Fern., a taxon frequently included in the circumpolar species *S. nivalis* L., or considered a variety, was determined on material from Mount Logan, Gaspé Peninsula, and found to be $2n = 40$. As the chromosome number of *S. nivalis* is $2n = 60$ (about 30 data from diverse countries), it seems that the plant described by Fernald in 1917 is specifically different. The authors suggest that *S. gaspensis* could be a stabilized relictual hybrid between *S. nivalis* and the closely related diploid species *S. tenuis* (Wahlenb.) H. Smith, $2n = 20$, or a polyploid originating from *S. tenuis*.

Key Words: *Saxifraga gaspensis, S. nivalis, S. tenuis,* chromosome number, distribution, endemism, Gaspé Peninsula, Québec, Canada

TAXONOMIC HISTORY

Saxifraga gaspensis was described by M. L. Fernald in 1917 from material collected in 1906 with J. F. Collins (600, GH) on calcareous slopes of Tabletop Mountain (Mount Jacques-Cartier) on the Gaspé Peninsula and first distributed in herbaria as *S. nivalis* L. The new species differed from the circumpolar arctic-alpine *S. nivalis* by its "rosette-leaves more narrowly cuneate-obovate and more gradually narrowed to a broad petiolar base," its less numerously flowered inflorescences which were spicate-racemose rather than spiciform to corymbiform, its shorter calyx lobes reflexed in fruit, its acute to subacute and narrower petals and its shorter capsules.

In the following decades, *S. gaspensis* was discovered in moist pockets and ravines on Mount Logan and Mount Blanc, west of the type locality, and it was also reported from northern Québec and Labrador (Rousseau, 1974). Although still retained as a distinct species by Fernald (1950) in the Gray's Manual, *S. gaspensis* is judged to be a synonym of *S. tenuis* or of *S. nivalis* var. *tenuis* Wahlenb. in more recent treatments (Scoggan, 1978; Kartesz, 1994). Hultén (1971), on the other hand, uses the name *S. gaspensis* on his maps but states that the species is doubtfully distinct from *S. nivalis* var. *tenuis.* Only Boivin (1966 and unpubl.) considered *S. gaspensis* [sub *S. nivalis* var. *gaspensis* (Fern.) Boivin] as a taxon differing from *S. nivalis* and *S. tenuis sensu stricto.*

However, in recent catalogs or documented lists of rare, endangered or vulnerable species in Canada or in Québec (Bouchard et al., 1983; Argus and Pryer, 1990; Lavoie, 1992), *S. nivalis* var. *gaspensis* is revived as, at least, a taxon in need of further research. For this reason and because of the urgent problem of determining if *S. gaspensis* must be included, or not, in the list of species to be legally protected, the present study was undertaken.

MATERIAL AND METHODS

Living material of *S. gaspensis* (some with seeds) was first collected in late August of 1993 in cold chimneys of Pease Basin on the eastern side of Mount Logan, for greenhouse culture. Additional specimens were also taken in June 1994 on schistose walls of Big Cascade, between Mounts Dodge and Griscom, east of the 1993 stations. For the cytological studies, fresh root tips were selected from potted plants and from seeds germinating on wet filter papers in Petri dishes. They were fixed in an acetic acid/absolute alcohol 1:3 mixture before coloration in aceto-carmine and squash in a drop of carmine. As a pre-treatment, before fixation, the potted plants or the Petri were kept in a refrigerator at 4°C for 4 to 7 hours.

RESULTS AND DISCUSSION

The chromosome number $2n = 40$ (Figure 1) was determined on one of the potted plants and two plantlets obtained from seeds collected in 1993 in Pease Basin. The same chromosome number ($2n =$ ca. 40) was also observed on the 1994 material from Big Cascade. This chromosome number differs from the numerous counts reported for *S. nivalis* ($2n = 60$) and *S. tenuis* ($2n = 20$) on circumpolar material from Greenland, Iceland, Spitzberg, Norway, Siberia, Alaska, British Columbia, Northwest Territories, etc. with the exception of a report by Krause and Beamish (1973) who have found $n = 20$ on one specimen of this group from the Yukon territories (Lapie Lake). These authors do not attempt to attach any binomial to the cytotypes ($n = 20$, $n = 10$) they have found in the Yukon but describe them as belonging to a large *S. nivalis-tenuis* complex. Our chromosome data, however, were specifically determined from specimens which were suspected to

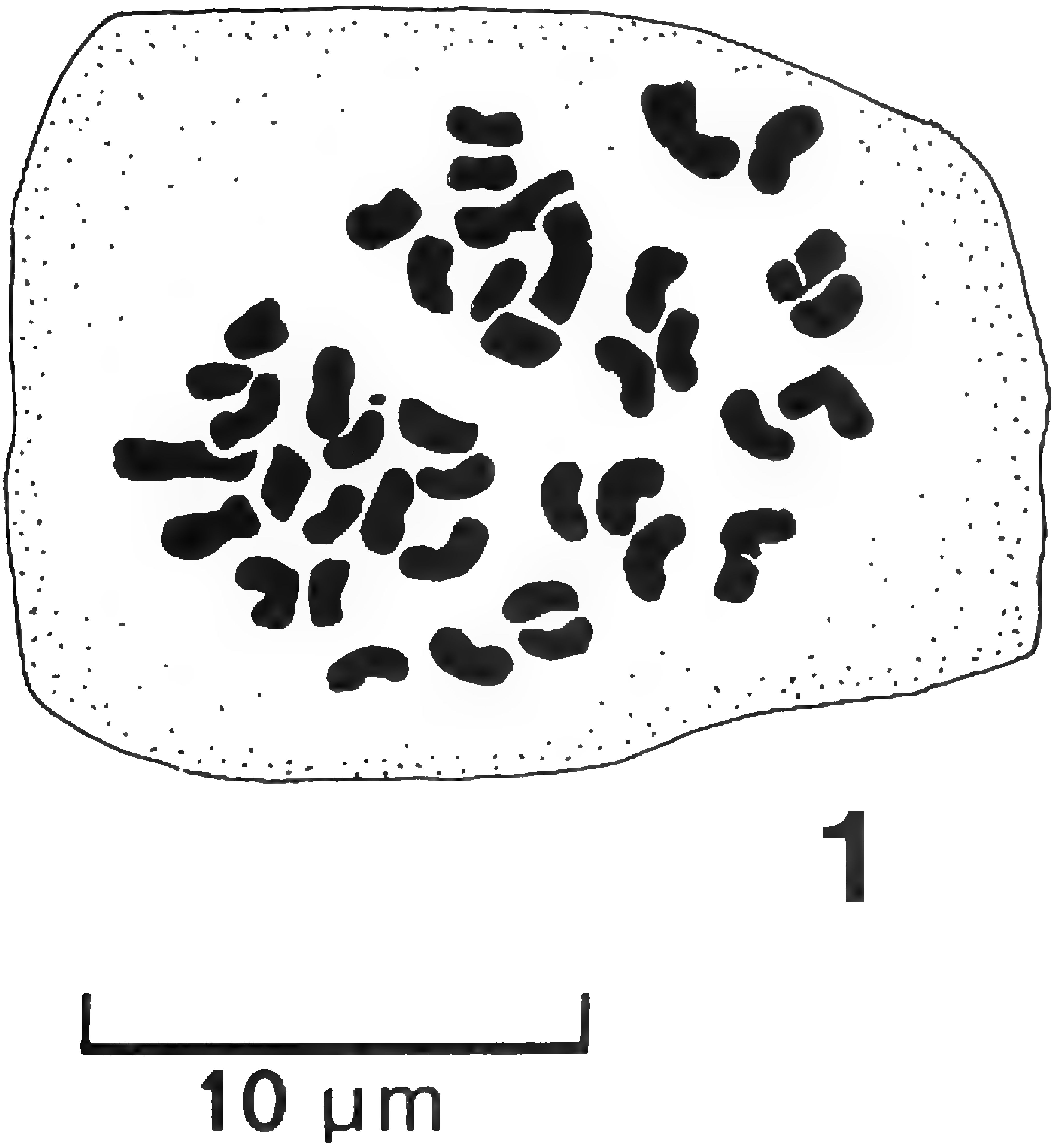

Figure 1. Somatic chromosomes of *Saxifraga gaspensis* Fern.; metaphase with $2n = 40$ chromosomes from a root-tip cell.

be *S. gaspensis,* so that we are inclined to consider this taxon as basically different from *S. nivalis* and *S. tenuis.*

The chromosome count ($n = 20$) of Krause and Beamish (1973) in the Yukon possibly belongs to a hybrid individual between *S. nivalis* ($2n = 60$) and *S. tenuis* ($2n = 20$), the two species growing together in this region where their differences "seem to break down and the plants appear to intergrade" as Krause and Beamish (1973) point out. The same situation may also prevail in northern Québec and Labrador where the mention of "*S. gaspensis*" refers perhaps to such hybrids.

It is quite possible that *S. gaspensis* shares the same hybrid origin but, as *S. tenuis* ($2n = 20$) is not reported for the Gaspé Peninsula and *S. nivalis sensu stricto* ($2n = 60$) possibly does not exist there either, we must suppose that *S. gaspensis* is a relictual stabilized hybrid able to reproduce and set viable seeds. This event could have occurred when the Gaspé Peninsula climate and flora were different and comparable to the actual situation in the arctic. Another possibility is that *S. gaspensis* is a tetraploid offspring of *S. tenuis* but an ancient origin must also be advocated in this case.

The study of the meiosis in *S. gaspensis* could perhaps provide an answer to these questions but a cytological examination of different populations of *S. nivalis sensu lato* in the Gaspé Peninsula and in northern Québec may be necessary to understand the whole problem. It can already be recommended, however, that the taxa belonging to the *S. nivalis* complex in the Gaspé Peninsula be protected as an endangered local taxa.

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The authors would like to express their gratitude to Michèle Parent for help in field trips, to Dr Alison Munson for revision of the English manuscript, to Jean Gagnon and Gildo Lavoie for helpful discussions and to Andrée Rodrigue for the typing of the text.

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BOOK REVIEW

Bremer, K. 1994. *Asteraceae, Cladistics & Classification.* 752 pp. Timber Press, Inc., 9999 S. W. Wilshire, Suite 124, Portland, Oregon 97225. ISBN 0-88192-275-7. ($79.95, hardcover).

". . . the book is about cladistics, phylogeny, and evolution of the Asteraceae, based on analysis of morphological data. It is also a cladistic evaluation of existing subfamilial, tribal, and subtribal classification, and a reference to the generic classification of the family." From the Preface.

There are 4 preliminary chapters—Cladistics, pp. 5–11; Classification, pp. 13–23; Morphology, pp. 24–35; and Evolution, pp. 36–46. The bulk of the book, pp. 49–680, is a subfamily by subfamily, tribe by tribe, subtribe by subtribe, genus by genus discussion of the morphology and classification of the family. There is a 46 page list of References, and a 23 page index.

When reviewing a "new" classification one may emphasize the non-congruity of the new classification with the one(s) it is intended to replace, or one may emphasize the similarities between the classifications. Figure 1 illustrates the evolution of the Classification of the Compositae from George Bentham (in G. Bentham and J. D. Hooker, Genera Plantarum, vol 2(1), 1873) to Wagenitz (in the 12th edition of A. Engler, Syllabus der Planzenfamillien, 1964), to the classification offered here by Bremer. Basically, Bremer and his colleagues have rearranged groups of species and genera that have been recognized as natural groups for many years. The innovations consist in the recognition or resurrection of segregate genera and the removal of many genera to unfamiliar locations in the great scheme of things.

One nomenclatural treatment is interesting. There is a subfamily Cichorioideae and a genus *Cichorium.* But *Cichorium* is placed in the tribe Lactuceae, unassigned to a subtribe. According to the Code, Article 19, Bremer's tribe Lactuceae should be Cichoreae (since it includes *Cichorium*), and there should be a subtribe Cichorinae to include *Cichorium* (which is currently "unassigned to a subtribe").

Bentham 1873	Wagenitz 1964	Bremer 1994
Tribes:	Subfamily Asteroideae	Subfamily Barnadesioideae
Vernoniaceae	Vernonieae	Barnadesieae
Eupatoriaceae	Eupatorieae	
Asteroideae	Cardueae	Subfamily Cichorioideae
Inuloideae	Heliantheae	
Helianthoideae	Helenieae	Mutisieae
Helenioideae	Senecioneae	Cardueae
Anthemideae	Calenduleae	Lactuceae
Senecioideae	Inuleae	Vernonieae
Calendulaceae	Astereae	Liabeae
Arctideae	Anthemideae	Arctoteae
Cynaroideae	Arctotideae	
Mutisiaceae	Mutisieae	Subfamily Asteroideae
Cichoriaceae		
	Subfamily Cichorioideae	Inuleae
		Plucheeae
	Cichorieae	Gnaphalieae
		Calenduleae
		Astereae
		Anthemideae
		Senecioneae
		Helenieae
		Heliantheae
		Eupatorieae

Figure 1. A comparison of the classifications of Bentham, Wagenitz and Bremer.

Another point of interest is the omission of any discussion, or even mention of, ×*Solidaster* Wehrhahn (= ×*Asterago* T. H. Everett), the putative hybrid between *Aster ptarnicoides* and an unknown *Solidago.* The plant has been known and cultivated in Europe since about 1910. Such a hybrid, if it does, in fact, have that parentage, might lead to some reconsideration of the subtribal placement of the *Aster* and *Solidago.*

There is here, a great deal of information and many provocative ideas. It will be of use for many years to come. However, only specialists in the Compositae will find it easy to use. At the practical level, the lack of indication of synonymy, the lack of indication of exactly where groups have been put, and the lack of indication of what species are included in which genera, makes the work difficult to use for non-synantherologists.

Many modern students seem to have forgotten that the two basic reasons for any classification are (1) to place similar (? = related) species together and (2) to facilitate the identification of individual plants by individuals other than the author(s). Other inferences of great interest may well flow from such a classification, but they are secondary to the identification of individual plants.

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RHODORA NEWS & NOTES

LISA A. STANDLEY

HIGHLIGHTS OF CLUB MEETINGS

February, 1995. The 906th Meeting of the New England Botanical Club was held at the Harvard University Biological Laboratories, with 58 members and guests present.

Dr. Benito Tan of Harvard's Farlow Herbarium spoke on "Philippine Mosses: Diversity, Biodiversity, and Wallace's Line." Ben started by noting that he would attempt to refute two dogmas—"if you've seen one moss you've seen them all"—and the concept that mosses are not useful as indicators of ecological change.

The Philippine archipelago is part of the Malesian region, which includes the Indonesian islands and New Guinea. There are sharp floristic and faunistic demarcations at the boundaries of, and within, this region—hundreds of genera do not extend across the boundaries despite close physical distance and no climatic differences. These boundaries generally coincide with deep sea trenches, and are now thought to be related to plate tectonic history. At least three major internal regions are recognized. Wallace's Line divides the east and west subunits of Malesia, and generally extends between Borneo and Celebes. The Philippines have been placed east, and west, of Wallace's Line by different investigators. Ben has been attempting to answer the question of whether Wallace's Line exists for mosses, and if the moss flora supports placing the Philippines in the western or eastern subunit of Malesia. He has also been documenting the bryophyte flora and floristic relationships of Palawan, an island group extending northward from Borneo.

Ben took the Club on a floristic tour of the vegetation types of the Philippines, ranging from low elevation rain forest, seasonally dry forest, limestone substrates, serpentine substrates, and high elevation cloud forests dominated by epiphytic bryophytes. The vascular and bryophyte floras of the Philippines contain species and genera that are widely distributed in the paleotropics, display eastern asian affinities, or are part of the maleasian/oceanic flora. The flora also includes remarkable endemics such as the angiosperm Rafflesia, and the 2-foot high moss *Dawsonia.*

The distribution of mosses in the Philippines can be explained by two hypotheses. Although the archipelago is not currently close to China, the affinities of the flora are eastern Asian. This is explained by the geological history of the region: the Philippines were once very close to China and were separated from it by the spreading of the South China Sea. The Philippines definitely belong west of Wallace's Line. The distribution of mosses within the archipelago may also be explained by past climatic changes. Although we tend to think of rain forests as being ancient, Malesia was probably substantially drier during the Pleistocene. Some bryophytes now consist of widely disjunct populations, and exist in scattered dry refugia among the more recent rain forests. Ben closed by noting that the moss flora of the Philippines is now threatened by deforestation, for lumber and for agriculture. This is especially evident on Palawan, where the more seasonally dry forests are being burned to create agricultural fields.

March, 1995 (907th Meeting). Dr. Michael Donoghue of Harvard University was welcomed back to the Club after several years in the deserts of the American Southwest. He spoke on his long-term studies on the genus *Viburnum,* particularly on studies on the New England species that reveal new information about the evolutionary history of the group. The 200-odd species of woody shrubs that make up the genus generally fall into a New World group, with fruits that develop from yellow through red to ripe purple fruits, which fall off. Old World species have ripe red fruits which persist on the plant. Arrowwood and highbush cranberry are typical representatives of each group. An analysis of cpDNA supports the hypothesis that blue fruits arose independantly in both groups. *Viburnum acerifolium* is anomalous, with persistent blue fruits, and may be most closely related to a species from the Caucasus. Several species of *Viburnum* also have large, peripheral sterile flowers that may be an adaptation to attract pollinators in shady understory environments. Mike has been testing this hypothesis, thus far inconclusively. In summary, *Viburnum* is an old genus that differentiated fairly early, spread geographically, and subsequently diverged. Based on Mike's experience, it is a rich source for understanding mechanisms of plant evolution.

April, 1995 (908th Meeting). Dr. Richard Evans Schultes was the annual Distinguished Speaker, speaking on the topic "Amazonia:

80,000 species of plants awaiting ethnobotanical study." Among his many career distinctions, Dr. Schultes was recently awarded the Linnaean Society Medal (analogous to the Nobel Prize), and has been a Club member since 1937. Dr. Schultes has worked on the medicinal flora of the western, Columbian, Amazon forest for more than 50 years—and consequently feels more familiar with the flora of the Amazon than that of New England. Many of the region's 80,000 species of flowering plants have never been described, let alone investigated. Remarkable features of the region include ancient, highly eroded sandstone mountains that support endemic species, and rivers with rapids and waterfalls. Dr. Schultes' lifetime of ethnobotanical research has focused on the Native American tribes of this region, who are dependent on a wide range of plants to meet diverse purposes. Coca is chewed on a daily basis, with no addiction, and enables Indians to endure hard physical labor and lack of food. Ten species of rubber (the genus *Hevea*) are native to the Amazon, and although used by the local tribes, have not been fully exploited. Dick once collected 3 tons of seed of a localized ecotype with high productivity, unfortunately displacing the local movie theater. A local palm, which produces an extraordinary number of seeds containing an oil similar to olive oil, has not been introduced into cultivation but is potentially a major oil crop. *Aristolochia medicinalis* is a panacea richly deserving of the specific epithet. Other plants, such as *Paullina yoco*, are used for stimulant beverages. An arrow poison, derived from the bark of lianas, has been successfully introduced into western medicine as a muscle relaxant. Another bark, containing rotenone, is used to stun fish. Various plants are used for spiritual purposes. Hallucinogens from a variety of sources are used by medicine men to communicate with spirits. Snuff, derived from the inner bark of a species of *Virola* (in the nutmeg family) is also a powerful hallucinogen.

Dr. Shultes shared photographs of many of his adventures in the Columbian Amazon region over the past 54 years. He danced in a grass skirt to scare off demons of bad weather, and breakfasted on tapioca bread with chili pepper. He concluded the talk by showing photographs of some of the more devastated areas of Brazilian deforestation, and urged the audience to visit the Amazon and experience the river and forest ecosystem while at least portions of it are intact.

GRADUATE STUDENT RESEARCH AWARD

The 1995 Graduate Student Research Award was presented to Peter Walker, a student at the University of Vermont, in support of his research entitled "Speciation in Ammophila: Sequence Variation in the Internal Transcribed Spacer of Nuclear Ribosomal DNA." This research is aimed at understanding the status and evolution of *Ammophila champlainensis,* thought to be a distinct taxon endemic to the Lake Champlain basin.

THE NEW ENGLAND BOTANICAL CLUB

22 Divinity Avenue
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The New England Botanical Club is a non-profit organization that promotes the study of plants of North America, especially the flora of New England and adjacent areas. The Club holds regular meetings, has a large herbarium of New England plants, and a library. It publishes a quarterly journal, RHODORA, which is now in its 95th year and contains about 400 pages a volume.

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STERILITY IN THE NORTH AMERICAN LAKE CRESS *NEOBECKIA AQUATICA* (BRASSICACEAE): INFERENCES FROM CHROMOSOME NUMBER

Donald H. Les, Gregory J. Anderson, and
Maryke A. Cleland

ABSTRACT

Sterility of lake cress results from uncertain factors and may be a significant element in the decline of populations over the past century. The inability of lake cress (*Neobeckia aquatica*) to produce viable seeds restricts its dispersal to vegetative fragments which are transported less effectively over long distances. We obtained mitotic counts of $2n = 24$ for individuals from seven populations of lake cress, a species for which the chromosome number was unreported previously. In context of chromosome number distribution in the Brassicaceae based on literature reports for 192 mustard genera, the base number of tribe *Arabideae* (in which lake cress is placed) and of all genera presumed to be closely related to lake cress is $x = 8$. The presence of 24 chromosomes indicates that lake cress is a triploid derived from an $x = 8$ chromosomal series. Highly sterile triploid hybrids ($2n = 3x = 24$) have also been reported in several genera related to lake cress. The extremely well-developed system of vegetative reproduction in lake cress may partially compensate for its sexual sterility. The discovery that lake cress is triploid offers a specific explanation for its sterility and discloses special considerations for the conservation of this rare species.

Key Words: Brassicaceae, *Arabideae, Neobeckia,* triploid, conservation

INTRODUCTION

The monotypic North American lake cress, *Neobeckia aquatica* (Eaton) Greene (Figure 1), is distinguished as one of few truly aquatic species in the mustard family, Brassicaceae (Cook, 1990). Lake cress is also known for its heterophylly, extreme range of vegetative polymorphism, and remarkable ability to regenerate

Figure 1. A specimen of the aquatic mustard *Neobeckia aquatica* showing dissected submersed foliage, entire emersed foliage, and racemose inflorescence. Although fruits form occasionally in this species, they typically (as in this specimen) lack seeds. Drawn from *Bryson 8865* (KNK). Bar = 1 cm.

from minute fragments of roots, stems and leaves (Foerste, 1889; La Rue, 1943; Mac Dougal, 1914). Although lake cress has been assigned variously to the genera *Armoracia, Nasturtium,* and *Rorippa* (Al-Shehbaz and Bates, 1987), a recent molecular systematic study supports the taxonomic recognition of *Neobeckia* as a monotypic sister genus to *Rorippa* (Les, 1994).

Once widely distributed in eastern North America, lake cress has become rare as a result of significant population losses throughout its former range, particularly in the central portion (Stuckey, 1987; Les, 1994). More detailed distributional information has been summarized in Les (1994). Conservation of lake cress is presently of concern in several states with categories of imperilment including rare (New York; Mitchell, 1986), threatened (Vermont; Crow et al., 1981), and endangered (New Jersey; NJDEP, 1991). Reasons for its rarity are not wholly evident although several explanations have been offered.

Habitat destruction or degradation are often cited as factors contributing to the present rarity of lake cress (e.g., La Rue, 1943; Myers and Henry, 1976; Stuckey, 1987; Swink, 1969). Stuckey (1987) attributed the disappearance of the species to turbidity and chemical pollution, observing that the greatest loss of lake cress populations has occurred in highly agricultural or industrialized regions. However, despite the fact that many extant lake cress populations occur in fairly pristine habitats, we have observed that populations can also thrive in substantially polluted sites (Les, pers. obs.).

Although habitat loss surely is at least partly responsible for the decline of lake cress, other factors must be considered. Lake cress appears to flourish locally and can become abundant once established (La Rue, 1943; Muenscher, 1930; Les, pers. obs.), yet the species has never become common (Al-Shehbaz and Bates, 1987). The local abundance of lake cress has been ascribed to its efficient vegetative reproduction (Pringle, 1879; La Rue, 1943) and tolerance to a wide range of environmental conditions owing to its phenotypic plasticity (Mac Dougal, 1914).

Pringle (1879) concluded that seeds provide the principal means of long-distance dispersal for the species; however, lake cress is known to be highly sterile (Foerste, 1881; La Rue, 1943; Mac Dougal, 1914; Muenscher, 1930, 1944; Gleason and Cronquist, 1991; Long and Lakela, 1971; Godfrey and Wooten, 1981; Al-Shehbaz and Bates, 1987; McCormac, 1992; Les, pers. obs.). Although seeds are produced on occasion (Murley, 1951; Rollins, 1993), their viability has never been demonstrated. La Rue (1943) suggested that the rarity of lake cress might be directly related to its poor seed production which reduces the potential for long-distance dispersal.

Rollins (1966) indicated that chromosome numbers often help to delimit problematic genera in the Brassicaceae. Because chromosome counts were previously unreported for *Neobeckia aquatica,* our primary objective was to establish the chromosome number for assisting with our assessment of its systematic relationship in the mustard family. We hoped that this basic information might shed light on the phylogenetic relationships of lake cress by indicating the specific ploidy level and chromosomal series from which it is derived. In addition, the association of sterility and high polyploidy in some mustards (e.g., in *Dentaria* by Montgomery, 1955), further warranted a cytological examination of lake cress. An explanation for sterility in lake cress is wanting (Rollins, 1993), in spite of the fact that such information could provide important insights to facilitate its recovery and conservation.

MATERIALS AND METHODS

To minimize impact on established plants, only detached lake cress leaves or shoot fragments were collected from four populations in Vermont during the summer of 1993 (permit obtained from Vermont Department of Fish and Wildlife). Ronald L. Stuckey and C. B. Hellquist provided us with living lake cress specimens from Ohio and Michigan, respectively. Robert W. Freckmann provided us with fresh lake cress leaves removed from plants collected in Wisconsin from which we regenerated complete plants (Table 1). Adventitious roots were then obtained by removing some of the leaves from the greenhouse plants and floating them in tap water until rooting plantlets regenerated (1–3 weeks).

Mitotic figures were obtained from squashes of newly emerged adventitious root tip cells following methods employed by Bernardello and Anderson (1990). Root tip sections 1–2 cm long were pretreated at room temperature for two hr in saturated aqueous paradichlorobenzene, then rinsed and fixed at room temperature for 18 hr in a 3:1 solution (v/v) of ethanol:acetic acid. Fixed

Table 1. Chromosome counts obtained for populations of *Neobeckia aquatica* from Michigan, Ohio, Vermont, and Wisconsin, USA.

Locality	Voucher	2*n* Counts Observed
MICHIGAN		
Cheboygan Co.		
Mullett Lake, Pigeon River Marsh	*Hellquist 15542* (NASC)	23, 24, 25
OHIO		
Franklin Co.		
Hoover Reservoir	*Stuckey s.n.* (CONN)	23, 23/24, 23/24, 24, 24, 25
VERMONT		
Addison Co.		
Lake Champlain, Catfish Bay	*Les s.n.* (CONN)	23, 23/25, 24, 24, 26
East Creek	*Les s.n.* (CONN)	23, 24, 24, 24, 24, 24
Shoreham, Lemon Fair River	*Les s.n.* (CONN)	24, 24, 25, 25, 25
Grand Isle Co.		
Lake Champlain, Isle La Motte	*Les s.n.* (CONN)	24, 24/25
WISCONSIN		
Marinette Co.		
Peshtigo Flowage	*Freckman s.n.* (CONN)	23, 24, 24, 25

root tips were stained in alcoholic hydrochloric acid-carmine (Snow, 1963) for five d. Stained root tips were placed in an aqueous 70% acetic acid solution for 30 min, then macerated, lightly heated, and squashed in a drop of 70% acetic acid. Squashes were studied with phase contrast and bright field optics using Olympus and Zeiss microscopes (the latter equipped with a 63× 1.4 NA Planapochromatic objective).

A minimum of 10 root tips/population furnished the two to six mitotic cells selected from each population for chromosome counts. Slides were made permanent with Euparal (Bradley, 1948) and cells were photographed with a Zeiss Universal microscope and Kodak Technical Pan film.

Chromosome numbers were obtained from the literature for 192 genera in 17 of the 19 tribes recognized by Schulz (1936). The complete compilation is available from the authors on request. As Manton (1932) did with "fundamental numbers (f)," we selected a reasonable ancestral chromosome number (x) for each genus, and from these, we inferred an ancestral number for each of the tribes. These determinations took into account discussions by Dvorák (1971), Harberd (1976), Manton (1932), Mulligan (1964, 1965, 1966), Rollins (1963, 1966), Rollins and Rüdenberg (1971, 1977, 1979) and Rollins and Shaw (1973).

To obtain a phylogenetic perspective, we mapped the inferred base numbers on a phylogenetic diagram of the cruciferous tribes derived from the evolutionary "tree" published by Schulz (1936). We also compared base numbers of aquatic genera in tribe *Arabideae* that appear closely related to lake cress in a cladogram constructed from DNA sequence data (Les, 1994). The placement of lake cress in tribe *Arabideae* (Schulz, 1936) is supported by its close relationship to *Armoracia, Cardamine, Nasturtium,* and *Rorippa* (Les, 1994). Schulz included all of these genera in tribe *Arabideae* except for *Armoracia* which he placed within tribe *Drabeae.*

RESULTS

Examination of lake cress populations revealed $2n$ counts of 23–26 chromosomes (Figure 2, Table 1). In some instances, the small size of chromosomes (0.6–0.8 μ) and presence of unidentified stained particles in the vicinity of nucleolar organizer regions, made counts difficult. The shape and appearance of the extrachromosomal particles were used to differentiate them from neighboring chromosomes. We consistently detected what appeared to be one pair of chromosomes with small 'satellite' regions in most preparations; however, inadequate resolution made this observation impossible to verify.

We observed cells of two types. Larger cells showed chromosomes dispersed over a lightly stained cytoplasm; smaller cells contained more densely arranged chromosomes against both dark and lightly stained cytoplasm. Chromosomes in smaller cells were generally easier to count because they lay more in a single plane than those of larger cells.

Three greenhouse plants flowered during Fall, 1995, but we were unable to obtain satisfactory preparations for meiotic counts. There were six fruits produced on these plants, but complete ovule abortion rendered them seedless in every instance.

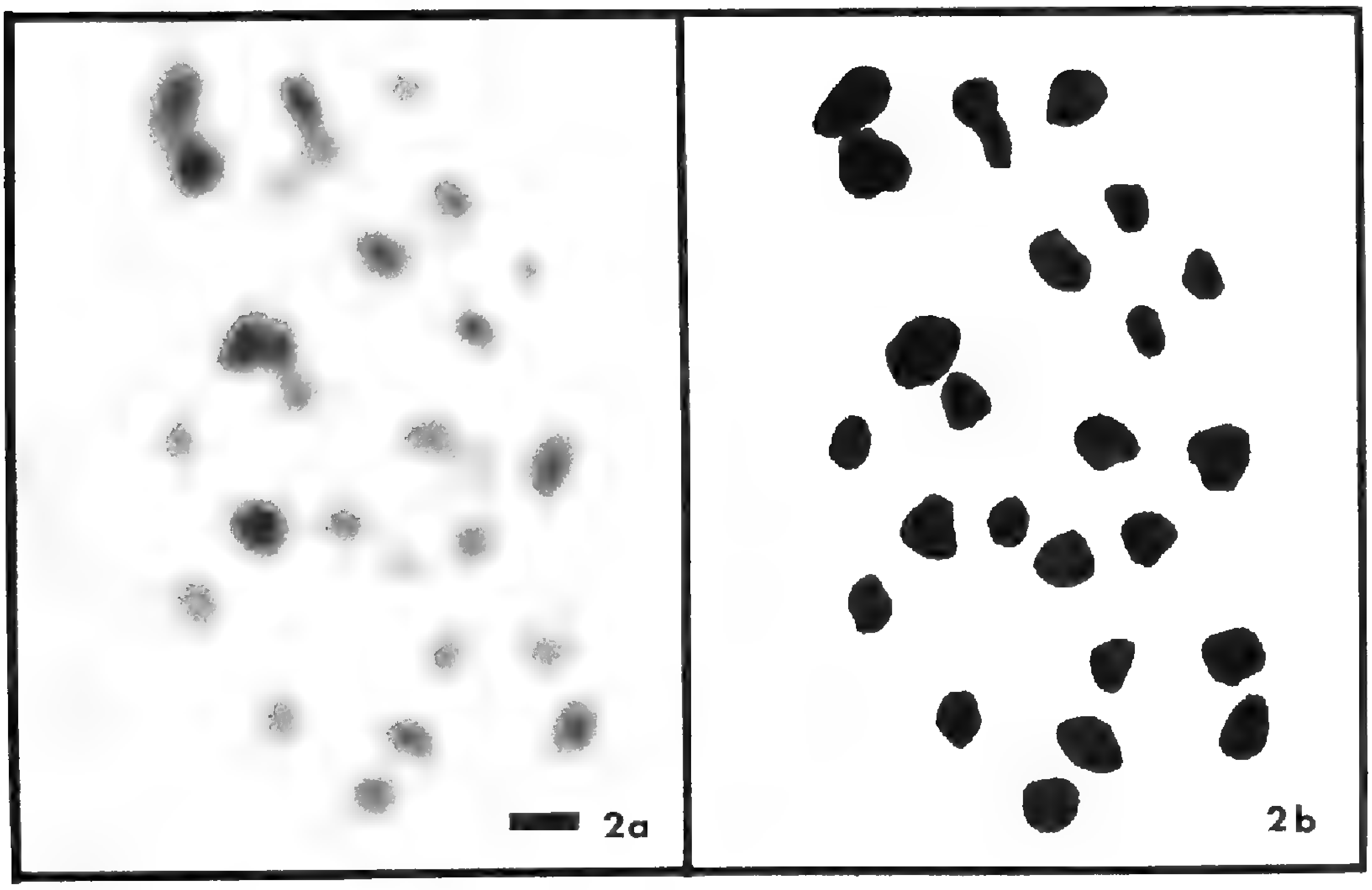

Figure 2. Example of mitosis in adventitious root cells of *Neobeckia aquatica* (Shoreham, Vermont locality). a: Micrograph showing characteristically small metaphase chromosomes. b: Interpretation of micrograph indicates the count $2n = 24$ chromosomes. Bar = 1 μm.

Our conclusions of tribal base numbers in Brassicaceae (Figure 3a) corresponded well with those proposed by Manton (1932), Mulligan (1964, 1965, 1966), Rollins (1966), and Rollins and Rüdenberg (1971, 1977, 1979). In the context of intertribal relationships proposed by Schulz (1936), a general trend toward reduced base numbers is observed from the putatively primitive to the more advanced tribes of the Brassicaceae (Figure 3a).

In 18 genera of tribe *Arabideae* with available counts, 12 (67%) have a likely base number of $x = 8$ and 4 (22%) a base number of $x = 7$. The base number of two genera (*Guillenia* and *Leavenworthia*) could not be reasonably determined. A base number of $x = 8$ characterizes all genera (*Armoracia, Cardamine, Nasturtium, Rorippa*) putatively allied with lake cress (Figure 3b).

DISCUSSION

Although intraspecific aneuploidy is prevalent among aquatic angiosperms (Les and Philbrick, 1993), variation in our reported counts for lake cress (Table 1) reflects the uncertainty of some

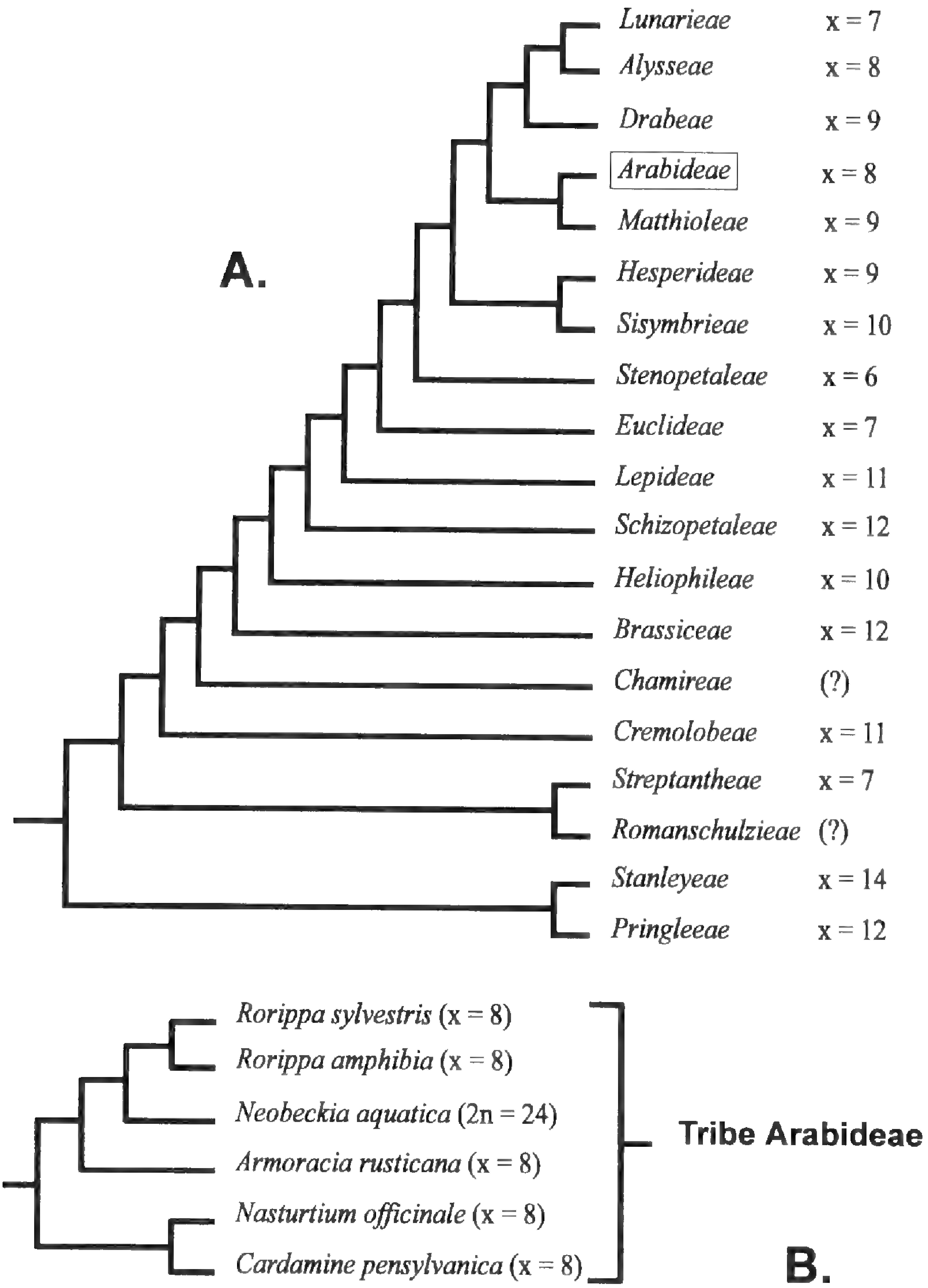

Figure 3. Putative phylogenetic relationships of mustards. A: Phylogenetic scheme of tribal interrelationships (redrawn from Schulz, 1936) and base chromosome numbers deduced from literature reports (see text). A box identifies the tribe (*Arabideae*) to which lake cress is assigned. In this interpretation, a general decrease in the base number is apparent from the putatively primitive to more advanced tribes. B: Phylogenetic relationships of aquatic mustard genera in tribe *Arabideae* (from Les, 1994) with deduced base chromosome numbers and the $2n$

counts and does not necessarily indicate the existence of discrete numbers for the species. We are convinced that the actual chromosome number of the species is $2n = 24$; however, in several preparations, it was difficult to clearly view all chromosomes or to positively differentiate chromosomes from anomalous inclusions (see Results). In several instances, this 'variation' was observed among cells from the same individual and from different individuals of the same population. Because of the clonal growth of this species, and lack of sexual reproduction, our replicate counts were not of individual genets but of clonally derived ramets.

Stuckey (1972) hypothesized that the genera *Armoracia, Cardamine, Nasturtium,* and *Rorippa* represented the closest relatives of *Neobeckia,* a conclusion consistent with a recent molecular systematic study of the group (Les, 1994). Hayek (1911) placed these genera together not only in the same tribe (*Arabideae*) but in the same subtribe (*Cardamininae*). Literature counts reported for these genera uniformly indicate a base number of $x = 8$. A basic number of $x = 8$ has also been determined for *Dentaria,* a genus sometimes merged with *Cardamine* (Montgomery, 1955). In tribe *Arabideae,* the base number $x = 8$ is very common with only a few instances of $x = 7$ or $x = 6$ (see Harberd, 1976).

Because they are not cladistically based, the phylogenetic relationships of mustard tribes (Figure 3a) proposed by Schulz (1936) must be interpreted conservatively. However, we are unaware of any more recent studies of intertribal relationships in the mustard family that are as comprehensive. Molecular systematic studies of *Arabidopsis* by Price et al. (1994) included representatives of only 5–6 mustard tribes. Although topologies of the molecular cladograms differed in some details from the phylogenetic tree of Schulz (1936), the relatively derived position of tribe *Arabideae* and the relatively basal position of tribes with higher basic numbers were consistently indicated. Thus, it is reasonable to conclude that chromosomal series with basic numbers less than twelve are probably derived by descending aneuploidy in advanced tribes such as *Arabideae.* Genera of tribe *Arabideae* that are closely

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number obtained for *Neobeckia.* A base chromosome number of $x = 8$ characterizes tribe *Arabideae* and the aquatic genera related to *Neobeckia.*

related to *Neobeckia* (Les, 1994) share the basic number of $x = 8$ (Figure 3b). Given that the most likely base number of tribe *Arabideae* is $x = 8$, the $2n = 24$ chromosome number of *Neobeckia aquatica* indicates that the species is triploid, at least in the populations studied.

The number $2n = 24$ is rare in tribe *Arabideae* and is indeed associated with triploid hybrids. In *Rorippa,* spontaneous triploids ($2n = 24$) have resulted from hybridization between two tetraploids ($2n = 32$), e.g., *R. amphibia* (L.) Besser and *R. palustris* (L.) Besser (Howard, 1947; Stace, 1975). The triploid hybrids are sterile with 7–8 bivalents and 8–10 univalents, whereas tetraploid hybrids are fertile. Mulligan and Porsild (1968) reported a natural triploid ($2n = 24$) hybrid between diploid ($2n = 16$) *R. barbareaefolia* (DC.) Kitagawa and tetraploid ($2n = 32$) *R. palustris* (= *R. islandica* (Oeder) Borbás). The triploids did not produce seed and had only 2% viable pollen. Triploid ($2n = 24$) hybrids also have been produced artificially in crosses between diploid ($2n = 16$) *R. austriaca* (Crantz) Besser and tetraploid ($2n = 32$) *R. sylvestris* (L.) Besser (Jonsell, 1968; Javurková-Kratochvílová and Tomsovic, 1972). In one case, only 14% of the seeds produced from this cross germinated; however, none of the plants ever reached the flowering stage (Jonsell, 1968). Sterile triploid hybrids ($2n = 24$) have also resulted from crosses between diploid ($2n = 16$) *R. austriaca* and tetraploid ($2n = 32$) *R. amphibia* (Javurková-Kratochvílová and Tomsovic, 1972; Jonsell, 1975).

In *Cardamine,* triploid ($2n = 24$) hybrids are produced in crosses between two diploids ($2n = 16$), *C. rivularis* Schur and *C. amara* L. (Urbanska-Worytkiewicz, 1977). Reproduction of these triploids is mainly vegetative but they are partly fertile with about 2–3% pollen viability (Urbanska-Worytkiewicz, 1977).

To enumerate, the triploid chromosome number of lake cress is indicated by the common occurrence of the $x = 8$ base number in the tribe *Arabideae,* the universal occurrence of $x = 8$ among the genera most closely related to lake cress, and the presence of the $2n = 24$ chromosome number in known triploid hybrids within tribe *Arabideae.* In addition, a significant correlation is the extreme sterility of lake cress, a feature long associated with triploidy in plants (Darlington and Mather, 1949). The relatively low chromosome number of lake cress indicates that sterility is not a consequence of high ploidy level as in the related genus *Dentaria* (Montgomery, 1955).

Sterility in the related horseradish (*Armoracia rusticana* L.) has been attributed to an interspecific hybrid origin (Weber, 1949), self-incompatibility, and accumulation of deleterious mutations from prolonged vegetative propagation (Stokes, 1955). Self-incompatibility has also been implicated in the low seed production of perennial *Rorippa* species, presumably due to the clonal growth of populations (Jonsell, 1968).

We also considered that sterility of lake cress may be a consequence of self-incompatibility (SI). Poor seed set is an inevitable consequence for clonal, SI species that experience extreme bottlenecks (Les, Reinartz, and Essleman, 1991; Reinartz and Les, 1994). In a survey of the mustard family, Bateman (1955) found that SI species occurred in 11/12 tribes surveyed, including the genera *Armoracia* and *Cardamine.* Self-incompatible species also occur in *Rorippa* (Jonsell, 1968), the most closely related genus to *Neobeckia.* Although self-compatible species have evolved repeatedly in the family, e.g., in *Cardamine, Nasturtium* and *Rorippa* (Bateman, 1955; Jonsell, 1968), SI could certainly be expected in *Neobeckia.* Sterility, however, precludes verification of SI in lake cress by experimental crossing studies. Nevertheless, triploidy is more likely to represent the proximate cause of sterility in the species.

The origin of triploidy in lake cress remains uncertain. At this time, we cannot determine whether the species represents an intraspecific hybrid or an interspecific hybrid resulting from a cross between diploids (e.g., *Cardamine,* above), tetraploids (e.g., *Rorippa,* above), or possibly a diploid and tetraploid (e.g., *Rorippa,* above).

Our study has confirmed that the triploid condition exists among different lake cress populations separated in some cases by more than 100 km in the northeastern USA, and in considerably more isolated populations from Michigan, Ohio, and Wisconsin. This indicates that the unusual cytotype is not simply a local, vegetatively propagated abnormality (see Les and Philbrick, 1993) but is widespread and at least characteristic of the northern populations. To our knowledge, the Wisconsin population represents the northwesternmost known station, and the Isle La Motte, Vermont population, the easternmost station for the species. The triploid number from the Ohio plant is also consistent with observations that other Ohio populations of lake cress may flower and fruit quite prolifically, yet apparently produce no viable seed (McCormac, 1992).

We cannot exclude the possibility that diploid or tetraploid cytotypes of lake cress may exist. Potentially, such individuals should be more fertile, yet seed set could remain scarce in populations due to confounding factors such as self-incompatibility. This is precisely the situation for *Apios americana* Medikus with sterile triploid populations in northern parts of its range, and diploid populations in the southern portion of its range in which seed set remains low due to self-incompatibility (Bruneau and Anderson, 1988). The possible existence of diploid or tetraploid lake cress can only be ascertained by further cytological examination of populations throughout its range. Our attempts to obtain material of this rare species from southern portions of its range, however, have thus far proven to be unsuccessful. A comprehensive survey of lake cress populations is highly recommended because the discovery of fertile plants could significantly influence conservation strategies for the species.

Except in the relatively rare cases of partially fertile triploids (e.g., *Cardamine*; Urbanska-Worytkiewicz, 1977), the sexual reproductive capacity of triploid plants is predictably low. The highly developed system of vegetative reproduction in lake cress provides a means of dispersal and reproduction despite the barrier to sexual reproduction that is imposed by its triploid cytotype. The lack of seed production, however, greatly compromises the ability of the species to disperse beyond local distances. Although shoot fragments of several other aquatic plants can be dispersed considerable distances by flexuous stems that become draped over waterfowl, etc. (Sculthorpe, 1967), the brittle nature of lake cress plants undoubtedly precludes this avenue of dispersal. Leaves of lake cress are the most likely vegetative propagules, and are probably difficult to transport over any significant distance.

Both habitat loss and the low vagility resulting from sterility can be linked to the disappearance of lake cress. In the past when habitats were abundant, the species may have survived adequately despite its poor vagility. Extensive habitat destruction coupled with the inability to effectively disperse may now destine the lake cress to successive population losses and ultimate demise. It is unlikely that vegetative propagules alone can adequately maintain dispersal among the remaining fragmented lake cress habitats. Without intervention, sites that have experienced local exterminations due to population crashes are likely to remain devoid of the species in a progression that may inevitably lead to extinction.

The realization that sterility in lake cress may be due to specific genetic (i.e., chromosomal) factors is important from a conservation standpoint. For example, it has long been known that vegetatively reproducing mustard crops (i.e., horseradish and watercress) can be severely damaged by fungal and viral pathogens (Crisp, 1976). Such threats are particularly serious for clonal plants like lake cress where seed production cannot be relied upon as a means of purging pathogens (Silander, 1985). In addition to the obvious importance of preserving remaining lake cress habitats, the implementation of artificial establishment techniques should be considered as a strategy to overcome the dispersal limitations imposed on this species by both biological and cultural factors.

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AN UNDESCRIBED SPECIES OF *LESQUERELLA* (CRUCIFERAE) FROM THE STATE OF WASHINGTON

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FLORENCE E. CAPLOW

ABSTRACT

Recent books covering the flora of Washington admit only one species of *Lesquerella, L. douglasii* S. Watson, to the flora of the state. A different, undescribed species of this genus has been recognized from recent collections. The new species was first collected in 1883 but the specimens from that gathering are incomplete and they were never appropriately utilized. The new species is named *L. tuplashensis* and it is compared with *L. douglasii,* its nearest relative.

Key Words: Hanford Nuclear Reservation, *Lesquerella tuplashensis, L. douglasii,* White Bluffs

INTRODUCTION

During the course of a survey of plants within the Hanford Nuclear Reservation in south-central Washington, an unexpected species of *Lesquerella* was found on the White Bluffs adjacent to the Hanford Reach of the Columbia River. The restricted habitat of this species is extremely dry and supports only a sparse vegetation. That the species is unique was determined by comparing it in detail with potentially related species of *Lesquerella* including the only other species known from the area, *L. douglasii* S. Watson, which occurs from northern Oregon to British Columbia (Rollins and Shaw, 1973). A recent taxonomic review of *Lesquerella* by one of us (Rollins, 1993) following on a monographic treatment of the genus (Rollins and Shaw, 1973) has provided a sound basis for interpreting the new material. All other known species of *Lesquerella* were considered as candidates for the unknown but were ruled out because they were distinctly different. As it turns out, this is not the first time the unknown species had been collected.

In 1883 T. S. Brandegee and Frank Tweedy, working as botanists for the Northern Transcontinental Survey (Rose, 1904), collected the species we here name *Lesquerella tuplashensis.* The Brandegee collection, his no. 635, bears the data, "White Bluffs of the Columbia, Washington Terr., July 1883," and is represented by specimens at GH, NY, and UC. We have seen only fragments of the Tweedy collection, no. 8, at GH, from the same locality, June, 1883. Unfortunately, this early material was not sufficiently complete, and to some extent anomalous, to be accurately identified. The Brandegee specimen in the Gray Herbarium has been successively named *Vesicaria montana* Gray?, *V. occidentalis* Watson?, and *V. douglasii,* the latter annotation by C. V. Piper. The generic name *Vesicaria* was used before *Lesquerella* was established. The notation on the label, *Vesicaria occidentalis,* is in Watson's handwriting and has the specific name *kingii* below it crossed out. The original identifier of the specimen and Watson were obviously uncertain about the identity of the material. Piper's annotation is unequivocal and it should be noted that he accepted (Piper, 1906) only one species of *Lesquerella* from the Columbia River area. He commented that the Brandegee specimens were erroneously associated with *L. occidentalis* in the Synoptical Flora (Gray, Watson, and Robinson, 1895). There Watson, who authored the treatment of *Lesquerella,* did indeed associate the Brandegee collection with *L. occidentalis,* but he also wrote, "taller specimens from the White Bluffs of the Columbia, Washington (*Brandegee*), have broadly obovate obtuse fruit and may be distinct." There is no mention of this specimen in Watson's earlier treatment (1885, 1888) of *Lesquerella.* Evidently Payson, in preparing his monograph of *Lesquerella* (1922) did not see the Brandegee or Tweedy material, or at least he did not mention them.

In more recent treatments of *Lesquerella* (Payson, 1922; Rollins and Shaw, 1973; Rollins, 1993) only one species, *L. douglasii,* is attributed to the state of Washington. A rather lengthy discussion, concerning specimens from Washington previously referred to other species, is given by Rollins and Shaw (1973) under the name *L. occidentalis.* One of the main points made there is that, although the Brandegee specimen was cited by Watson in his original presentation of *L. occidentalis* as a new species, and is therefore a syntype, the specimen is not of that species as it is presently understood. This discussion should be consulted by anyone seriously interested in the problem.

In our judgment, there is no doubt that *Lesquerella tuplashensis* is related to *L. douglasii* and it is our assumption that it was derived evolutionally from that species. Because of the silique shape, ovule number, and trichome type, *L. tuplashensis* is referable to group 8 (Rollins and Shaw, 1973). Of the eleven species included there, *L. tuplashensis* is most similar to *L. douglasii.* It is perhaps significant that *L. tuplashensis* is restricted in distribution to a specialized habitat and has few plant associates, several of limited distribution, whereas *L. douglasii* has a much broader geographic range and occurs in a variety of habitats with a much wider range of associated species. The interpretation that *L. tuplashensis* is a derived species fits the general situation in *Lesquerella* (Rollins and Shaw, 1973; Rollins, 1993) where there are numerous examples of a similar relationship between widespread species of diverse habitats and apparently derived taxa of limited distribution adapted to restricted, usually highly calcareous, sites. The rigorous edaphic factors there exerting unusual selection pressure on plants able to cope with such sites may have contributed to their having evolved into distinct taxa. But it must be admitted that evolution could have proceeded either way, from widespread to restricted species or from restricted to widespread species.

Lesquerella tuplashensis Rollins, Beck & Caplow, *sp. nov.*

TYPE: U.S.A. Washington, Franklin County: White Bluffs, T13N, R27E, S11, W½, above the Columbia River, caliche soil at edge of eroding bluff, 20 July 1994, *K. Beck & F. Caplow 94001* (Holotype: GH; Isotype: WTU). Associated species: *Artemisia tridentata* Nutt., *Astragalus caricinus* (Jones) Barneby, *Cryptantha spiculifera* (Piper) Payson, *Eriogonum microthecum* Nutt., and *Poa sandbergii* Vasey.

Herba perennis multicaulis, caudicibus simplicibus crassiusculis, caulibus erectis vel prope decumbentibus 1–2 dm altis, foliis basalibus petiolatis integris vel sparse lobatis dense pubescentibus argenteis (1.5)2–4(–6) cm longis, foliis caulinis imbricatis, sepalis oblongis 3–4 mm longis, petalis luteis anguste lingulatis 4.5–5 mm longis, pedicellis fructiferis late divaricatis rectis 9–11(–13) mm longis, siliquis subglobosis vel fere obovatis 3–4 mm longis, stylis 2.5–3 mm longis, loculis (2–) 3–4 ovulatis, seminibus suborbicularibus ca. 2 mm diametro, cotyledonibus accumbentibus.

Perennial, caudex simple, to 1 cm thick; stems mostly arising below the leaf rosette, several to numerous, slightly decumbent to erect, densely pubescent, 1–2(–3.5) dm tall; basal leaves rosulate, densely pubescent, silvery, (1.5)2–4(–6) cm long, rounded to broadly obtuse at apex, (0.5–)1–1.5(–2.5) cm wide, outer leaves

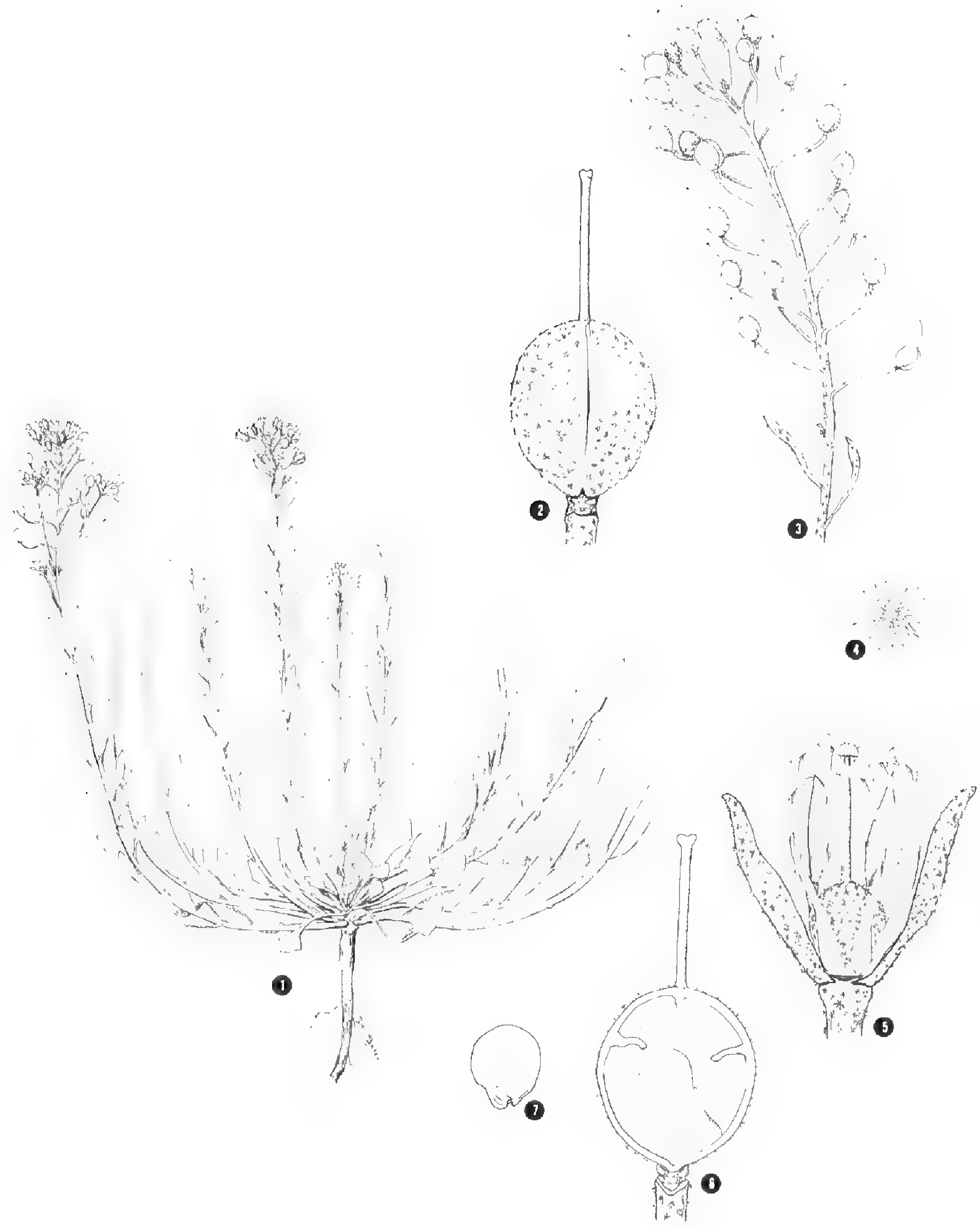

Figure 1–7. *Lesquerella tuplashensis.* Magnifications are approximate. Figure 1, habit × ⅓; figure 2, silique × 7; figure 3, infructescence × ⅔; figure 4, trichome × 12; figure 5, flower × 7; figure 6, replum × 7; figure 7, seed × 7.

usually entire with nearly orbicular blades and slender petioles, inner similar but usually few-lobed or sometimes entire; cauline leaves densely overlapping, obovate to spatulate, sometimes narrower, obtuse to more nearly rounded at apex, petiolate except the uppermost, 1–1.5 cm long, 4–8 mm wide; leaf trichomes dense and silvery occurring in several layers over the entire surface, radiate, appressed, rays mostly forked, fused toward base, ray tips 15–18; inflorescences usually dense, 3–6 cm long; sepals ascending to erect, narrowly oblong, densely pubescent on the exterior, 3–4 mm long; petals yellow, narrowly oblanceolate to spatulate, not unguiculate, 4.5–5 mm long; fruiting pedicels densely pubescent, widely spreading to slightly ascending, straight or nearly so, 9–11(–13) mm long; siliques slightly obovoid to subglobose, turgid, substipitate, 3–4.5 mm long, densely pubescent on exterior, glabrous on interior, silique trichomes mostly stipitate, not appressed; styles 2.5–3 mm long; ovules 2–3(–4) per locule; septum entire or rarely slightly perforate; seeds orbicular to broadly oblong, compressed, ca. 2 mm long, immarginate, radical equaling cotyledons; cotyledons accumbent.

ADDITIONAL SPECIMENS EXAMINED: U.S.A., Washington, Franklin County: White Bluffs, above the Columbia River, T13N, R27E, S11, W½, edge of eroding bluff in shallow caliche soil, 18 Aug. 1994, *Beck & Caplow 94002* (GH, WTU); same general locality, July, 1883, *T. S. Brandegee 635* (GH, NY, UC); same locality, June, 1883, *F. Tweedy 866* (GH); T13N, R28E, S33, NW ¼ of NW ¼ in hard calcium carbonate "caliche" with *Poa sandbergii* Vasey, *Cryptantha spiculifera* (Piper) Payson, *Eriogonum microthecum* Nutt., and *Eurotia lanata* (Pursh) Moq., June 1, 1995, *Beck & Caplow 95085* (GH); T13N, R27E, S24, NE ¼ of NE ¼, May 19, 1995, *Beck & Caplow 95053* (GH); T12N, R28E, S11, NW ¼ of SW ¼, June 1, 1995, *Beck & Caplow* (GH).

The name "tuplashensis" refers to the White Bluffs of the Columbia River where the species occurs. "Tuplash" is a place name for the White Bluffs in the Sahaptin language, the language of the Wanapum Tribe and other tribes whose traditional territories include the White Bluffs. "Plash" refers to the distinctive white color of the bluffs (Relander, 1956).

In comparing *Lesquerella tuplashensis* with its related *L. douglasii,* we find that most features are similar. Basically the cauline leaves of *L. tuplashensis* are imbricated and there is a range from linear to petiolate with a broad rounded blade, while those of *L. douglasii* are loosely arranged and narrowly linear. The basal leaves, especially those of the outer margin, of *L. tuplashensis* are more rounded and broader than those of *L. douglasii.* The most noticeable distinction between the two species is in the trichomes of the siliques. Trichomes on the exterior surfaces of the silique valves of *L. tuplashensis* have the radiate portion raised on a stipe-like stalk whereas the comparable trichomes of *L. douglasii* are sessile and the radiate portion is appressed to the valve surface. In general habit, the plants of *L. tuplashensis* are more compact and denser than those of *L. douglasii.*

Lesquerella tuplashensis grows on the upper edge and upper face of the White Bluffs adjacent to the Columbia River. The only known population is found on the upper zone and top of a near vertical exposure of cemented, highly alkaline calcium carbonate paleosol (a "caliche" soil). Nearby Soil Conservation Service soil samples of a buried horizon of the same calcium carbonate layer contained 79% calcium carbonate and had a pH of 8.4 (Soil Conservation Service, unpubl.). This hard calcium carbonate paleosol caps several hundred feet of alkaline, easily eroded, lacustrine sediments of the Ringold Formation (Newcomb, 1958). The average annual precipitation for the area is 12 cm (Rickard et al., 1988).

The population is approximately two to seven m wide and extends for 17 km along the upper edge of the bluffs. The holotype was collected from the northern end of the population. Although there are scattered small exposures of similar caliche substrate in coulees to the north of the White Bluffs, these areas were examined and the species was not present. The White Bluffs population may be the only one of the species.

The vegetational cover of the bluffs is extremely sparse but includes, in addition to *Lesquerella tuplashensis,* a number of plant species that are rare in Washington: *Cryptantha spiculifera* (Piper) Payson, *Astragalus geyeri* Gray, *Cuscuta denticulata* Engelm., and *Camissonia pygmaea* (Dougl.) Raven.

ACKNOWLEDGMENTS

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THE VASCULAR PLANTS OF FORT DEVENS, MASSACHUSETTS

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ABSTRACT

As part of the process of closing Fort Devens in north central Massachusetts, an intensive two year survey of vascular plants growing in the undeveloped area (6700 acres) of the fort was completed. A total of 857 naturally occurring taxa in 394 genera and 121 families were identified, including 18 rare taxa and 29 county records. The unusual diversity of taxa for the area is due to several factors which include land use history and the physical setting, as well as management practices and military activity which created or maintained early and mid-successional habitats.

Key Words: Fort Devens, Massachusetts, vascular flora, rare plants

INTRODUCTION

Fort Devens, the only army post in New England, had its main installation about 30 miles northwest of Boston in the towns of Ayer and Shirley, Middlesex County, and Harvard and Lancaster, Worcester County (Figure 1). It was founded in 1917 to train soldiers for World War I. Additional land, south of Route 2, was acquired between 1941 and 1943 and became the South Post. In the mid 1970's, about 700 acres of wetlands along the east side of the Nashua River on the South Post, were transferred to the U.S. Fish and Wildlife Service and now form the Oxbow National Wildlife Refuge. The post was recommended for realignment and closing in 1988 and closed in March, 1996. The approximately 6700-acre, undeveloped area of Fort Devens was reportedly the largest single area of natural land under uniform management in north central Massachusetts (U.S. Army Corps Engineers, 1989). As part of the procedures associated with closing the fort, a number of biological surveys were made. The objective of this study was to assemble as complete a collection as possible of the vascular plants that occurred naturally on Fort Devens, emphasizing fed-

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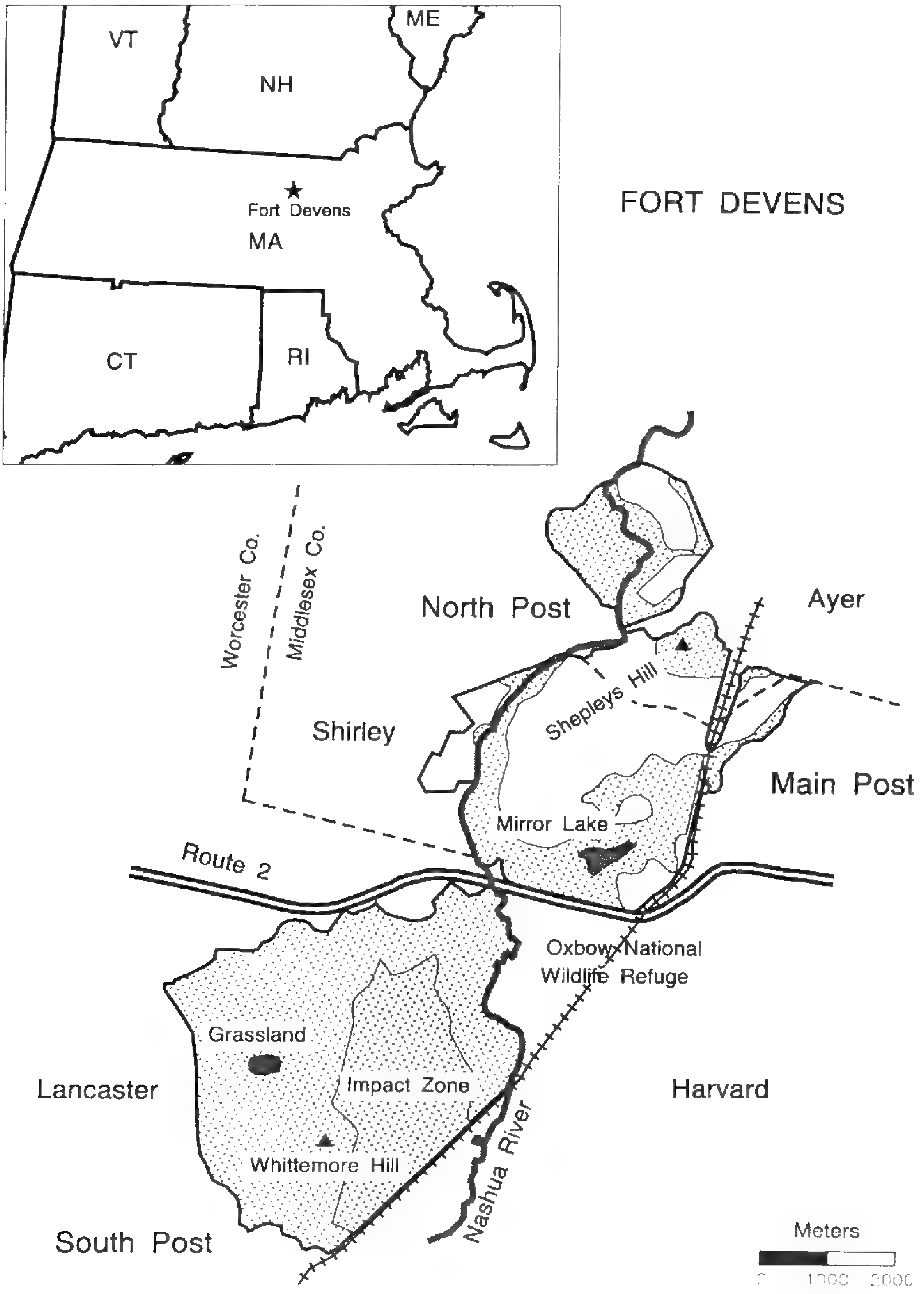

Figure 1. Map showing the location of Fort Devens in Massachusetts, and an enlargement of the Post. The boundaries of Fort Devens are indicated by a solid line. The dashed lines indicate the boundary between Worcester and Middlesex Counties. This boundary follows the Nashua River on the Main Post. The approximately 6700-acre undeveloped area of Fort Devens, which was sampled, is indicated by stippling; the developed area, which was not sampled, is left blank. The location of the maintained grassland on the South Post is indicated by a black oval. The triangles indicate the position of Shepleys and Whittemore Hills.

eral and state rare taxa. In addition to helping with decisions on future land use, this survey provides a baseline from which to monitor future changes.

The approximately 9240-acre Fort Devens was divided into three areas: the South Post (4830 acres), south of Route 2; the Main Post (3550 acres); and the North Post (860 acres), the last two north of Route 2 (Figure 1). Most of the buildings and other facilities were in the latter two areas while the South Post, used primarily for training, remained relatively undeveloped, and has been retained by the army as the Devens Reserve Forces Training Area. Approximately 800 acres in the floodplain and on adjacent slopes of the Nashua River on the former Main and North Posts were transferred to the U.S. Fish and Wildlife Service and have been added to the Oxbow National Wildlife Refuge. With the exception of a few natural areas, such as those near Mirror Lake, most of the remainder of the North and Main Posts is scheduled for development (T. Poole, pers. comm.).

Much of Fort Devens is within the glacial landform of Lake Nashua (Koteff, 1980) and is characterized by broad, flat terraces of sandy, well drained deltaic sediments. Areas of stratified clay deposits support wetlands (Mott and O'Brian, 1981). Other glacial features include esker-like ridges around some ponds on the South Post and along the west bank of the Nashua River on the North Post. In addition, there are steep sand and gravel ridges around Mirror Lake on the Main Post. Other important features include the Nashua River floodplain which extends for 8 miles through the fort. Elevations range from 61 m in the floodplain of the Nashua River to about 140 m on Whittemore Hill on the South Post. Exposed bedrock is uncommon, and is found at Shepleys Hill on the North Post and in a few scattered outcrops.

The area occupied by Fort Devens was originally forested, but by the time the military post was established, most of the land had been cleared and farmed. There was also some small scale industrial activity along the river and streams (Fitch and Glover, 1989). Farming continued on the South Post into the 1940's. About the time the post was closed, forested areas occupied 62 percent of the South Post, and 36 percent of the Main and North Posts (U.S. Fish and Wildlife Service, 1992). The South Post also included a 250-acre grassland, kept open by burning and mowing, which was used for parachute drops.

METHODS

An intensive, systematic survey of the flora on the approximately 6700 acres of undeveloped land on the post, including the "Impact Zone" (Figure 1) was conducted over two growing seasons. Most of the collection was done during 1991 by D. Hunt and R. Zaremba, focusing principally on the South Post (Hunt, 1991). Additional collections were made during 1993 by D. Hunt, C. R. Lombardi, and K. Searcy focusing on natural areas on the Main and North Post (Lombardi, 1994). Finally, a few additional species were added as the result of other types of vegetation studies conducted in 1994 and 1995.

Sampling was designed using topographic maps and a grid overlay to insure that some part of every 400 m^2 was observed. In addition, habitats from localities representing the full range of elevation, slope, and substrate types (U.S.D.A. Soil Conservation Service, 1985, 1989) were examined. All community types based on New York State's Natural Heritage Program Community Classification (Reschke, 1990) and all forest cover types (based on 1980 aerial photographs) were also examined. When necessary, aquatic vegetation was sampled from a canoe.

Collections were made about every two weeks from early May to October. All native, naturalized and escaped taxa, including those that were probably introduced but had become part of a successional plant community, were collected. Every reasonable effort was made to collect specimens with reproductive material. Information recorded included latitude and longitude using UTM coordinates (to 100 m); elevation; substrate type; topography; associated taxa; and relative abundance, assessed as a combination of the size of the population and number of occurrences; as well as the specific collection locality, habitat or natural community, and date. Whenever a federally- or state-listed rare taxon was found, population boundaries were determined and population size was estimated. Potential county records were checked against a list prepared by Sorrie (1991). For the most part, nomenclature follows *The Flora of North America* (Flora of North America Editorial Committee, 1993) for pteridophytes and gymnosperms and the *Manual of Vascular Plants of North Eastern United States and Adjacent Canada* (Gleason and Cronquist, 1991) for angiosperms. *Hortus Third* (Bailey and Bailey, 1976) was used for names of naturalized plants not included in Gleason and Cronquist. Where names for rare taxa found at Fort Devens differed between Gleason and Cronquist and the Massachusetts rare plant list (Division of Fisheries and Wildlife, 1992), the latter were retained, and the synonyms indicated in Appendix 1. A complete set of voucher specimens has been deposited at the University of Massachusetts (MASS).

RESULTS AND DISCUSSION

The flora includes 857 taxa in 394 genera and 121 families (Appendix 1). The distribution of taxa among groups is as follows: 11 (1.3%) fern allies, 22 (2.6%) ferns, 13 (1.5%) gymnosperms, 247 (28.8%) monocots, and 564 (65.8%) dicots. Approximately 80 percent of the taxa are native, a figure similar to that reported for central and eastern United States and adjacent Canada (Fernald, 1950). While additional taxa are likely to be found, the plants collected to date are undoubtedly a sizable fraction of those on the post. Intensive collections in 1993 added 102 new taxa (12%). The 1994 and 1995 studies of oxbow ponds and surrounding marshes, among the most species-rich areas on the post, added only seven new taxa (<1%).

The undeveloped portion of Fort Devens supports an unusually high diversity of plants for an area its size in north central Massachusetts. One factor contributing to species diversity on the post is historic land use. Much of the fort was farmland in the not-too-distant past. As a result, a great deal of the vegetation is currently in various stages of succession, providing habitats ranging from successional old fields to second-growth forests. The relatively recent agricultural influence is seen in the persistence of species such as *Asparagus officinalis* and *Triticum aestivum.* Other weedy species were undoubtedly introduced along the roads and railroads. Past habitation is also reflected by artificial lakes which provide habitats for aquatic species and by abandoned home sites, the source for naturalized and escaped species such as *Convallaria majalis, Phlox paniculata, Syringa vulgaris* and *Vinca minor.*

A second group of factors affecting species diversity are land management practices and military activity on the post. Land management practices included mowing, controlled burning, and clear and selective cutting. Military activity associated with training and the use of heavy equipment, like tanks, created open areas of various sizes for colonization by early successional species. In addition, one unusual habitat disturbance at Fort Devens is the occurrence of annual fires resulting from flares and ammunition detonation in the "Impact Zone" on the South Post. The fires have produced an area of fire-tolerant upland species (U.S. Fish and Wildlife Service, 1992). These types of activities contributed to species diversity by creating and maintaining a mosaic of early and mid-successional habitats within various communities. Other habitats associated with military occupation at the post include landfills, rubble dumps, gravel mines, hydrological impoundments and sewage processing beds. At the time of the survey, deliberately created or maintained successional habitats supported almost one third (27%) of the species, and close to half (44.4%) of the state listed rare species. Successional habitats appear to be important for many rare species. Indeed, Sorrie (1989) has pointed out that the loss of early successional habitats appears to account for about 65% of the species extirpated from Massachusetts.

Finally, a major factor contributing to species diversity is the physical setting. The post has a varied topography ranging from flat terraces to steep slopes such as those found at the edge of the Nashua River floodplain, on eskers, and on the South Post plateau. Stream drainages provide relief on a smaller scale. In addition, the post has markedly contrasting soil types ranging from drought prone Windsor and Hinkley soils, common in the deltaic deposits, to poorly drained soils such as Limerick, Swansea and Freetown soils of the Nashua River floodplain and scattered wetlands.

This combination of slopes and soil types supports a wide array of plant communities. Fort Devens has widespread plant communities such as the Appalachian oak-pine forest (AOPF), hemlock-northern hardwood forest (HNHF) and red maple hardwood swamp (RMHS). In addition, there are also a number of communities which are listed as uncommon or restricted in Massachusetts (Swain, 1993). One of these, the pitch pine-scrub oak barrens (PPSOB), found on drought prone soils, is uncommon at inland locations. A number of wetland communities on the post are also of restricted distribution or are uncommon in the state (Swain, 1993). These include the southern New England floodplain forest (FF), dominated by silver maple, occurring as a relatively narrow, intermittent strip along the Nashua River; several dwarf shrub bogs (DSB) and forested peatlands such as the black spruce-tamarck bog (BSTB), supporting plants of a more northern distribution; seep communities within the RMHS dominated by black ash; sandy bottom kettlehole ponds, with fluctuating water levels, providing exposed, inland, non-calcareous, lake shore habitats (INCLS) with species more characteristic of the coastal plain; and a small, medium fen (MF). Collectively these and the other wetland communities account for 36% of the species, but only about 14% of the total area of the post.

Rare Species

Eighteen taxa found growing naturally at Fort Devens are listed as either federally or state endangered, threatened (Division of Fisheries and Wildlife, 1992), or are on the state watch list (Sorrie, 1990) (Table 1). Populations of *Pinus resinosa, Podophyllum peltatum* and *Populus balsamifera,* which are on the state watch list, were obviously planted or were escapes, and were not included in the tally.

Six species, *Bidens discoidea, Eleocharis obtusa* var. *ovata* (*E. ovata*), *Panicum philadelphicum, Sparganium minimum, Utricularia minor,* and *Wolffia brasiliensis,* were associated with oxbow

Table 1. Rare taxa from Fort Devens, Massachusetts. E = Endangered, T = Threatened, SC = Special Concern, W = Watchlist.

Taxon	Mass. Status	Approx. No. of Individuals
Arabis drummondii	W	20
Aster radula	W	200
Bidens discoidea	W	200
Carex typhina	T	250
Cassia hebecarpa	E	80
Cyperus houghtonii	E	1000
Eleocharis obtusa var. *ovata*	E	2000
Eragrostis capillaris	W	100
Geranium bicknellii	W	100
Leptoloma cognatum	W	200
Liatris borealis	SC	5–10
Lupinus perennis	W	3000
Panicum philadelphicum	SC	100
Smilacina trifolia	W	500
Sparganium minimum	E	1000+
Stellaria borealis	W	100
Utricularia minor	W	100
Wolffia brasiliensis	W	large

ponds in the Nashua River floodplain. *Bidens discoidea* was found growing as an epiphyte on the tangled lower stems of buttonbush, *Cephalanthus occidentalis. Eleocharis obtusa* var. *ovata,* a taxon whose status appears unclear, was found in sedge meadows which had been scoured two years before (T. Poole, pers. comm.). The annual, *Panicum philadelphicum,* was observed in mud flats left exposed by drying oxbow lakes during the unusually dry summer of 1995. *Sparganium minimum* had a large population in the shallow water of an oxbow lake. Although it is a species more common in northern New England (Crow and Hellquist, 1981), two populations have been reported from adjacent Middlesex County (Crow and Hellquist, 1981). It was previously reported from Lake Quinsigamond, Worcester Co. (Jackson, 1909), but no herbarium specimens were found (Sorrie, 1987). *Utricularia minor* and *Wolffia brasiliensis* both have large populations in one or two oxbow lakes and also occur in widely scattered localities in Massachusetts (Hellquist and Crow, 1982; Crow and Hellquist, 1985). It is suggested that at least the former species may be overlooked in the state (Sorrie, 1990).

In addition to oxbow ponds, several other wetland areas on the post supported rare species. *Carex typhina* was found in a mixed oak forest along the sandy banks of a small stream. This apparently relatively dry habitat contrasts with the silver maple-green ash floodplain forest reported for other populations of the species in the state (Sorrie, 1987). *Aster radula* occurred in an open, recently-burned peaty meadow. *Smilacina trifolia,* another species with northern affinities, was abundant in a black spruce-tamarack swamp, and a small population of *Stellaria borealis* was found under powerlines along a small stream in a rich, fen-like area.

Another group of rare species was found in the dry, sandy glacial outwash plains associated with the pitch pine-scrub oak barrens. These included *Cyperus houghtonii, Eragrostis capillaris, Leptoloma cognatum, Liatris borealis* (*Liatris scariosa* var. *novae-angliae*), and *Lupinus perennis.* Many of these are successional species dependent on disturbance or fire. *Cyperus houghtonii,* with no other current stations in the state, was found on a disturbed, gravelly esker slope in one of the rifle ranges. The population size of this species showed large fluctuations between 1991 and 1993. The relatively few individuals of *Liatris borealis,* found in mowed roadsides and along a railroad track, were part of a much larger population under powerlines on adjacent property. *Liatris bo-*

Table 2. County Records from Fort Devens, Massachusetts.

County	Collectors and Number
MIDDLESEX COUNTY	
Native	
Callitriche stagnalis	*Hunt and Zaremba 1597*
Scirpus x*peckii*	*Hunt and Zaremba 2543*
Introduced	
Malus floribunda	*Hunt and Zaremba 2008*
WORCESTER COUNTY	
Native	
Bidens aristosa	*Hunt and Zaremba 2386*
Carex bebbii	*Hunt and Zaremba 415*
Carex hystericina	*Hunt and Zaremba 766*
Carex laevivaginata	*Hunt and Zaremba 324*
Carex typhina	*Hunt and Zaremba 1480*
Eleocharis obtusa var. *ovata*[1]	*Hunt and Zaremba 1068*
Elodea canadensis[1]	*Hunt and Zaremba 1306*
Epilobium palustre	*Hunt and Zaremba 1888*
Galium aparine	*Hunt and Zaremba 2575*
Galium trifidum[1]	*Hunt and Zaremba 2574*
Geranium bicknellii[1]	*Hunt and Zaremba 2467*
Potamogeton zosteriformis	*Enz, Lindwall, Hickler, Searcy 179*
Scirpus georgianus	*Hunt MA-687*
Sparganium minimum[1]	*Enz, Lindwall, Hickler, Searcy 129*
Introduced	
Catalpa bignonioides	*Hunt and Zaremba 1304*
Cerastium semidecandrum	*Hunt and Zaremba 248*
Convallaria majalis	*Hunt and Zaremba 242*
Draba verna	*Lombardi and Searcy 164*
Elaeagnus umbellata	*Hunt and Zaremba 77*
Epipactis helleborine	*Hunt and Zaremba 2489*
Euonymus alatus	*Hunt and Zaremba 2496*
Larix decidua	*Hunt and Zaremba 1259*
Malus baccata	*Hunt and Zaremba 152*
Physocarpus opulifolius var. *opulifolius*[1]	*Hunt and Zaremba 1184*
Trifolium dubium	*Hunt MA-554*
Urtica dioica var. *dioica*	*Hunt and Zaremba 943*

[1] Reported from Worcester County (Jackson, 1909) but no herbarium specimens have been found (Sorrie, 1991).

realis is declining in Massachusetts and is now found primarily in the southeastern part of the state. *Lupinus perennis* is another species declining in Massachusetts. Like *Liatris borealis,* populations of *Lupinus perennis* were found in disturbed areas along roads. However, it also occurred in the "Impact Zone" where fires were frequent.

Finally, several rare species occurred in other obviously disturbed habitats. These included *Arabis drummondii* which was found in a mowed strip beside a road, *Cassia hebecarpa* (*Senna hebecarpa*) found in alluvial thickets along a powerline, and *Geranium bicknellii* found in a wet area along powerlines. The latter species is apparently adventive in eastern Massachusetts and it is uncertain whether the Fort Devens populations are native. Populations of *G. bicknellii* declined drastically between 1991 and 1993 probably due to the cessation of mowing of the powerlines where they occurred.

County Records

Based on a checklist of county records (Sorrie, 1991), twenty nine species collected at Fort Devens were herbarium county records for either Middlesex or Worcester County (Table 2). A number of those listed were previously reported for Worcester County (Jackson, 1909) but appear to be undocumented (Sorrie, 1991). County records include two state endangered, *Eleocharis obtusa* var. *ovata* and *Sparganium minimum*; one state threatened, *Carex typhina*; and one watch list species, *Geranium bicknellii.* Almost half are introduced species of disturbed or successional habitats. Many are relatively common elsewhere and are known from adjacent counties in the eastern part of the state. In contrast, *Scirpus xpeckii,* a sterile hybrid between *S. atrovirens* and *S. cyperinus* (Tucker, 1992) found on a steep slope of a narrow ravine in mixed hardwood forest, has previously been reported from only the western part of the state (Sorrie, 1991; Tucker, 1992).

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APPENDIX 1: ANNOTATED LIST OF THE VASCULAR PLANTS OF FORT DEVENS, MASSACHUSETTS

The appendix lists the taxa, abundance, and community type in which the taxon was collected. Some taxa also occurred in communities other than the one in which the specimen was collected; and, for a few, the community in which a specimen was collected was not typical for the taxon on the post. Where a taxon was observed at only one site, the general location (North, Main or South Post) is also given.

Abundance estimates are for the entire post and were based on the population size and number of communities in which a taxon was observed. Taxa were classed as rare, small population at one site; infrequent, large numbers at one site, or low numbers in one or two communities; occasional, large numbers in one or two communities or low numbers in several communities; common, several communities in large numbers or low numbers in most communities; abundant, in most communities in large numbers.

Abbreviations for the community types in Reschke (1990) are as follows: AOPF = Appalachian Oak-Pine Forest, BCL = Brushy Cleared Land, BMMF = Beech Maple Mesic Forest, BSTB = Black Spruce Tamarack Bog, COF = Chestnut Oak Forest, DEM = Deep Emergent Marsh, DSB = Dwarf Shrub Bog, EP = Eutrophic Pond, FF = Floodplain Forest, GM = Gravel Mine, HHS = Hemlock-Hardwood Swamp, HNHF = Hemlock-Northern Hardwood Forest, INCLS = Inland Non-Calcareous Lake Shore, LD = Landfill/Dump, MCS = Main Channel Stream, MF = Medium Fen, ML = Mowed Land, MS = Midreach Stream, OL = Oxbow Lake, PNHF = Pine-Northern Hardwood Forest, PPOF = Pitch Pine-Oak Forest, PPSOB = Pitch Pine-Scrub Oak Barrens, RMHS = Red Maple-Hardwood Swamp, RSGB = Riverside Sand/Gravel Bar, SA.M = Sand Mine, SEM = Shallow Emergent Marsh, SH = Successional Hardwoods, SM = Sedge Meadow, SNSG = Successional Northern Sandplain Grassland, SOF = Successional Old Field, SS = Shrub Swamp, SU.S = Successional Shrubland.

LYCOPODIOPHYTA (Clubmosses)

LYCOPODIACEAE

Diphasiastrum digitatum (Dillenius ex A. Braun) Holub occasional; PNHF
Diphasiastrum tristachyum (Pursh) Holub occasional; PPSOB
Huperzia lucidula (Michx.) Trev. infrequent; PNHF
Lycopodiella inundata (L.) Holub rare; SEM—South Post
Lycopodium clavatum L. infrequent; PPSOB
Lycopodium obscurum L. common; PNHF

SELAGINELLACEAE

Selaginella apoda (L.) Spring rare; SH—Main Post

EQUISETOPHYTA (Horsetails)

EQUISETACEAE

Equisetum arvense L. occasional; RMHS

Equisetum fluviatile L. infrequent; SEM
Equisetum hyemale L. subsp. *affine* (Engelmann) Calder & R. L. Taylor infrequent; BCL
Equisetum sylvaticum L. infrequent; RMHS

POLYPODIOPHYTA (Ferns)

ASPLENIACEAE
Asplenium platyneuron (L.) BSP. rare; BMMF—Main Post

BLECHNACEAE
Woodwardia virginica (L.) J.E. Smith infrequent; DSB

DENNSTAEDTIACEAE
Dennstaedtia punctilobula (Michx.) T. Moore occasional; SH
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A. Heller abundant; SNSG

DRYOPTERIDACEAE
Athyrium filix-femina (L.) Roth ex Mertens var. *angustum* (Willd.) G. Lawson occasional; FF
Deparia acrostichoides (Swartz) M. Kato rare; BMMF—Main Post
Dryopteris cristata (L.) A. Gray occasional; PNHF
Dryopteris intermedia (Muhlenberg ex Willd.) A. Gray common; PNHF
Dryopteris marginalis (L.) A. Gray infrequent; PNHF
Onoclea sensibilis L. common; RMHS
Polystichum acrostichoides (Michx.) Schott infrequent; AOPF

OPHIOGLOSSACEAE
Botrychium dissectum Sprengel rare; PNHF—South Post
Botrychium virginianum (L.) Swartz rare; BBMF—Main Post

OSMUNDACEAE
Osmunda cinnamomea L. common; RMHS
Osmunda claytoniana L. infrequent; PNHF
Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray occasional; SEM

POLYPODIACEAE
Polypodium virginianum L. infrequent; AOPF

PTERIDACEAE
Adiantum pedatum L. rare; HNHF—Main Post

THELYPTERIDACEAE
Phegopteris connectilis (Michx.) Watt rare; BMMF—Main Post
Thelypteris noveboracensis (L.) Nieuwl. occasional; PNHF

Thelypteris palustris Schott occasional; MF
Thelypteris simulata (Davenp.) Nieuwl. infrequent; RMHS

PINOPHYTA (Gymnosperms)

CUPRESSACEAE

Juniperus communis L. infrequent; SU.S
Juniperus virginiana L. rare; SU.S—South Post

PINACEAE

Larix decidua Miller rare; SH—South Post
Larix laricina (DuRoi) K. Koch infrequent; BSTB
Picea abies (L.) Karst rare; SH—South Post
Picea glauca (Moench) Voss rare; RMHS—South Post
Picea mariana (Miller) BSP. infrequent; BSTB
Pinus resinosa Aiton infrequent; SU.S
Pinus rigida Miller abundant; PPOF
Pinus strobus L. abundant; SOF
Pinus sylvestris L. rare; SH—Main Post
Tsuga canadensis (L.) Carrière occasional; HHS

TAXACEAE

Taxus baccata L. rare; SU.S—South Post

MAGNOLIOPHYTA (Flowering Plants)

MAGNOLIOPSIDA (Dicots)

ACERACEAE

Acer negundo L. var. *negundo* rare; SH—Main Post
Acer pensylvanicum L. rare; AOPF—South Post
Acer platanoides L. rare; SH—South Post
Acer rubrum L. abundant; RMHS
Acer saccharinum L. occasional; FF
Acer saccharum Marshall var. *saccharum* common; SH

AMARANTHACEAE

Amaranthus hybridus L. rare; LD—Main Post
Amaranthus palmeri S. Wats. rare; BCL—North Post
Froelichia gracilis (Hook.) Moq. rare; ML—North Post

ANACARDIACEAE

Cotinus coggygria Scop. rare; BCL—Main Post
Rhus copallinum L. infrequent; FF
Rhus glabra L. infrequent; BCL
Rhus typhina L. occasional; BCL
Toxicodendron radicans (L.) Kuntze occasional; BCL
Toxicodendron vernix (L.) Kuntze infrequent; RMHS

APIACEAE (UMBELLIFERAE)

Aethusa cynapium L. rare; BCL—South Post
Cicuta bulbifera L. occasional; SM
Cicuta maculata L. infrequent; SEM
Daucus carota L. occasional; BCL
Hydrocotyle americana L. occasional; HHS
Sanicula marilandica L. infrequent; SH
Sium suave Walter infrequent; SEM
Zizia aurea (L.) W. Koch rare; SH—Main Post

APOCYNACEAE

Apocynum androsaemifolium L. rare; BCL—South Post
Vinca minor L. rare; SH—South Post

AQUIFOLIACEAE

Ilex laevigata (Pursh) A. Gray infrequent; SS
Ilex verticillata (L.) A. Gray common; RMHS
Nemopanthus mucronatus (L.) Trel. occasional; SS

ARALIACEAE

Aralia hispida Vent. infrequent; BCL
Aralia nudicaulis L. common; RMHS
Panax trifolium L. occasional; PNHF

ASCLEPIADACEAE

Asclepias amplexicaulis J.E. Smith infrequent; PPSOB
Asclepias exaltata L. rare; BCL—South Post
Asclepias incarnata L. var. *pulchra* (Ehrh.) Pers. infrequent; SM
Asclepias syriaca L. occasional; SOF

ASTERACEAE (COMPOSITAE)

Achillea millefolium L. infrequent; BCL
Ambrosia artemisiifolia L. infrequent; SOF
Anaphalis margaritacea (L.) Benth. & Hook. rare; AOPF—North Post
Antennaria neglecta Greene var. *canadensis* (Greene) Cronq. infrequent; SOF
Antennaria neglecta Greene var. *neodioica* (Greene) Cronq. infrequent; SNSG
Anthemis arvensis L. infrequent; SA.M
Arctium minus Schk. infrequent; BCL
Artemisia vulgaris L. occasional; BCL
Aster acuminatus Michx. occasional; PNHF
Aster cordifolius L. occasional; SH
Aster divaricatus L. common; AOPF
Aster dumosus L. rare; SH—South Post
Aster ericoides L. rare; ML—Main Post
Aster lanceolatus Willd. var. *simplex* (Willd.) A.G. Jones infrequent; SH
Aster lateriflorus (L.) Britton infrequent; BMMF
Aster linariifolius L. infrequent; AOPF

Aster macrophyllus L. infrequent; AOPF
Aster novae-angliae L. infrequent; SH
Aster novi-belgii L. infrequent; MF
Aster patens Aiton var. *patens* infrequent; AOPF
Aster paternus Cronq. infrequent; PPOF
Aster puniceus L. infrequent; RMHS
Aster radula Aiton rare; SEM—South Post
Aster umbellatus Miller infrequent; MF
Aster undulatus L. infrequent; SU.S
Bidens aristosa (Michx.) Britton rare; RMHS—South Post
Bidens cernua L. infrequent; SEM
Bidens connata Muhl. infrequent; SS
Bidens discoidea (T. & G.) Britton infrequent; SS
Bidens frondosa L. infrequent; BCL
Centaurea maculosa Lam. occasional; PPSOB
Chrysanthemum leucanthemum L. infrequent; BCL
Cichorium intybus L. rare; SU.S—South Post
Cirsium arvense (L.) Scop. var. *horridum* Wimmer & Graebner rare; MF—South Post
Cirsium muticum Michx. rare; HHS—South Post
Cirsium pumilum (Nutt.) Sprengel rare; SOF—North Post
Cirsium vulgare (Savi) Tenore infrequent; BCL
Conyza canadensis (L.) Cronq. var. *canadensis* occasional; BCL
Coreopsis lanceolata L. rare; BCL—North Post
Crepis tectorum L. rare; SA.M—Main Post
Erechtites hieracifolia (L.) Raf. var. *hieracifolia* infrequent; SEM
Erigeron annuus (L.) Pers. infrequent; SH
Erigeron pulchellus Michx. var. *pulchellus* infrequent; SH
Erigeron strigosus Muhl. var. *strigosus* occasional; BCL
Eupatorium fistulosum Barratt occasional; SH
Eupatorium perfoliatum L. var. *perfoliatum* infrequent; SM
Eupatorium pilosum Walter rare; AOPF—South Post
Eupatorium purpureum L. infrequent; SEM
Eupatorium rugosum Houttuyn infrequent; SH
Euthamia graminifolia (L.) Nutt. var. *nuttallii* (Greene) W. Stone occasional; BCL
Euthamia tenuifolia (Pursh) Nutt. rare; INCLS—South Post
Galinsoga parviflora Cav. rare; BCL—Main Post
Gnaphalium obtusifolium L. var. *obtusifolium* infrequent; BCL
Gnaphalium uliginosum L. infrequent; RMHS
Helenium flexuosum Raf. rare; SOF—North Post
Helianthus divaricatus L. rare; AOPF—South Post
Hieracium aurantiacum L. infrequent; SOF
Hieracium caespitosum Dumort infrequent; BCL
Hieracium flagellare Willd. infrequent; BCL
Hieracium floribundum Wimmer & Grab. infrequent; BCL
Hieracium paniculatum L. infrequent; AOPF
Hieracium pilosella L. infrequent; BCL
Hieracium scabrum Michx. infrequent; BCL

Hieracium venosum L. infrequent; AOPF
Krigia virginica (L.) Willd. infrequent; SNSG
Lactuca biennis (Moench) Fern. rare; HNHF—Main Post
Lactuca canadensis L. infrequent; BCL
Leontodon autumnalis L. var. *autumnalis* infrequent; BCL
Liatris borealis Nutt. (*Liatris scariosa* (L.) Willd. var. *novae-angliae* Lunell) rare; PPSOB—North Post
Matricaria matricarioides (Less.) Porter rare; BCL—South Post
Prenanthes altissima L. var. *altissima* rare; RMHS—South Post
Prenanthes trifoliolata (Cass.) Fern. infrequent; HNHF
Rudbeckia hirta L. var. *pulcherrima* Farw. infrequent; BCL
Rudbeckia laciniata L. var. *laciniata* rare; SH—Main Post
Senecio aureus L. infrequent; MF
Solidago bicolor L. occasional; AOPF
Solidago caesia L. occasional; AOPF
Solidago canadensis L. var. *canadensis* occasional; SEM
Solidago gigantea Aiton infrequent; BCL
Solidago juncea Aiton common; SEM
Solidago nemoralis Aiton var. *nemoralis* common; SNSG
Solidago odora Aiton var. *odora* occasional; SU.S
Solidago puberula Nutt. var. *puberula* occasional; AOPF
Solidago rugosa Miller subsp. *rugosa* var. *rugosa* common; BCL
Solidago rugosa Miller subsp. *rugosa* var. *villosa* (Pursh) Fern. rare; AOPF—South Post
Solidago uliginosa Nutt. rare; RMHS—South Post
Tanacetum vulgare L. rare; BCL—South Post
Taraxacum officinale Weber infrequent; BCL
Tragopogon dubius Scop. rare; BMMF—North Post
Tussilago farfara L. rare; BCL—Main Post

BALSAMINACEAE
Impatiens capensis Meerb. occasional; SS

BERBERIDACEAE
Berberis thunbergii DC. infrequent; FF
Berberis vulgaris L. infrequent; SH
Podophyllum peltatum L. rare; PNHF—South Post

BETULACEAE
Alnus incana (L.) Moench. common; RMHS
Alnus serrulata (Aiton) Willd. infrequent; SS
Betula alleghaniensis Britton occasional; SS
Betula lenta L. occasional; HNHF
Betula papyrifera Marshall var. *cordifolia* (Regel) Fern. infrequent; HNHF
Betula papyrifera Marshall var. *papyrifera* occasional; FF
Betula populifolia Marshall common; BCL
Carpinus caroliniana Walter occasional; RMHS

Corylus americana Walter common; BCL
Corylus cornuta Marshall infrequent; PNHF
Ostrya virginiana (Miller) K. Koch infrequent; AOPF

BIGNONIACEAE

Catalpa bignonioides Walter infrequent; FF

BORAGINACEAE

Echium vulgare L. infrequent; BCL
Myosotis laxa Lehm. occasional; SEM
Myosotis scorpioides L. infrequent; SEM

BRASSICACEAE (CRUCIFERAE)

Alliaria petiolata (Bieb.) Cavara & Grande infrequent; FF
Arabis drummondii A. Gray rare; BCL—North Post
Arabis glabra (L.) Bernh. infrequent; BCL
Barbarea vulgaris R. Br. occasional; SM
Berteroa incana (L.) DC. rare; GM—Main Post
Brassica rapa L. rare; BCL—North Post
Capsella bursa-pastoris (L.) Medikus infrequent; BCL
Cardamine pensylvanica Muhl. occasional; RMHS
Draba verna L. rare; ML—Main Post
Erysimum cheiranthoides L. rare; PPOF—North Post
Hesperis matronalis L. rare; PPOF—North Post
Lepidium campestre (L.) R. Br. occasional; SNSG
Lepidium densiflorum Schrader infrequent; BCL
Lepidium virginicum L. var. *virginicum* occasional; BCL
Raphanus raphanistrum L. rare; PPOF—North Post
Rorippa palustris (L.) Besser var. *hispida* (Desv.) Rydb. rare; SEM—Main Post
Rorippa palustris (L.) Besser var. *palustris* infrequent; FF
Sisymbrium altissimum L. rare; BCL—North Post
Thlaspi arvense L. rare; BCL—Main Post

CABOMBACEAE

Brasenia schreberi J. F. Gmelin infrequent; EP
Cabomba caroliniana A. Gray infrequent; EP

CAESALPINIACEAE

Cassia hebecarpa Fern. (*Senna hebecarpa* (Fern.) Irwin & Barneby) rare; BCL—Main Post
Chamaecrista fasciculata (Michx.) Greene infrequent; SOF
Chamaecrista nictitans (L.) Moench rare; ML—Main Post
Gleditsia triacanthos L. rare; LD—Main Post

CALLITRICHACEAE

Callitriche heterophylla Pursh infrequent; SEM
Callitriche stagnalis Scop. infrequent; MCS

CAMPANULACEAE

Campanula aparinoides Pursh infrequent; SEM
Lobelia cardinalis L. var. *cardinalis* infrequent; RMHS
Lobelia inflata L. occasional; SOF
Lobelia spicata Lam. var. *spicata* infrequent; SNSG

CANNABACEAE

Humulus japonicus Siebold & Zucc. rare; BCL—North Post

CAPRIFOLIACEAE

Diervilla lonicera Miller occasional; BCL
Lonicera canadensis Marshall infrequent; MF
Lonicera morrowii A. Gray occasional; BCL
Lonicera sempervirens L. var. *sempervirens* infrequent; SH
Lonicera tatarica L. infrequent; BCL
Sambucus canadensis L. var. *canadensis* occasional; SS
Viburnum acerifolium L. occasional; SH
Viburnum alnifolium Marshall rare; PNHF—Main Post
Viburnum dentatum L. var. *lucidum* Aiton common; RMHS
Viburnum nudum L. var. *cassinoides* (L.) T. & G. occasional; PNHF
Viburnum lentago L. infrequent; SH
Viburnum opulus L. var. *americanum* Aiton rare; RMHS—North Post

CARYOPHYLLACEAE

Arenaria lateriflora L. occasional; SH
Cerastium semidecandrum L. infrequent; BCL
Cerastium vulgatum L. infrequent; BCL
Dianthus armeria L. infrequent; SH
Gypsophila muralis L. infrequent; SNSG
Saponaria officinalis L. infrequent; SOF
Scleranthus annuus L. infrequent; BCL
Silene antirrhina L. infrequent; SNSG
Silene latifolia Poiret infrequent; BCL
Silene vulgaris (Moench) Garcke occasional; SNSG
Spergularia rubra (L.) J. & C. Presl infrequent; BCL
Stellaria borealis Bigelow rare; MF—South Post
Stellaria graminea L. infrequent; BCL
Stellaria media (L.) Villars rare; ML—North Post

CELASTRACEAE

Celastrus orbiculatus Thunb. infrequent; SH
Euonymus alatus (Thunb.) Siebold rare; BMMF—Main Post

CERATOPHYLLACEAE

Ceratophyllum demersum L. infrequent; EP
Ceratophyllum echinatum A. Gray infrequent; EP

CHENOPODIACEAE
Chenopodium album L. infrequent; SNSG
Chenopodium pumilio R. Br. rare; BCL—Main Post

CISTACEAE
Helianthemum bicknellii Fern. infrequent; SNSG
Helianthemum canadense (L.) Michx. occasional; PPOF
Lechea intermedia Leggett occasional; AOPF
Lechea maritima Leggett occasional; BCL
Lechea mucronata Raf. infrequent; AOPF

CLETHRACEAE
Clethra alnifolia L. occasional; SM

CLUSIACEAE (GUTTIFERAE)
Hypericum boreale (Britton) E. Bickn. infrequent; SM
Hypericum canadense L. occasional; INCLS
Hypericum ellipticum Hook. rare; SM—South Post
Hypericum gentianoides (L.) BSP. occasional; BCL
Hypericum majus (A. Gray) Britton infrequent; SEM
Hypericum mutilum L. infrequent; SM
Hypericum perforatum L. occasional; BCL
Hypericum prolificum L. rare; PNHF—South Post
Hypericum punctatum Lam. infrequent; SH
Triadenum fraseri (Spach) Gleason rare; SEM—South Post
Triadenum virginicum (L.) Raf. occasional; SM

CONVOLVULACEAE
Calystegia sepium (L.) R. Br. occasional; BCL

CORNACEAE (includes NYSSACEAE)
Cornus alternifolia L.f. infrequent; PNHF
Cornus amomum Miller var. *amomum* occasional; FF
Cornus canadensis L. infrequent; RMHS
Cornus florida L. occasional; AOPF
Cornus racemosa Lam. common; BCL
Cornus rugosa Lam. infrequent; BMMF
Nyssa sylvatica Marshall var. *sylvatica* infrequent; AOPF

CRASSULACEAE
Sedum purpureum (L.) J.A. Schultes rare; BCL—North Post

CUCURBITACEAE
Echinocystis lobata (Michx.) T. & G. rare; FF—South Post

CUSCUTACEAE

Cuscuta gronovii Willd. infrequent; BMMF

DROSERACEAE

Drosera intermedia Hayne infrequent; DSB
Drosera rotundifolia L. rare; INCLS—South Post

ELAEAGNACEAE

Elaeagnus umbellata Thunb. infrequent; SU.S

ERICACEAE

Andromeda glaucophylla Link rare; DSB—South Post
Arctostaphylos uva-ursi (L.) Sprengel infrequent; PPOF
Chamaedaphne calyculata (L.) Moench occasional; DSB
Epigaea repens L. occasional; BCL
Eubotrys racemosa (L.) Nutt. infrequent; INCLS
Gaultheria procumbens L. common; AOPF
Gaylussacia baccata (Wangenh.) K. Koch common; DSB
Gaylussacia frondosa (L.) T. & G. occasional; AOPF
Kalmia angustifolia L. occasional; SEM
Kalmia latifolia L. occasional; AOPF
Kalmia polifolia Wangenh. rare; DSB—South Post
Ledum groenlandicum Oeder infrequent; BSTB
Lyonia ligustrina (L.) DC. infrequent; MF
Rhododendron canadense (L.) Torr. infrequent; BSTB
Rhododendron prinophyllum (Small) Millais rare; HNHF—Main Post
Rhododendron viscosum (L.) Torr. infrequent; HNHF
Vaccinium angustifolium Aiton abundant; PNHF
Vaccinium corymbosum L. common; INCLS
Vaccinium macrocarpon Aiton infrequent; INCLS
Vaccinium oxycoccos L. rare; DSB—South Post
Vaccinium pallidum Aiton common; COF

EUPHORBIACEAE

Acalypha gracilens A. Gray var. *gracilens* rare; BCL—Main Post
Acalypha rhomboidea Raf. infrequent; BCL
Euphorbia cyparissias L. infrequent; SOF
Euphorbia esula L. rare; FF—North Post
Euphorbia maculata L. occasional; SU.S
Euphorbia nutans Lagasca rare; SU.S—Main Post

FABACEAE

Amphicarpaea bracteata (L.) Fern. occasional; RMHS
Apios americana Medikus infrequent; BCL
Baptisia tinctoria (L.) R. Br. infrequent; SNSG
Coronilla varia L. rare; BCL—Main Post

Desmodium canadense (L.) DC. infrequent; BCL
Desmodium glutinosum (Muhl.) A. Wood rare; BMMF—North Post
Desmodium marilandicum (L.) DC. infrequent; AOPF
Desmodium nudiflorum (L.) DC. rare; AOPF—Main Post
Desmodium rotundifolium DC. rare; AOPF—Main Post
Lespedeza capitata Michx. occasional; BCL
Lespedeza hirta (L.) Hornem. subsp. *hirta* infrequent; AOPF
Lespedeza intermedia (S. Wats.) Britton occasional; AOPF
Lespedeza virginica (L.) Britton rare; AOPF—Main Post
Lotus corniculatus L. infrequent; SOF
Lupinus perennis L. infrequent; SNSG
Medicago lupulina L. infrequent; BCL
Medicago sativa L. infrequent; SOF
Melilotus alba Medikus infrequent; BCL
Melilotus officinalis (L.) Pallas. infrequent; BCL
Robinia hispida L. rare; SOF—South Post
Robinia pseudoacacia L. infrequent; SH
Trifolium arvense L. occasional; BCL
Trifolium aureum Pollich infrequent; BCL
Trifolium campestre Schreber rare; BCL—Main Post
Trifolium dubium Sibth. rare; BCL—Main Post
Trifolium hybridum L. infrequent; BCL
Trifolium pratense L. infrequent; BCL
Trifolium repens L. infrequent; BCL
Vicia cracca L. infrequent; BCL
Vicia tetrasperma (L.) Moench rare; BCL—South Post
Wisteria sinensis (Sims) Sweet rare; AOPF—Main Post

FAGACEAE

Castanea dentata (Marshall) Borkh. infrequent; SU.S
Fagus grandifolia Ehrh. occasional; BMMF
Quercus alba L. common; SU.S
Quercus bicolor Willd. occasional; SEM
Quercus coccinea Muenchh. occasional; SU.S
Quercus ilicifolia Wangenh. common; AOPF
Quercus prinoides Willd. occasional; PPSOB
Quercus prinus L. infrequent; COF
Quercus rubra L. common; SU.S
Quercus velutina Lam. abundant; AOPF

FUMARIACEAE

Corydalis sempervirens (L.) Pers. rare; AOPF—Main Post

GENTIANACEAE

Bartonia virginica (L.) BSP. rare; SEM—South Post
Gentiana clausa Raf. infrequent; RMHS

GERANIACEAE

Erodium cicutarium (L.) L'Her. rare; BCL—North Post
Geranium bicknellii Britton infrequent; BCL
Geranium maculatum L. occasional; SH

GROSSULARIACEAE

Ribes americanum Miller rare; BMMF—Main Post
Ribes hirtellum Michx. infrequent; RMHS
Ribes sativum Syme rare; SH—Main Post

HALORAGACEAE

Myriophyllum heterophyllum Michx. infrequent; EP
Myriophyllum humile (Raf.) Morong rare; INCLS—South Post
Proserpinaca palustris L. var. *crebra* Fern. & Griscom infrequent; INCLS

HAMAMELIDACEAE

Hamamelis virginiana L. common; AOPF

JUGLANDACEAE

Carya cordiformis (Wangenh.) K. Koch infrequent; BMMF
Carya glabra (Miller) Sweet common; SU.S
Carya ovata (Miller) K. Koch occasional; SH
Juglans cinerea L. rare; BMMF—Main Post
Juglans nigra L. rare; SH—Main Post

LAMIACEAE (LABIATAE)

Galeopsis tetrahit L. var. *bifida* (Boenn.) Lej. & Courtois infrequent; FF
Glecoma hederacea L. rare; SH—South Post
Hedeoma pulegioides (L.) Pers. rare; BCL—Main Post
Leonurus cardiaca L. rare; BCL—South Post
Lycopus americanus Muhl. infrequent; SEM
Lycopus uniflorus Michx. occasional; SEM
Lycopus virginicus L. infrequent; INCLS
Mentha arvensis L. var. *canadensis* (L.) Kuntze infrequent; MF
Nepeta cataria L. rare; BCL
Physostegia virginiana (L.) Benth. var. *virginiana* rare; BCL—South Post
Prunella vulgaris L. var. *lanceolata* (Barton) Fern. occasional; BCL
Pycnanthemum tenuifolium Schrader rare; SH—South Post
Scutellaria galericulata L. infrequent; SM
Scutellaria lateriflora L. rare; RMHS—South Post
Trichostema dichotomum L. occasional; BCL

LAURACEAE

Lindera benzoin (L.) Blume common; HHS
Sassafras albidum (Nutt.) Nees occasional; AOPF

LENTIBULARIACEAE

Utricularia gibba L. infrequent; SM
Utricularia minor L. rare; OL—South Post
Utricularia purpurea Walter infrequent; EP
Utricularia radiata Small infrequent; EP
Utricularia vulgaris L. infrequent; EP

LYTHRACEAE

Decodon verticillatus (L.) Elliott infrequent; DSB
Lythrum salicaria L. infrequent; FF

MELASTOMATACEAE

Rhexia virginica L. infrequent; AOPF

MOLLUGINACEAE

Mollugo verticillata L. infrequent; BCL

MONOTROPACEAE

Monotropa hypopithys L. infrequent; AOPF
Monotropa uniflora L. infrequent; AOPF

MYRICACEAE

Comptonia peregrina (L.) J.M. Coulter occasional; BCL
Myrica gale L. infrequent; SS
Myrica pensylvanica Mirbel. rare; PNHF—Main Post

NYCTAGINACEAE

Mirabilis nyctaginea (Michx.) MacMillan infrequent; BCL

NYMPHAEACEAE

Nuphar variegata Durand infrequent; MCS
Nymphaea odorata Aiton var. *odorata* occasional; MCS

OLEACEAE

Fraxinus americana L. occasional; SH
Fraxinus nigra Marshall infrequent; RMHS
Ligustrum vulgare L. rare; SH—Main Post
Syringa vulgaris L. rare; SH—South Post

ONAGRACEAE

Circaea alpina L. var. *alpina* infrequent; RMHS
Circaea lutetiana L. var. *canadensis* L. occasional; RMHS
Epilobium angustifolium L. var. *angustifolium* infrequent; PPSOB
Epilobium glandulosum Lehm. occasional; MF

Epilobium leptophyllum Raf. rare; SEM—Main Post
Epilobium palustre L. rare; DSB—South Post
Ludwigia palustris (L.) Elliott infrequent; MS
Oenothera biennis L. occasional; BCL
Oenothera parviflora L. rare; PPSOB—North Post
Oenothera perennis L. occasional; BCL
Oenothera tetragona Roth rare; BCL—Main Post

OROBANCHACEAE

Orobanche uniflora L. var. *uniflora* rare; BCL

OXALIDACEAE

Oxalis stricta L. infrequent; BCL

PAPAVERACEAE

Chelidonium majus L. infrequent; BCL
Sanguinaria canadensis L. rare; BMMF—Main Post

PHYTOLACCACEAE

Phytolacca americana L. infrequent; PPSOB

PLANTAGINACEAE

Plantago aristata Michx. infrequent; SNSG
Plantago lanceolata L. occasional; BCL
Plantago major L. infrequent; BCL
Plantago rugelii Decne. infrequent; SOF

PLATANACEAE

Platanus occidentalis L. infrequent; SH

POLEMONIACEAE

Phlox paniculata L. rare; SH—South Post

POLYGALACEAE

Polygala paucifolia Willd. infrequent; AOPF
Polygala polygama Walter var. *obtusata* Chodat infrequent; SNSG
Polygala sanguinea L. occasional; MF

POLYGONACEAE

Polygonella articulata (L.) Meissner occasional; BCL
Polygonum amphibium L. var. *emersum* Michx. infrequent; FF
Polygonum arifolium L. infrequent; RMHS
Polygonum aviculare L. occasional; BCL
Polygonum careyi Olney rare; INCLS—South Post

Polygonum cilinode Michx. infrequent; RMHS
Polygonum cuspidatum Sieb. & Zucc. infrequent; SH
Polygonum hydropiper L. infrequent; RMHS
Polygonum hydropiperoides Michx. occasional; FF
Polygonum lapathifolium L. infrequent; FF
Polygonum pensylvanicum L. occasional; BCL
Polygonum persicaria L. infrequent; FF
Polygonum punctatum Elliott var. *confertiflorum* (Meissner) Fassett infrequent; SEM
Polygonum sagittatum L. occasional; SEM
Polygonum scandens L. var. *scandens* occasional; BCL
Rumex acetosella L. occasional; BCL
Rumex crispus L. infrequent; BCL
Rumex obtusifolius L. occasional; LD
Rumex orbiculatus A. Gray rare; MF—South Post
Rumex salicifolius J.A. Weinm. var. *triangulivalvis* (Danser) Hickman rare; MS—Main Post

PORTULACACEAE
Portulaca oleracea L. rare; BCL—South Post

PRIMULACEAE
Lysimachia ciliata L. infrequent; BCL
Lysimachia quadrifolia L. occasional; BCL
Lysimachia terrestris (L.) BSP. common; INCLS
Trientalis borealis Raf. common; RMHS

PYROLACEAE
Chimaphila maculata (L.) Pursh var. *maculata* infrequent; AOPF
Chimaphila umbellata (L.) Barton var. *cisatlantica* S. F. Blake infrequent; AOPF
Pyrola chlorantha Swartz rare; AOPF—South Post
Pyrola elliptica Nutt. infrequent; FF
Pyrola rotundifolia L. var. *americana* (Sweet) Fern. infrequent; AOPF

RANUNCULACEAE
Actaea alba (L.) Miller infrequent; HNHF
Actaea rubra (Aiton) Willd. infrequent; BMMF
Anemone quinquefolia L. occasional; RMHS
Anemonella thalictroides (L.) Spach rare; BMMF—North Post
Aquilegia canadensis L. infrequent; BCL
Caltha palustris L. infrequent; RMHS
Clematis virginiana L. occasional; SS
Coptis trifolia (L.) Salisb. occasional; PNHF
Hepatica americana (DC.) Ker Gawler rare; BMMF—North Post
Ranunculus abortivus L. var. *abortivus* infrequent; FF
Ranunculus acris L. infrequent; BCL
Ranunculus bulbosus L. infrequent; BCL

Ranunculus flabellaris Raf. rare; SEM—Main Post
Ranunculus recurvatus Poiret infrequent; SH
Ranunculus repens L. infrequent; PNHF
Ranunculus sceleratus L. var. *sceleratus* rare; EP—North Post
Thalictrum pubescens Pursh occasional; SS

RHAMNACEAE

Ceanothus americanus L. var. *americanus* infrequent; BCL
Rhamnus cathartica L. infrequent; BCL
Rhamnus frangula L. occasional; MF

ROSACEAE

Agrimonia gryposepala Wallr. infrequent; BMMF
Amelanchier arborea (Michx. f.) Fern. occasional; AOPF
Amelanchier canadensis (L.) Medikus infrequent; SS
Amelanchier spicata (Lam.) K. Koch rare; PPSOB—North Post
Aronia arbutifolia (L.) Elliott infrequent; AOPF
Aronia melanocarpa (Michx.) Elliott occasional; FF
Aronia prunifolia (Marshall) Rehder infrequent; AOPF
Crataegus chrysocarpa Ashe rare; PNHF—South Post
Crataegus coccinea L. rare; PNHF—South Post
Crataegus flabellata (Bosc) K. Koch infrequent; SH
Crataegus intricata Lange infrequent; SH
Crataegus pruinosa (Wendl.) K. Koch infrequent; PNHF
Crataegus succulenta Schrader rare; PNHF—Main Post
Fragaria virginiana Duchesne occasional; SH
Geum canadense Jacq. rare; FF
Geum laciniatum Murray infrequent; SH
Geum rivale L. rare; MF—South Post
Malus baccata (L.) Borkh. rare; SH—South Post
Malus floribunda Siebold ex Van Houtte rare; PPSOB—North Post
Malus pumilla Mill. infrequent; SU.S
Malus sieboldii (Regel) Rehd. rare; BCL—North Post
Physocarpus opulifolius (L.) Maxim. var. *opulifolius* rare; BMMF—Main Post
Potentilla argentea L. infrequent; BCL
Potentilla canadensis L. occasional; SU.S
Potentilla norvegica L. occasional; BCL
Potentilla recta L. infrequent; BCL
Potentilla simplex Michx. common; BCL
Prunus americana Marshall rare; PPSOB—Main Post
Prunus pensylvanica L. f. occasional; SNSG
Prunus pumila L. var. *cuneata* (Raf.) L.H. Bailey infrequent; SNSG
Prunus serotina Ehrh. common; SNSG
Prunus virginiana L. occasional; SOF
Rosa carolina L. infrequent; PPSOB
Rosa multiflora Thunb. infrequent; BCL
Rosa palustris Marshall occasional; RMHS
Rosa virginiana Miller infrequent; AOPF

Rubus allegheniensis T.C. Porter occasional; BCL
Rubus flagellaris Willd. common; BCL
Rubus hispidus L. occasional; PPSOB
Rubus idaeus L. var. *strigosus* (Michx.) Maxim. occasional; RMHS
Rubus occidentalis L. infrequent; BCL
Rubus pubescens Raf. occasional; RMHS
Sorbus aucuparia L. rare; RMHS—Main Post
Spiraea alba Duroi var. *latifolia* (Aiton) Dippel common; AOPF
Spiraea nipponica Maxim. rare; SU.S
Spiraea tomentosa L. var. *tomentosa* infrequent; SM

RUBIACEAE
Cephalanthus occidentalis L. occasional; SS
Diodia teres Walter infrequent; BCL
Galium aparine L. infrequent; RMHS
Galium circaezans Michx. var. *hypomalacum* Fern. infrequent; PNHF
Galium mollugo L. rare; BCL—South Post
Galium obtusum Bigelow var. *obtusum* rare; FF—North Post
Galium palustre L. occasional; FF
Galium tinctorium L. var. *tinctorium* infrequent; SEM
Galium trifidum L. var. *trifidum* infrequent; SS
Galium triflorum Michx. occasional; PNHF
Hedyotis caerulea (L.) Hook. occasional; BCL
Mitchella repens L. occasional; PNHF

SALICACEAE
Populus balsamifera L. rare; LD—Main Post
Populus deltoides Marshall var. *deltoides* infrequent; AOPF
Populus grandidentata Michx. occasional; BCL
Populus nigra L. rare; SH—Main Post
Populus tremuloides Michx. occasional; SNSG
Populus xjackii Sarg. infrequent; LD
Salix babylonica L. rare; SS—South Post
Salix bebbiana Sarg. occasional; BCL
Salix discolor Muhl. rare; SU.S—South Post
Salix eriocephala Michx. infrequent; BCL
Salix humilis Marshall infrequent; PPSOB
Salix nigra Marshall occasional; SS
Salix petiolaris J. E. Smith rare; BCL—North Post
Salix sericea Marshall occasional; SM

SANTALACEAE
Comandra umbellata (L.) Nutt. var. *umbellata* infrequent; AOPF

SARRACENIACEAE
Sarracenia purpurea L. var. *purpurea* infrequent; DSB

SAXIFRAGACEAE

Chrysosplenium americanum Schwein. occasional; RMHS
Penthorum sedoides L. infrequent; SEM
Philadelphus coronarius L. rare; SU.S—South Post
Saxifraga pensylvanica L. infrequent; MF
Tiarella cordifolia L. var. *cordifolia* infrequent; HHS

SCROPHULARIACEAE

Agalinis purpurea (L.) Pennell var. *parviflora* (Benth.) B. Boivin occasional; BCL
Aureolaria pedicularia (L.) Raf. var. *pedicularia* occasional; AOPF
Aureolaria virginica (L.) Pennell rare; AOPF—Main Post
Chaenorrhinum minus (L.) Lange rare; BCL—North Post
Chelone glabra L. infrequent; MF
Gratiola aurea Pursh infrequent; INCLS
Linaria canadensis (L.) Dum.-Cours. infrequent; BCL
Linaria vulgaris Miller infrequent; PPSOB
Lindernia dubia (L.) Pennell var. *dubia* infrequent; FF
Melampyrum lineare Desr. var. *americanum* (Michx.) Beauverd occasional; COF
Mimulus ringens L. var. *ringens* infrequent; SM
Scrophularia lanceolata Pursh rare; PPSOB—Main Post
Scrophularia marilandica L. rare; SH—Main Post
Verbascum thapsus L. infrequent; BCL
Veronica arvensis L. rare; ML—North Post
Veronica chamaedrys L. rare; SH—South Post
Veronica officinalis L. rare; SOF—South Post
Veronica peregrina L. var. *peregrina* infrequent; BCL
Veronica peregrina L. var. *xalapensis* (HBK.) St. John & Warren rare; BCL—South Post
Veronica scutellata L. infrequent; SEM
Veronica serpyllifolia L. var. *serpyllifolia* infrequent; BCL

SOLANACEAE

Physalis heterophylla Nees var. *ambigua* (A. Gray) Rydb. rare; SOF—North Post
Solanum carolinense L. var. *carolinense* rare; BCL—South Post
Solanum dulcamara L. infrequent; SEM
Solanum nigrum L. var. *virginicum* L. infrequent; BCL

TILIACEAE

Tilia americana L. infrequent; SH

ULMACEAE

Ulmus americana L. occasional; SH
Ulmus parvifolia Jacq. rare; SU.S—Main Post
Ulmus pumila L. rare; SA.M—Main Post

URTICACEAE

Boehmeria cylindrica (L.) Swartz occasional; SEM
Pilea pumila (L.) A. Gray occasional; PNHF
Urtica dioica L. var. *dioica* occasional; FF

VERBENACEAE

Verbena bracteata Lagasca & Rodriguez infrequent; PPSOB
Verbena hastata L. infrequent; RSGB
Verbena urticifolia L. var. *urticifolia* rare; SH—South Post

VIOLACEAE

Viola conspersa Reichenb. infrequent; BCL
Viola cucullata Aiton occasional; RMHS
Viola lanceolata L. var. *lanceolata* occasional; INCLS
Viola macloskeyi F. Lloyd var. *pallens* (Banks) C. L. Hitchc. occasional; RMHS
Viola pedata L. rare; PPOF—North Post
Viola sagittata Aiton occasional; SNSG
Viola sororia Willd. occasional; PNHF

VITACEAE

Parthenocissus quinquefolia (L.) Planchon occasional; SH
Parthenocissus vitacea (Knerr) A. Hitchc. common; SH
Vitis aestivalis Michx. var. *argentifolia* (Munson) Fern. infrequent; SH
Vitis labrusca L. occasional; PNHF
Vitis riparia Michx. infrequent; SH

LILIOPSIDA (Monocots)

ACORACEAE

Acorus calamus L. infrequent; DEM

AGAVACEAE

Yucca filamentosa L. rare; SH—South Post

ALISMATACEAE

Alisma triviale Pursh infrequent; RMHS
Sagittaria engelmanniana J. G. Smith infrequent; SEM
Sagittaria latifolia Willd. var. *latifolia* infrequent; RMHS

ARACEAE

Arisaema triphyllum (L.) Schott occasional; RMHS
Calla palustris L. infrequent; RMHS
Peltandra virginica (L.) Schott & Endl. infrequent; OL
Symplocarpus foetidus (L.) Nutt. occasional; RMHS

COMMELINACEAE

Commelina communis L. rare; SH—Main Post
Tradescantia ohiensis Raf. rare; SOF—South Post
Tradescantia virginiana L. rare; SOF—South Post

CYPERACEAE

Bulbostylis capillaris (L.) C. B. Clarke occasional; BCL
Carex albicans Willd. var. *emmonsii* (Dewey) Rettig infrequent; PPSOB
Carex albolutescens Schwein. infrequent; AOPF
Carex argyrantha Tuckerman infrequent; AOPF
Carex atlantica L. Bailey var. *atlantica* occasional; DSB
Carex atlantica L. Bailey var. *capillacea* (L. Bailey) Cronq. occasional; BSTB
Carex bebbii (L.H. Bailey) Fern. infrequent; BCL
Carex blanda Dewey infrequent; SH
Carex brevior (Dewey) Mackenzie infrequent; SOF
Carex bromoides Willd. infrequent; RMHS
Carex brunnescens (Pers.) Poiret infrequent; MF
Carex bullata Schk. occasional; SEM
Carex canescens L. infrequent; SS
Carex cephalophora Muhl. var. *cephalophora* rare; BMMF—Main Post
Carex cephalophora Muhl. var. *mesochorea* (Mackenzie) Gleason rare; SNSG—South Post
Carex comosa F. Boott infrequent; SEM
Carex crinita Lam. infrequent; SM
Carex debilis Michx. var. *rudgei* L. Bailey occasional; BCL
Carex digitalis Willd. infrequent; PNHF
Carex echinata Murray var. *echinata* infrequent; SM
Carex foenea Willd. rare; RMHS—South Post
Carex folliculata L. occasional; RMHS
Carex gracillima Schwein. infrequent; SH
Carex gynandra Schwein. occasional; RMHS
Carex hystericina Muhl. rare; SM—South Post
Carex intumescens Rudge occasional; RMHS
Carex lacustris Willd. occasional; BSTB
Carex laevivaginata (Kük.) Mackenzie occasional; RMHS
Carex lasiocarpa Ehrh. var. *americana* Fern. infrequent; SS
Carex laxiculmis Schwein. rare; SH—South Post
Carex laxiflora Lam. infrequent; AOPF
Carex leptalea Wahlenb. rare; MF—South Post
Carex leptonervia (Fern.) Fern. infrequent; PNHF
Carex lupulina Muhl. infrequent; RMHS
Carex lurida Wahlenb. occasional; SM
Carex muhlenbergii Schk. var. *muhlenbergii* infrequent; AOPF
Carex normalis Mackenzie infrequent; RMHS
Carex pensylvanica Lam. abundant; AOPF
Carex prasina Wahlenb. infrequent; RMHS
Carex projecta Mackenzie infrequent; FF
Carex radiata (Wahlenb.) Small occasional; SEM

Carex rostrata J. Stokes infrequent; SEM
Carex scabrata Schwein. infrequent; BMMF
Carex scoparia Schk. common; BCL
Carex stipata Muhl. var. *stipata* infrequent; SEM
Carex stricta Lam. occasional; SM
Carex swanii (Fern.) Mackenzie common; BCL
Carex tenera Dewey infrequent; PNHF
Carex tribuloides Wahlenb. infrequent; FF
Carex trisperma Dewey occasional; BSTB
Carex typhina Michx. rare; PNHF—South Post
Carex umbellata Schk. infrequent; PPSOB
Carex vesicaria L. rare; FF—South Post
Carex vestita Willd. occasional; SNSG
Carex vulpinoidea Michx. infrequent; BCL
Cyperus bipartitus Torr. infrequent; SEM
Cyperus dentatus Torr. occasional; SU.S
Cyperus erythrorhizos Muhl. infrequent; SM
Cyperus esculentus L. infrequent; LD
Cyperus filiculmis Vahl occasional; AOPF
Cyperus houghtonii Torr. infrequent; SNSG
Cyperus strigosus L. occasional; SM
Dulichium arundinaceum (L.) Britton occasional; SM
Eleocharis acicularis (L.) Roemer & Schultes infrequent; SM
Eleocharis obtusa (Willd.) J.A. Schultes var. *ovata* (Roth) Drapalik & Mohlenbrock (*E. ovata* (Roth) Roemer & Schultes, in part) occasional; SM
Eleocharis ovata (Roth) Roemer & Schultes, sensu stricto infrequent; SM
Eleocharis smallii Britton rare; FF—South Post
Eleocharis tenuis (Willd.) Schultes var. *borealis* (Svenson) Gleason infrequent; SM
Eriophorum virginicum L. infrequent; SEM
Rhynchospora alba (L.) Vahl infrequent; DSB
Rhynchospora capitellata (Michx.) Vahl occasional; SEM
Scirpus cyperinus (L.) Kunth occasional; SM
Scirpus expansus Fern. infrequent; SEM
Scirpus georgianus R. M. Harper infrequent; SH
Scirpus hattorianus Makino infrequent; RMHS
Scirpus xpeckii Britton rare; SH—Main Post
Scirpus validus Vahl infrequent; DEM

ERIOCAULACEAE
Eriocaulon aquaticum (Hill) Druce infrequent; INCLS

HYDROCHARITACEAE
Elodea canadensis Michx. infrequent; SEM
Elodea nuttallii (Planchon) St. John infrequent; MS

IRIDACEAE
Iris pseudacorus L. rare; SEM—South Post

Iris versicolor L. occasional; SM
Sisyrinchium angustifolium Miller rare; BCL—Main Post
Sisyrinchium atlanticum E. Bickn. infrequent; SU.S
Sisyrinchium montanum Greene infrequent; SOF

JUNCACEAE

Juncus acuminatus Michx. infrequent; SEM
Juncus bufonius L. var. *bufonius* rare; BCL—Main Post
Juncus canadensis J. Gay infrequent; SM
Juncus effusus L. var. *solutus* Fern. & Weigand occasional; MF
Juncus greenei Oakes & Tuckerman occasional; SNSG
Juncus marginatus Rostk. infrequent; RMHS
Juncus pelocarpus E. Meyer infrequent; INCLS
Juncus tenuis Willd. var. *dichotomus* (Elliott) A. Wood infrequent; BCL
Juncus tenuis Willd. var. *tenuis* occasional; AOPF
Luzula multiflora (Retz.) Lej. occasional; BCL

LEMNACEAE

Lemna minor L. infrequent; OL
Spirodela polyrhiza (L.) Schleiden infrequent; MS
Wolffia brasiliensis Weddell (*W. papulifera* C. Thompson) infrequent; OL
Wolffia columbiana Karsten infrequent; EP

LILIACEAE

Allium canadense L. var. *canadense* infrequent; BCL
Asparagus officinalis L. rare; SOF—South Post
Clintonia borealis (Aiton) Raf. occasional; MF
Convallaria majalis L. rare; SH—South Post
Erythronium americanum Ker Gawler rare; FF—South Post
Hemerocallis fulva (L.) L. rare; SOF—South Post
Hemerocallis lilioasphodelus L. rare; SU.S—South Post
Hypoxis hirsuta (L.) Cov. rare; BCL—Main Post
Lilium canadense L. infrequent; FF
Lilium philadelphicum L. var. *philadelphicum* infrequent; SU.S
Maianthemum canadense Desf. var. *canadense* abundant; SNSG
Medeola virginiana L. occasional; PNHF
Polygonatum pubescens (Willd.) Pursh infrequent; BMMF
Smilacina racemosa (L.) Desf. occasional; AOPF
Smilacina stellata (L.) Desf. var. *stellata* rare; FF—North Post
Smilacina trifolia (L.) Desf. rare; BSTB—South Post
Trillium cernuum L. infrequent; PNHF
Trillium undulatum Willd. infrequent; BSTB
Uvularia perfoliata L. rare; HNHF—Main Post
Uvularia sessilifolia L. occasional; RMHS
Veratrum viride Aiton infrequent; RMHS

NAJADACEAE

Najas flexilis (Willd.) Rostkov & Schmidt infrequent; EP

ORCHIDACEAE

Cypripedium acaule Aiton occasional; AOPF
Epipactis helleborine (L.) Crantz rare; BMMF—Main Post
Goodyera pubescens (Willd.) R. Br. infrequent; AOPF
Habenaria clavellata (Michx.) Sprengel infrequent; HHS
Habenaria psycodes (L.) Sprengel var. *grandiflora* (Bigelow) A. Gray infrequent; MF
Habenaria psycodes (L.) Sprengel var. *psycodes* infrequent; RMHS
Spiranthes cernua (L.) Rich infrequent; INCLS
Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer rare; PPSOB—South Post

POACEAE (GRAMINEAE)

Agrostis capillaris L. infrequent; AOPF
Agrostis hyemalis (Walter) BSP. var. *hyemalis* infrequent; SA.M
Agrostis hyemalis (Walter) BSP. var. *scabra* (Willd.) Blomq. occasional; INCLS
Agrostis perennans (Walter) Tuckerman var. *perennans* abundant; AOPF
Agrostis stolonifera L. var. *palustris* (Huds.) Farw. infrequent; FF
Alopecurus pratensis L. rare; SOF—Main Post
Andropogon gerardii Vitman infrequent; SOF
Andropogon virginicus L. var. *virginicus* infrequent; INCLS
Anthoxanthum odoratum L. occasional; BCL
Aristida dichotoma Michx. occasional; SNSG
Aristida oligantha Michx. infrequent; SU.S
Brachyeletrum erectum (Schreber) P. Beauv. var. *glabratum* (Vasey) T. Koyama & Kawano occasional; PNHF
Bromus ciliatus L. infrequent; BCL
Bromus inermis Leysser infrequent; SOF
Bromus japonicus Thunb. rare; SOF—South Post
Bromus tectorum L. infrequent; SOF
Calamagrostis canadensis (Michx.) P. Beauv. occasional; SEM
Calamagrostis cinnoides (Muhl.) Barton infrequent; BCL
Cenchrus longispinus (Hackel) Fern. infrequent; BCL
Cinna arundinacea L. occasional; SH
Cinna latifolia (Trevir.) Griseb. infrequent; RMHS
Dactylis glomerata L. occasional; BCL
Danthonia compressa Austin infrequent; BCL
Danthonia spicata (L.) P. Beauv. occasional; SOF
Deschampsia flexuosa (L.) Trin. occasional; AOPF
Digitaria ischaemum (Schreber) Muhl. infrequent; MF
Digitaria sanguinalis (L.) Scop. occasional; ML
Echinochloa muricata (P. Beauv.) Fern. var. *muricata* occasional; FF
Elymus virginicus L. infrequent; FF
Elytrigia repens (L.) Nevski infrequent; BCL
Eragrostis capillaris (L.) Nees rare; SU.S—Main Post
Eragrostis cilianensis (All.) Janchen rare; BCL—South Post
Eragrostis minor Host rare; ML—North Post
Eragrostis pectinacea (Michx.) Nees occasional; ML
Eragrostis spectabilis (Pursh) Steudel occasional; SNSG

Festuca elatior L. rare; BCL—North Post
Festuca filiformis Pourret infrequent; BCL
Festuca ovina L. occasional; BCL
Festuca rubra L. occasional; BCL
Festuca subverticillata (Pers.) E. Alexeev. infrequent; FF
Glyceria acutiflora Torr. rare; INCLS—South Post
Glyceria borealis (Nash) Batchelder rare; SS—Main Post
Glyceria canadensis (Michx.) Trin. infrequent; MF
Glyceria grandis S. Wats. infrequent; SS
Glyceria melicaria (Michx.) C. E. Hubbard infrequent; RMHS
Glyceria striata (Lam.) A. Hitchc. var. *striata* occasional; RMHS
Leersia oryzoides (L.) Swartz infrequent; SM
Leersia virginica Willd. occasional; RMHS
Leptoloma cognatum (Schultes) Chase infrequent; BCL
Lolium perenne L. var. *aristatum* Willd. infrequent; BCL
Lolium perenne L. var. *perenne* infrequent; BCL
Muhlenbergia frondosa (Poiret) Fern. infrequent; SH
Muhlenbergia glomerata (Willd.) Trin. var. *glomerata* infrequent; SU.S
Muhlenbergia mexicana (L.) Trin. infrequent; SH
Muhlenbergia uniflora (Muhl.) Fern. infrequent; BCL
Oryzopsis asperifolia Michx. infrequent; PNHF
Oryzopsis pungens (Torr.) A. Hitchc. rare; HNHF—Main Post
Panicum boreale Nash infrequent; AOPF
Panicum capillare L. infrequent; ML
Panicum clandestinum L. occasional; SNSG
Panicum columbianum Scribn. occasional; BCL
Panicum depauperatum Muhl. infrequent; PPSOB
Panicum dichotomiflorum Michx. infrequent; SNSG
Panicum dichotomum L. infrequent; AOPF
Panicum lanuginosum Elliott var. *implicatum* (Scribn.) Fern. occasional; BCL
Panicum lanuginosum Elliott var. *lindheimeri* (Nash) Fern. rare; COF—South Post
Panicum lanuginosum Elliot var. *tennesseense* (Ashe) Gleason occasional; AOPF
Panicum linearifolium Scribn. rare; BCL—Main Post
Panicum oligosanthes Schultes occasional; SNGS
Panicum philadelphicum Bernh. rare; SM—South Post
Panicum rigidulum Nees infrequent; INCLS
Panicum virgatum L. rare; RSGB—South Post
Paspalum setaceum Michx. var. *muhlenbergii* (Nash) D. Banks infrequent; ML
Phalaris arundinacea L. occasional; BCL
Phleum pratense L. occasional; BCL
Phragmites australis (Cav.) Trin. rare; PNHF—South Post
Poa alsodes A. Gray infrequent; SH
Poa annua L. infrequent; BCL
Poa compressa L. occasional; BCL
Poa palustris L. infrequent; FF
Poa pratensis L. common; BCL
Puccinellia fernaldii (A. Hitchc.) E. G. Voss rare; FF—South Post
Puccinellia pallida (Torr.) R. T. Clausen infrequent; SS

Schizachyrium scoparium (Michx.) Nash var. *scoparium* abundant; AOPF
Secale cereale L. rare; BCL—South Post
Setaria faberi R. Herrm. rare; LD—Main Post
Setaria glauca (L.) P. Beauv. infrequent; ML
Setaria viridis (L.) P. Beauv. infrequent; ML
Sporobolus vaginiflorus (Torr.) A. Wood infrequent; LD
Triticum aestivum L. rare; BCL—Main Post

PONTEDERIACEAE

Pontederia cordata L. occasional; DEM

POTAMOGETONACEAE

Potamogeton crispus L. rare; MS—Main Post
Potamogeton diversifolius Raf. infrequent; SEM
Potamogeton epihydrus Raf. infrequent; SEM
Potamogeton gramineus L. infrequent; EP
Potamogeton natans L. infrequent; SEM
Potamogeton pusillus L. rare; EP—Main Post
Potamogeton spirillus Tuckerman infrequent; MS
Potamogeton zosteriformis Fern. infrequent; OL

SMILACACEAE

Smilax herbacea L. infrequent; FF
Smilax rotundifolia L. infrequent; RMHS

SPARGANIACEAE

Sparganium americanum Nutt. infrequent; DEM
Sparganium chlorocarpum Rydb. infrequent; SEM
Sparganium eurycarpum Engelm. infrequent; SM
Sparganium minimum (Hartm.) Fr. rare; SEM—Main Post

TYPHACEAE

Typha latifolia L. occasional; SEM

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FRAGARIA MULTICIPITA, REDUCED TO THE RANK OF FORMA

PAUL M. CATLING, JACQUES CAYOUETTE, AND JOSEPH POSTMAN

ABSTRACT

The distinctive features of *Fragaria multicipita* Fernald, including small size, multicipital habit, floral aberrations and absence of runners to a greater or lesser degree, are symptoms of strawberry multiplier disease resulting from mycoplasma infection. Direct evidence of the disease in *F. multicipita* plants was obtained through graft inoculation using normal *F. chiloensis* which developed increasingly pronounced multiplier disease-like symptoms after three months. Plants referable to *F. multicipita* were not confined to specialized habitats. The chromosome number of $2n = 56$ obtained from five small multicipital plants representing four locations was the same as that widely reported for the *F. virginiana* complex in North America. These observations suggest that *F. multicipita* is only a diseased form of *F. virginiana,* despite the stability of its distinctive traits in cultivation and the potential adaptive nature of these traits on cool disturbed rivershores. Accordingly, the new combination, *Fragaria virginiana* Duch. ssp. *glauca* (S. Wats.) Staudt f. *multicipita* (Fern.) Catling & J. Cayouette, is proposed.

Key Words: *Fragaria multicipita, Fragaria virginiana,* strawberry, taxonomy, disease, mycoplasma, endemism, Québec, Canada

INTRODUCTION

Fragaria multicipita was described by Fernald in 1908 without any discussion of its origin and affinities. Plants referable to it were not found again until 1992 (Catling, 1993). Some of the characteristics of *F. multicipita* are suggestive of a subarctic or ice front relict. The cushion-like habit increasing temperature and resisting abrasion, parabolic flowers, and the genotypic dwarfing are features of plants of cold, exposed environments (Savile, 1972). The multiple crowns accumulate debris more readily than the more familiar fewer-crowned plants growing nearby (Catling, pers. obs.). These potential adaptations and occurrence in a specialized rivershore environment, as well as a suggestion of stability of distinctive traits in uniform garden culture, are consistent with species rank (Catling, 1993) and the concept of an ice front relict. Such speculations can become attractive and some botanists have conjectured (pers. comm.) that the small size and relict nature of *F. multicipita* make it a potential diploid or tetraploid progenitor of the North American octoploid *Fragaria virginiana* complex.

On the other hand Reed (1966) speculated that "*F. multicipita* may be virus-infected plants," and few authors have perpetuated the name (Catling, 1993). As noted previously, a decision on the appropriate rank required more study (Catling, 1993). Here we report on some recent studies including: (1) the nature of distinctive morphological traits, (2) the possibility of disease being a causal factor, (3) consideration of habitat aspects, and (4) chromosome numbers.

METHODS

Morphological Observations

Material of *Fragaria* from throughout the Gaspé peninsula was maintained in cultivation in the glass house in Ottawa over a two-year period. Included were 22 plants referable to *F. virginiana* Duch. ssp. *virginiana* with spreading hairs on the scapes and petioles, and 30 referable to *Fragaria virginiana* ssp. *glauca* (S. Wats.) Staudt (including *F. viginiana* var. *terrae-novae* (Rydb.) Fern. & Wieg.) with ascending hairs on scapes and petioles, and 10 plants referable to *F. multicipita* Fern., including some with spreading petiole hairs and some with ascending petiole hairs. These plants were grown in similar soil mix in similar pots and were subject to similar watering and light regimes. The extent to which distinctive features of the plants at the time of collection were maintained in cultivation was noted.

Evidence for Disease as a Causal Factor

The literature on strawberry diseases was surveyed to determine which diseases might produce a small-leaved, bushy strawberry lacking runners. Direct evidence of mycoplasma infection was sought through standard leaflet graft inoculation (Converse, 1987a). This technique involved cutting petioles of test plants into a "V" shape and inserting them into the cut petiole of an indicator plant established as appropriate through previous experimentation. Five normal *F. virginiana* plants including ssp. *glauca* (N2, N9, N15) with ascending hairs and ssp. *virginiana* (N8) with spreading hairs, and 3 multicipital plants (including one with spreading hairs (M15), and one with ascending hairs (M23)) were grafted to normal *F.*

chiloensis plants. Vouchers of material used in graft inoculation were placed in DAO and MT.

Habitat Aspects

Field work in August 1993 was directed to determining whether or not plants referable to *F. multicipita* were confined to specialized habitats, and the extent to which they occurred with other *Fragaria* taxa.

Chromosome Numbers

Young root tips of plants used for cytological study (Tables 1 and 2) were collected and pre-treated in water, refrigerated for three hours, fixed in Farmer's fixative (glacial acetic acid:absolute

Table 1. Locations, DAO voucher number, plant appearance, collection number, petiole hair orientation and root tip chromosome determination for various strawberry plants collected along the Rivière Ste.-Anne in Gaspé, Québec, that were used in the study.

Location	Voucher no.	Appearance	Coll. no./petiole orientation	2*n* =
1. 49°02′55″/66°28′50″ gravel bar on W side of Rivière Ste.-Anne 9 km SSE of Ste.-Anne-des-Monts	682393	multicipital	M11/ascending	ca. 56
	682394	multicipital	M10/ascending	56
	686462	normal	N2/spreading	56
	686451	normal	N10/ascending	56
	none	normal	N8/spreading	none
2. 49°00′50″/66°28′15″ gravel bar on W side of Rivière Ste.-Anne 13 km SSE of Ste.-Anne-des-Monts	686473, 74, 77, 92	multicipital	M15/ascending	56
	686461	normal	N15/ascending	ca. 56
3. 48°55′20″/66°06′30″ gravel roadside on W side of hwy 299 at Chute du Diable, Rivière Ste.-Anne	686472, 78, 91	multicipital	M9/ascending	56
	686449	normal	N9/ascending	ca. 56
4. 49°05′40″/66°30′20″ gravel bar on W side of Rivière Ste.-Anne 4 km SSE of Ste.-Anne-des-Monts	686475	multicipital	M24/ascending	56
	686450	normal	N1/ascending	56
	none	multicipital	M23/spreading	none

Table 2. Additional notes on particular voucher specimens prepared from cultivated plants.

686475. Plants with few runners less than 10 cm long developed over 50 crowns as did the daughter plants from short runners, but leaflets remained less than 20 mm long and petioles less than 7 cm long after two years in culture.

686472, 686478, 686491. After culture for one year, developed over 100 crowns but retained small leaflets less than 28 mm long, and short petioles less than 10 cm long. Inner floral parts of many, but not all flowers, developed into new plants and petals in some cases were green, reduced and ascending.

686473, 686474, 686477, 686492. After two years in cultivation, developed into a "bush" with over 150 crowns, but never developed runners and retained its small leaflets less than 32 mm long and short petioles less than 12 cm long.

682393. After two years in cultivation, developed into a "bush" with over 150 crowns, but never developed runners and retained its small leaflets less than 27 mm long and short petioles less than 7 cm long. The petals of many flowers were greenish and ascending, but white, spreading petals were produced on the same plant.

682394. After two years in cultivation, developed numerous fragile runners to 20 cm long but retained its small leaflets less than 20 mm and short petioles less than 7 cm long. The petals of many flowers were greenish and ascending but white, spreading petals were produced on the same plant.

686449–51, 686461–2. These plants, referable to *F. virginiana* ssp. *glauca* (S. Wats.) Staudt, had leaflets 30–80 mm long, petioles 10–20 cm long, less than 5 crowns and stout runners 20–72 cm long. There were no floral anomalies.

ethanol, 1:3) for 12 hours and stored in 70% ethanol. Staining was done in alchoholic hydrochloric acid-carmine (Snow, 1963). Chromosome counts were made on the best cells in late prophase or early metaphase. At least two cells from each collection were examined. Voucher herbarium specimens for both morphological observations and chromosome counts were placed in DAO and MT.

RESULTS AND DISCUSSION

Morphological Observations

Small multicipital plants with petioles less than 12 cm and leaflets 5–32 mm, referable to *F. multicipita* when collected, retained their small size and multicipital habit for two years in cultivation, although some developed into dense clumps with over 200 ramets. The adjacent few-crowned plants referable to *F. virginiana* Duch. ssp. *virginiana* with spreading hairs on the scapes and petioles or *Fragaria virginiana* ssp. *glauca* (S. Wats.) Staudt with ascending hairs on scapes and petioles, also retained their larger size, with petioles 10–20 cm and leaflets mostly 30–80 mm long, over the two year period (see also Table 2). It was noted previously that the stability of distinctive traits of *F. multicipita* in culture was consistent with its recognition (Catling, 1993). As might be expected, 10 multicipital plants marked in 1992 had also retained their distinctive features in nature one year later.

Multicipital plants always had relatively short leaflets less than 32 mm long and petioles less than 15 cm, but they ranged from no runner production, to some that produced few runners less than 10 cm long, to some that produced runners to 25 cm long. Only the larger multicipital plants produced runners but not all of them did so.

No additional distinctive morphological features were found to be associated with the *F. multicipita* plants, with the exception that the majority of plants from three localities, which were not flowering when collected, developed aberrant flowers with either petals green, reduced in size, more or less connate and ascending, or petals normal but inner floral parts developing into new plants. No such aberrations were present elsewhere in the glasshouse collection, nor were they observed in nature. Indeed such aberrations are rare, so to find them in approximately half of the *F. multicipita* plants, from three out of six known, suggested that the plants were diseased.

Variation in hair type on petioles of *F. multicipita* plants suggests these plants may not belong to a monophyletic taxon. Ascending hairs on petioles ally *F. multicipita* to *F. virginiana* ssp. *glauca,* but at two of the six localities the small, multicipital plants had spreading hairs, thus allying them to ssp. *virginiana.* Such pubescence characteristics in *Fragaria* are stable in cultivation and mostly consistent within plants and mostly not intergrading. Although a species may have geographically based infrataxa distinguished by pubescence orientation, as in *F. virginiana* or *F. chiloensis,* the appearance of both kinds of pubescence within a putative, narrowly confined endemic was a surprise.

Disease as a Causal Factor

In strawberries, small size, multicipital habit, and absence of runners to a greater or lesser degree, are well documented symptoms of multiplier and witches'-broom diseases which are associated with mycoplasma infection (viz. Boone, 1970; Converse, 1987b; Mass, 1984). Thus the distinctive morphology of *F. multicipita* may be simply a consequence of disease. The floral aberrations, noted above as the only other distinctive traits of plants referable to *F. multicipita,* are a result of green petal disease caused by a leafhopper-borne mycoplasma (viz. Chiykowski and Craig, 1975; Cousin et al., 1970; Mass, 1984).

The plants referable to *F. multicipita* were also the most difficult to maintain in cultivation. Approximately half died over the two year period, whereas the loss of plants referable to either ssp. of *F. virginiana* was less than 1%.

Normal *F. chiloensis* plants with grafted leaves from multicipital plants developed symptoms of multiplier disease three months after inoculation. These symptoms included reduced leaf size, shorter runners and proliferation of the crown. The symptoms became increasingly conspicuous in the new growth with increased time after three months. The normal *F. chiloensis* with grafted leaves from normal plants of *F. virginiana* ssp. *virginiana* or ssp. *glauca* collected near muticipital plants produced no disease symptoms. The fact that the multicipital and related characteristics could be transmitted from multicipital plants to normal plants suggests very strongly that *F. multicipita* is a pathogen-induced taxon.

Habitat Aspects

Additional field study revealed occurrence of plants referable to *F. multicipita* on a gravel roadside (Table 1), where no other endemic, disjunct, or unusual plants were present. At each site where *F. multicipita* occurred (Table 1), plants referable to *F. virginiana* ssp. *virginiana* and/or *F. virginiana* ssp. *glauca* were also present. Plants referable to *F. multicipita* could not be found in specialized alpine, subalpine or serpentine habitats. The river bars do represent a specialized habitat, but are also occupied by "weedy" species (Catling, 1993). The distinctive features of *F. multicipita* (or the traits of the diseased plants), i.e. small size and bushy form (see above) may adapt them to the cool rivershore environment where wind and water are important factors, thus explaining their increased prevalence along the rivershores. Alternative, but not mutually exclusive, explanations include the possibility that the rivershore habitat is more conducive to the spread of the disease and/or that plants in this habitat are more susceptible.

Chromosome Numbers

The octoploid chromosome number of $2n = 56$ obtained from five multicipital plants representing four locations (Table 1) is the same as that widely reported for the *F. virginiana* complex in North America (Staudt, 1962; Reed, 1966). Plants referable to *F. virginiana* ssp. *virginiana* or *F. virginiana* ssp. *glauca* that were growing intermixed or within one metre of the *F. multicipita* plants also had a chromosome number of $2n = 56$ (Tables 1 and 2).

CONCLUSIONS

Accepting the distinctive morphology of *F. multicipita* as simply a consequence of disease seems to be the most appropriate decision since: (1) the relationship between diagnostic traits and disease is well documented, (2) other characteristics of the taxon such as the difficulty of culture and the high incidence of floral aberration are also associated with disease, (3) there are no distinctive morphological traits that are not associated with disease, (4) multicipital and related characteristics were transmitted from multicipital plants to normal plants, (5) plants referable to *F. multicipita* are not confined to specialized habitats and their prevalence along cool rivershores may be explained in terms of the adaptive nature of traits of diseased plants, (6) the plants referable to *F. multicipita* always occurred with plants referable to *F. virginiana,* (7) its chromosome number is the same as that of the widespread octoploid *F. virginiana,* despite remarkable differences in plant size which result in the expectation of a lower chromosome number. Consequently we propose the new combination:

Fragaria virginiana Duch. ssp. **glauca** (S. Wats.) Staudt f. **multicipita** (Fern.) Catling & J. Cayouette, *stat. et comb. nov.* BASIONYM: *Fragaria multicipita* Fernald, Rhodora 10: 49–50. 1908. Type: QUEBEC: Gaspé Ouest Municipality: Cap Chat Township: gravelly and sandy beaches and bars of the River Ste. Anne-des-Monts, 14–17 July 1906, *M. L. Fernald* and *J. F. Collins 230* (Holotype: GH!; Isotype: GH!).

From examination of the holotype of *Fragaria multicipita* (GH), as well as reference to Fernald's original description, where petioles are described as "appressed silky," it is clear that *Fragaria multicipita* has to be included within the ssp. *glauca* when transferred to *F. virginiana.* This leaves the small, multicipital plants with spreading hairs without a name. We propose not to provide a name for these since it is conceiveable that any species of *Fragaria* could assume this morphology with infection by certain mycoplasmas. The advantage in retaining a rank for the name *multicipita* is that it enables the classification system to account for the unusual morphology, which would otherwise continue to raise questions not readily answerable by a systematist. A similar situation exists within the eastern North American *Trillium grandiflorum* (Michx.) Salisb., where the plants with green striped petals, which are sometimes considered as a consequence of mycoplasma infection (e.g., Chinnappa, 1982; Hooper et al., 1971; Pringle, 1970), are accorded the rank of *forma,* thus providing a name and some associated information on an aberration that is frequently an object of questions.

The status of *F. multicipita* does not upset the concept of the Gulf of St. Lawrence region as a region of endemism since there are numerous other endemics known from the region (Catling, 1993; Catling & Cayouette, 1994). Whereas there are other taxa described by Fernald that were later found to be diseased plants or freaks, such as *Carex elachycarpa* Fern. and *C. josselynii* (Fern.) Mackenzie (Reznicek & Ball, 1979), the fact remains that many of the taxa he described have been found, through recent detailed study, to be worthy of recognition as hybrids (e.g. *Juncus* × *oronensis* Fern., *Eleocharis* × *macounii* Fern.) or at, below or even above the ranks he ascribed to them (e.g. *Malaxis bayardii* Fern., *Cleistes bifaria* Fern.). Thus in the broad context, the fate of *F. multicipita* does not reduce the significance of Fernaldian taxa.

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STATUS OF THE DEERBERRY, *VACCINIUM STAMINEUM* L. (ERICACEAE), IN CANADA*

BRUCE A. FORD

ABSTRACT

Vaccinium stamineum L. (deerberry) is a widespread species in the United States that reaches its northern limit in the Niagara Falls and Thousand Islands area of southern Ontario, Canada. Only five stations occur in Ontario, with the most extensive populations being found within St. Lawrence Islands National Park. Dry, open, rocky woods, with a history of fire, are the preferred habitat for this species in Canada. Whereas the largest stations are currently under government protection, their proximity to existing trails, a lack of seedling recruitment, and encroachment by later successional vegetation suggests that this species could become extirpated if the factors affecting its vulnerability are not reversed. For these reasons *V. stamineum* is recognized as a threatened species in Canada.

Key Words: *Vaccinium stamineum,* Canada, conservation status, threatened species

INTRODUCTION

Vaccinium stamineum L. is one of the most distinctive blueberry species found in North America. A suite of unique features, including a deeply 5-lobed, campanulate corolla and exsert stamens, distinguish this plant from all other *Vaccinium* L. spp. and have resulted in its placement in the monotypic section *Polycodium* (Raf.) Rehder. This section has no apparent affinity to Neotropical, Old World tropical or North American members of the genus (Vander Kloet, 1988).

The deerberry is a highly polymorphic species that exhibits considerable variation in the hairiness of the pedicels, hypanthium, fruit, twig glandularity, the number of flowers per inflorescence, heterophylly, plant glaucescence, and fruit color. As a result of this variability, there has been considerable debate as to the number of taxa that should be recognized. For example, Ash (1931) divided *Polycodium* into 6 sections and 21 species. On the

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* Based on a COSEWIC status report by the author. Copies of the report are available at cost from the Canadian Nature Federation, 1 Nicholas St., Ottawa, Ontario K1N 7B7. Threatened status was assigned by COSEWIC on April 14, 1994.

other hand, Camp (1945) considered this taxon little more than a series of clines. In more modern taxonomic works, Baker (1970) maintained a single species with one additional variety (*V. stamineum* var. *sericeum* (Mohr) Ward). Ward (1974) recognized five varieties of *V. stamineum* in Florida, but conceded that when outside populations are examined, a large number of individuals are difficult to place. Finally, Vander Kloet (1988), in his monograph on the genus *Vaccinium* in North America, recognized only one species with no infraspecific taxa. I am following Vander Kloet's circumscription of *V. stamineum* for this paper.

DISTRIBUTION

Vaccinium stamineum is endemic to eastern North America where it is found from southern Ontario south to central Florida (Figure 1). This species occurs westward to eastern Texas, eastern Oklahoma, and southeastern Kansas. It appears to be absent from northern Missouri, Illinois, and northern Indiana. A few outlying populations occur in central Mexico (Figure 1). In Canada, *V. stamineum* is known from five extant stations in Ontario (Figure 1). Three stations are found in the Thousand Islands area, Leeds County; the other two occur near Niagara Falls, in the Regional Municipality of Niagara. By far the largest populations are found in the Thousand Islands (Table 1). An additional station occurs in the Thousand Islands on Wellesley Island, Jefferson County, New York, only a few kilometers from the Ontario populations (Crowder, 1982a).

The occurrence of *V. stamineum* in Canada has been known for almost 200 years. Deerberry was first collected in the Niagara region in 1798 (*Masson 15436* CAN) and in the Thousand Islands in 1876 (*Macoun 15437* CAN). Other early collections were made in 1896 at Queenston Heights (*Scott 14400* CAN), in 1891 in Stamford (now part of the city of Niagara Falls) (*Macoun 15438* CAN) and Niagara-on-the-Lake (*Dearness 1351* DAO), and in 1937 in St. David's (*Simmons s.n.* TRT).

HABITAT

In Ontario, *V. stamineum* occurs most frequently in dry, rocky woods with a canopy closure of approximately 40%. Plants are not usually found in open sites or in areas with deep shade. When

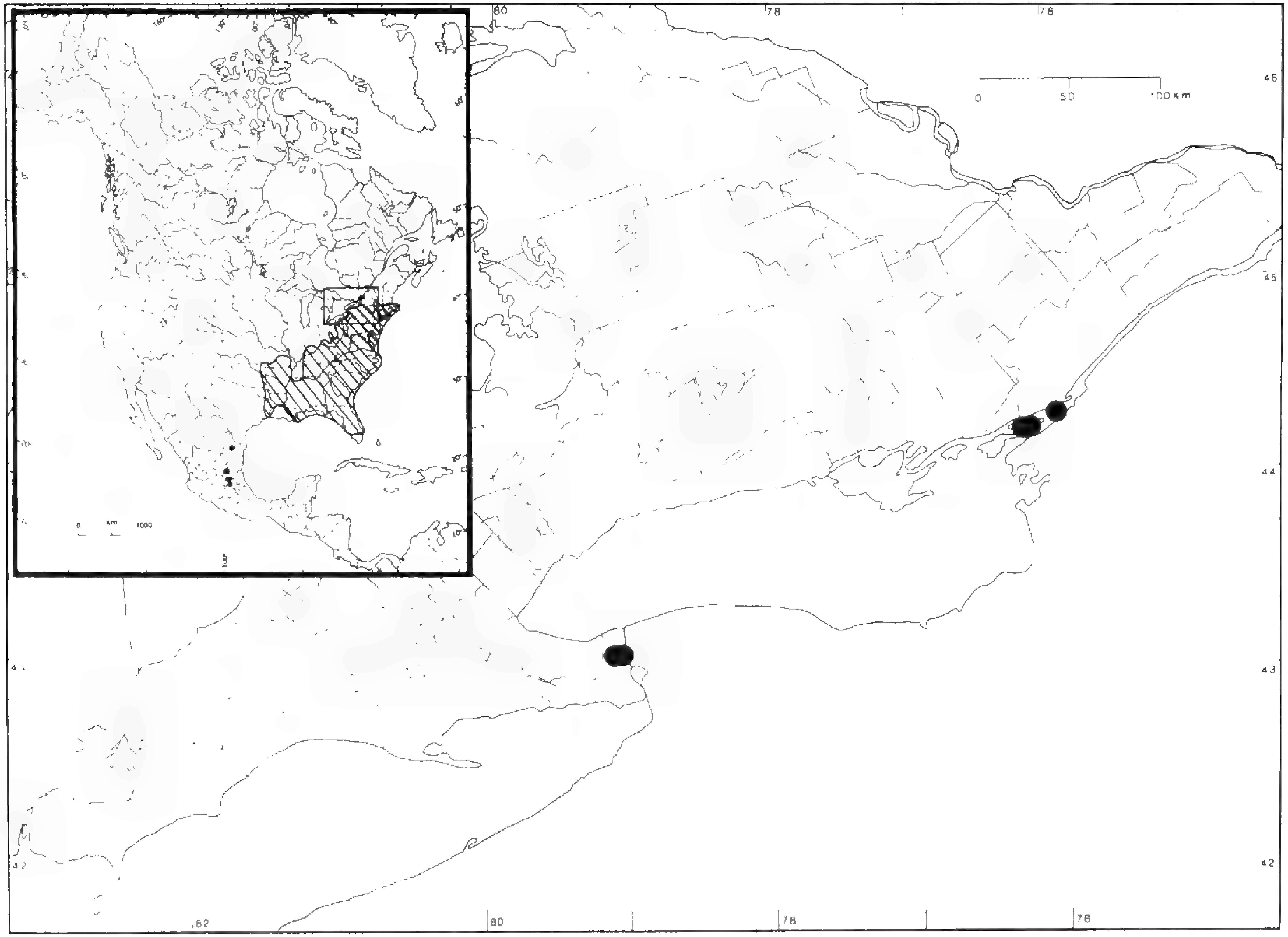

Figure 1. Distribution of *Vaccinium stamineum* in North America and Ontario. North American map after Vander Kloet (1988). Rectangle on North American map indicates location of detail.

Table 1. Site locations, representative specimens, and clump sizes for extant populations of *Vaccinium stamineum* in Ontario. The term clump is defined as a discrete group of stems. A clump may or may not represent more than one individual. Clump numbers and sizes for Leeds County populations are those documented in an unpublished study by St. Lawrence Islands National Park.

Location	Clump #	Clump Size (m)
Regional Municipality of Niagara, City of Niagara Falls, Whirlpool. Representative specimens: *Eckel 8604088* (BUF); *Scott s.n.* (DAO, TRT)	1.	<1.0 × 1.0
Regional Municipality of Niagara, City of Niagara Falls, Bruce Trail near Mewburn Road. Representative specimen: *Hardy & DeBus s.n.* (BUF).	1.	<1.0 × 1.0
Leeds County, Front of Escott Twp., West end of Grenadier Island, St. Lawrence Islands National Park. Representative specimens: *Cody & Munro 21779* (DAO, TRT); *Cody & Munro 22740* (DAO); *Munro s.n.* (DAO); *Dore et al. 25122* (DAO); *Woods & Woods s.n.* (CAN).	1.	1.6 × 1.6
	2.	1.2 × 1.2
	3.	1.0 × 0.6
	4.	2.4 × 2.5
	5.	1.4 × 1.4
	6.	1.4 × 1.5
	7a.	1.6 × 3.8
	7b.	3.2 × 3.0
	8.	1.0 × 1.0
	9.	1.0 × 1.0
	10.	1.9 × 2.2
Leeds County, Front of Leeds and Landsdowne Twp., Endymion Island, St. Lawrence Islands National Park. Representative specimens: *Ford s.n.* (TRTE) (2 sheets). (see Ford (1984) for further details on this population)	1.	3.5 × 3.5
	2.	3.0 × 3.5
Leeds County, Front of Leeds and Landsdowne Twp., Deathdealer Island. Representative specimen: *Chamberlin s.n.* (CAN).	1.	1.8 × 2.5
	2.	3.0 × 2.3

they do occur in these extreme conditions, plants often appear sickly with chlorotic and/or wilted leaves. In the Thousand Islands, populations are associated with a variety of tree and shrub species such as: *Amelanchier* Medic. sp., *Carya ovata* (Mill.) K. Koch, *Pinus rigida* Mill., *P. strobus* L., *Prunus serotina* Ehrh., *Quercus alba* L., *Q. rubra* L., *Lonicera dioica* L., *Rubus strigosus* Michx., *Vaccinium angustifolium* Ait., *V. pallidum* Ait., and *Viburnum rafinesquianum* Schultes. In many instances these species appear to be encroaching upon *V. stamineum.* The Niagara Falls populations are associated with *Quercus* L., *Fraxinus* L., and *Crataegus* L. spp.

A number of provincially rare plants occur near stations of *V. stamineum* in the Thousand Islands (Argus et al., 1982–1987). On Endymion Island, *Pinus rigida* Mill., *Vulpia octoflora* (Walt.) Rydb., and *Solidago arguta* Ait. are known to occur (Geomatics International Inc., 1992). *Pinus rigida, Solidago arguta,* and *Solidago puberula* Nutt. have been recorded from Grenadier Island (Geomatics International Inc., 1992).

Populations grow on both granite-gneiss and limestone substrates; the former in the Thousand Islands area, the latter in the Niagara region. Soils are usually sandy with a low organic content. In the Thousand Islands, soils are acidic with a pH of 3.4–5.9 with low levels of exchangeable cations such as calcium and magnesium. Organic carbon and soil moisture are also low. Leaf litter is present to a depth of 13 cm and soil depths range from 0–61 cm (Crowder, 1982a, 1982b). Plants are found on both steep slopes (to ca. 45° and usually south-facing) and on flat ground, with all sites being well drained (Crowder, 1982a, 1982b; Ford, unpubl. data). The soil characteristics of the Niagara population are unknown. In the United States, deerberry grows in similar soil conditions but is also known to frequent moist thickets, low woods, and hammocks (Crowder, 1982a; Ward, 1974).

Vaccinium stamineum is a species often associated with burnt sites (Crowder, 1982a, 1982b). This is certainly the case in the Thousand Islands area where deerberry is associated with a number of fire-tolerant species such as *Pinus rigida* and *Vaccinium angustifolium.* The fire history of the Niagara stations is unknown.

GENERAL BIOLOGY

In Canada, most plants flower between the end of May and the end of June. Flowers are protandrous, the pollen being ready for dispersal a day or two before the stigma becomes receptive. In *V. stamineum,* the pendant nature of the flowers causes the pollen to be shed downwards, making autogamy unlikely. Fruit set requires floral visitation by insects, such as bees, that collect pollen by sonication of the anthers ("buzz-pollination") (Cane et al., 1985). Over 30 species of bees have been recorded visiting deerberry; however, most are either infrequent visitors or are nectar-seeking and thus insignificant pollen vectors (Cane et al., 1985). One species, *Melitta americana* Smith (Melittidae), however, has been found to be abundant on flowering deerberry bushes in central New York and may be the primary pollinator of deerberry throughout its range. Cane et al. (1985) observed female *M. americana* sonicating deerberry anthers while taking in nectar and carrying pure deerberry pollen loads, unlike another common visitor *Xylocopa virginica* (L.) (Anthophoridae). Crowder (1982b) found "adequate numbers of pollinators" at the Grenadier Island station but it is not known whether *M. americana* was the primary pollen vector at this site.

Vegetative reproduction is well developed in blueberries with many species producing rhizomes. When disturbed, these rhizomes often sucker producing either clumps or colonies (Baker, 1970). Later, the tissues connected with the parent plant break down leaving the branch as an established younger plant (Baker, 1970; Crowder, 1982a).

POPULATION SIZE AND TRENDS

Like other blueberries, *V. stamineum* is known to spread vegetatively making it difficult to determine how many individuals make up a population. Most populations are characterized by discrete clumps (Table 1). The greatest size and number of clumps are found on Grenadier and Endymion Islands, Leeds County (Table 1). Clumps at these sites may have arisen through the fragmentation of a single individual or may represent different genotypes.

Most deerberry stations in Canada occur next to well-used trails and there is evidence that trail use is having a negative impact on some populations. For example, the Mewburn Road station occurs adjacent to the Bruce Trail and has been impacted by hikers as well as routine trail maintenance (Meyers, 1985, pers. comm.). Both the Grenadier and Endymion Island stations are found next to well-used paths. The fragmented nature of the deerberry populations on these islands may be the result of trampling.

Deerberry appears to produce abundant seeds in the Thousand Islands area, although seedlings are not produced (Crowder, 1982a). The frequent association of deerberry with known fire-tolerant species indicates that deerberry may require post-fire conditions to germinate. In the Thousand Islands area, conditions may have been more favorable for seed germination before the turn of the century when deforestation and fires were more frequent (Crowder, 1982b).

Climate may also be a factor affecting seedling growth. In a study of *V. angustifolium,* Vander Kloet (1976) discovered that seedling establishment is unlikely except under the following sequence of events: 1) a cool, wet spring; 2) a wet August and September; and 3) a mild winter or winter with good snow cover. This sequence of events had not occurred in eastern Ontario in 40 years. Similar climatic conditions may be required for seedling establishment in *V. stamineum.*

SPECIAL SIGNIFICANCE OF THE SPECIES

Only three members of the genus *Vaccinium* are used widely in the agricultural industry: *Vaccinium macrocarpon* Ait., *V. corymbosum* L., and *V. angustifolium. Vaccinium stamineum* is usually considered to be unpalatable, although certain shrubs can yield delicious fruit. In the southern Appalachians, deerberry is used for pies, jams, and jellies (Ballinger et al., 1981; Strausbaugh and Core, 1958; Stupka, 1964). Indeed, early authors state that deerberry has horticultural potential because of its large fruit, upland adaptation, and drought tolerance. The shrub is sometimes cultivated as an ornamental (Crowder, 1982a).

PROTECTION

Although it is considered a threatened species in Canada, deerberry has no legal protection (Ford, 1993). In the United States, deerberry is regarded as a "G5T5 species" by the Nature Conservancy which means that it is "abundant and demonstrably secure." The status in selected states is as follows: Illinois, SH (historical occurrence not having been verified since the turn of the century); Kansas, S1 (critically imperiled); Missouri, SX (apparently extirpated without expectation that it will be rediscovered) (Argus and Pryer, 1990). The status of deerberry in Mexico is unknown but it is locally common in pine forests and is perhaps under collected (Vander Kloet, pers. comm.).

EVALUATION OF STATUS

Vaccinium stamineum is found at five stations in Ontario. Populations in the Niagara Region are extremely small and threatened with imminent extirpation. In the Thousand Islands area, two key populations are found within St. Lawrence Islands National Park. Despite the protected status of this plant in the park, the proximity of populations to existing trails, lack of seedlings, and encroachment by later successional vegetation suggests that this species could decline if not actively managed.

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ALLELOPATHIC EFFECTS OF *LANTANA CAMARA* (VERBENACEAE) ON MORNING GLORY (*IPOMOEA TRICOLOR*)

CHRISTINA M. CASADO

ABSTRACT

Allelopathic effects of *Lantana camara* L. foliar leachates and dried leaf amendments on *Ipomoea tricolor* Cav. radicle growth, shoot emergence, and plant biomass were examined over a 50-day period. Aqueous leaf extracts of *L. camara* decreased radicle growth of *Ipomoea* but germination percentage was not inhibited. Dried leaf residue in soil growth media delayed shoot emergence from soil. Plant biomass after 50 days was not affected by the presence of *L. camara* soil amendments. Leaf extracts in petri dishes were more inhibitory than was dried leaf material in soil. These results indicate the presence of phytotoxic compounds in *L. camara*. Allelopathic effects of these compounds are significant during early germination of *Ipomoea*, while plants older than 2 weeks appear unaffected. In the soil environment allelopathic effects are minimal, possibly due to chemical binding, microbial action, or both.

Key Words: allelopathy, exotic weeds, germination, *Ipomoea, Lantana,* morning glory

INTRODUCTION

Lantana camara L. (Verbenaceae) is a shrub of West Indian or South American origin (Schemske, 1983) that is considered one of the world's worst weeds (Holm et al., 1971). It grows in moist open soil and flowers throughout the year. Proliferation in Australia and the United States has been facilitated by its introduction as an ornamental. Along the edges of Australian rainforests in Queensland, *L. camara* thickets persist for decades. I have observed these thickets encroach on native vegetation and restrict rainforest regeneration. In Florida, *L. camara* has been listed as a "Category I" exotic pest by the Florida Exotic Pest Plant Council since 1991. Category I designates those species invading or disrupting native plant communities in Florida. The list places *L. camara* among the state's most invasive plants including *Casuarina, Melaleuca,* and *Pueraria* (Exotic Pest Plant Council, 1992).

Although sensitive to frost, *L. camara* occurs throughout much of Florida (Figure 1), and is reported to be a problem in pastures and in nature preserves (Gregg, 1994). Eradication efforts by mowing, herbicides, and burning cost millions of dollars annually

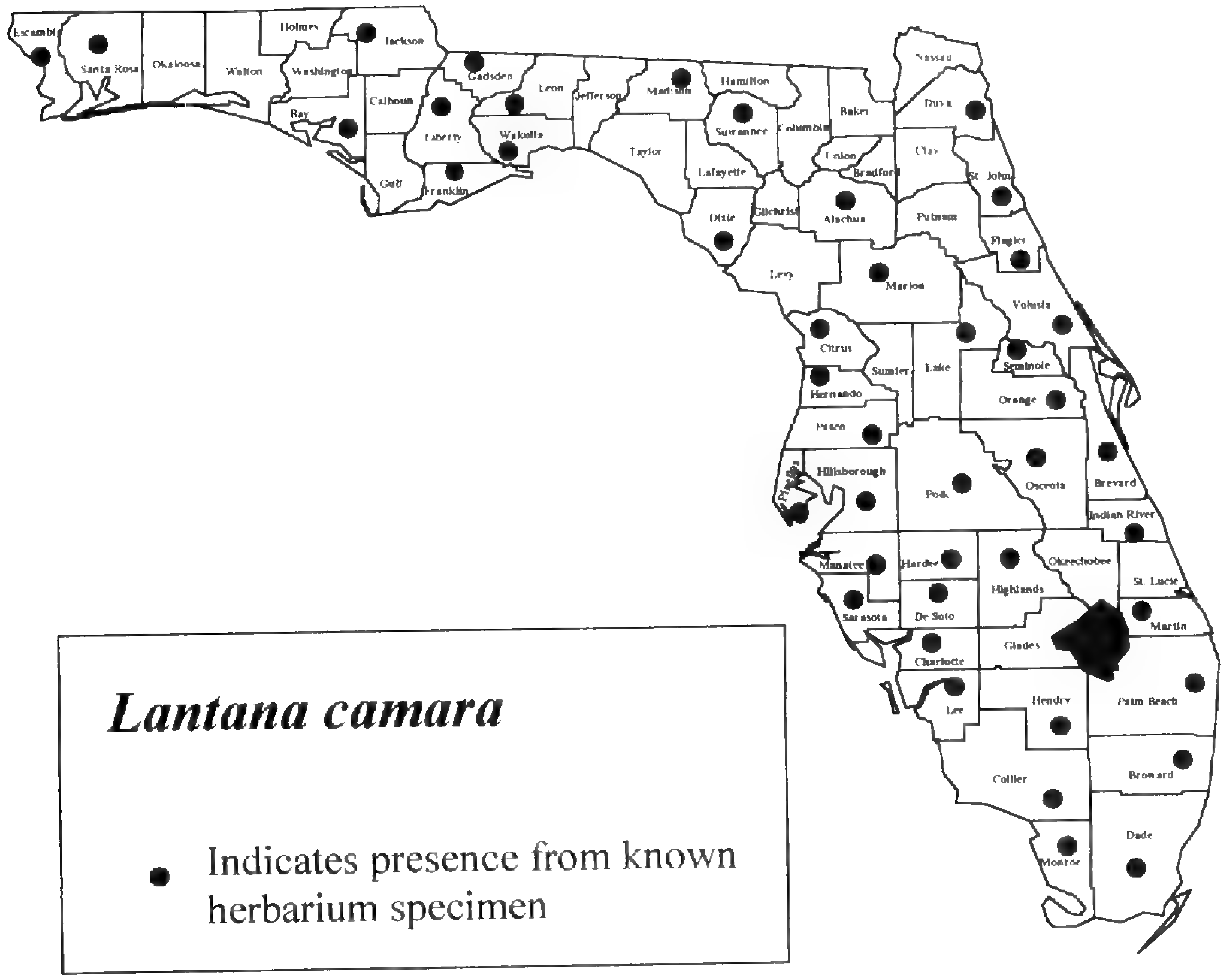

Figure 1. Distribution of *Lantana camara* in Florida counties (adapted from Wunderlin et al., 1995).

(Gregg, 1994). In citrus groves, *L. camara* has been observed to interfere with application of fertilizer, herbicides, and with harvesting (Achhireddy and Singh, 1984). The weed is toxic and potentially lethal to livestock and children (Mortan, 1971). Its tendency to develop pure stands in diverse environments (Achhireddy and Singh, 1984) has led workers to study the basis for the competitive success of *L. camara.*

Allelopathy, as defined by Rice (1984) is a harmful chemical effect by one species upon another. It is more specific than competition because it depends on the addition of a chemical compound to the environment by the inhibitory (allelopathic) species. *Lantana camara* has been shown to be allelopathic to Milkweed Vine (*Morrenia odorata*) in soil assays (Achhireddy and Singh, 1984) and to Duckweed (*Lemna spp.*) and Ryegrass (*Lolium*) in the laboratory (Jain et al., 1989; Singh et al., 1989). Thirteen allelopathic compounds have been identified in leaves of *L. camara* (Jain et al., 1989).

In this study on the extent of allelopathic effects of *L. camara,* I used Heavenly Blue morning glory (*Ipomoea tricolor* Cav.) as the test species. Genetically uniform seed lots of this cultivar are commercially available, and it is closely related to *I. purpurea* (L.) Roth. naturalized (introduced but non-intrusive) throughout Florida and much of the eastern seaboard of the United States. In Florida, *Ipomoea* occurs with *L. camara* in cypress-pine regrowth forests and in similar subclimax forest communities. However, it has not been observed using *L. camara* as a support, suggesting that *L. camara* might be inhibiting the growth of *Ipomoea* nearby. In this study, the presence of compounds in *L. camara* which might be allelopathic against *Ipomoea* was tested by germinating *Ipomoea* seeds in aqueous extracts of *L. camara,* and by growing seedlings of *Ipomoea* in potting soil to which dried leaves of *Lantana* had been added. A reduction of *Ipomoea* growth in *Lantana*-laced media (vs. the same media but without *Lantana* extract or dried leaves) would support the idea that allelochemicals are at least partly responsible for the ability of *Lantana* to grow as pure stands, free of *Ipomoea* and other naturalized and native species in Florida.

MATERIALS AND METHODS

Petri Dish Assays

Shoots of *L. camara* were collected in January 1994 from a disturbed site on 107 Ave, Homestead, Florida. Leaves were then air dried at 80°C. A 5% aqueous extract was made by steeping 5 g of *L. camara* leaves in 100 ml deionized water at 25°C overnight, then filtering the solution through Whatman No. 1 paper. The extract (designated as 5%) was diluted with deionized water to make 2.5% and 1.25% solutions using methods similar to those of Achhireddy and Singh (1989). The pH of all extracts ranged between 6.7 and 7.0.

Seeds of *Ipomoea tricolor* (Heavenly Blue morning glory) were purchased from Johnny's Selected Seeds in Albion, Maine, and rinsed overnight in running tap water. Those which had swollen and showed emerging radicles were then used in petri dish assays and in soil assays (below). Ten swollen seeds were placed in each petri dish. Dishes contained filter paper wetted with 10 ml of aqueous *L. camara* leaf extract at 5%, 2.5%, 1.25%, or 0% (water

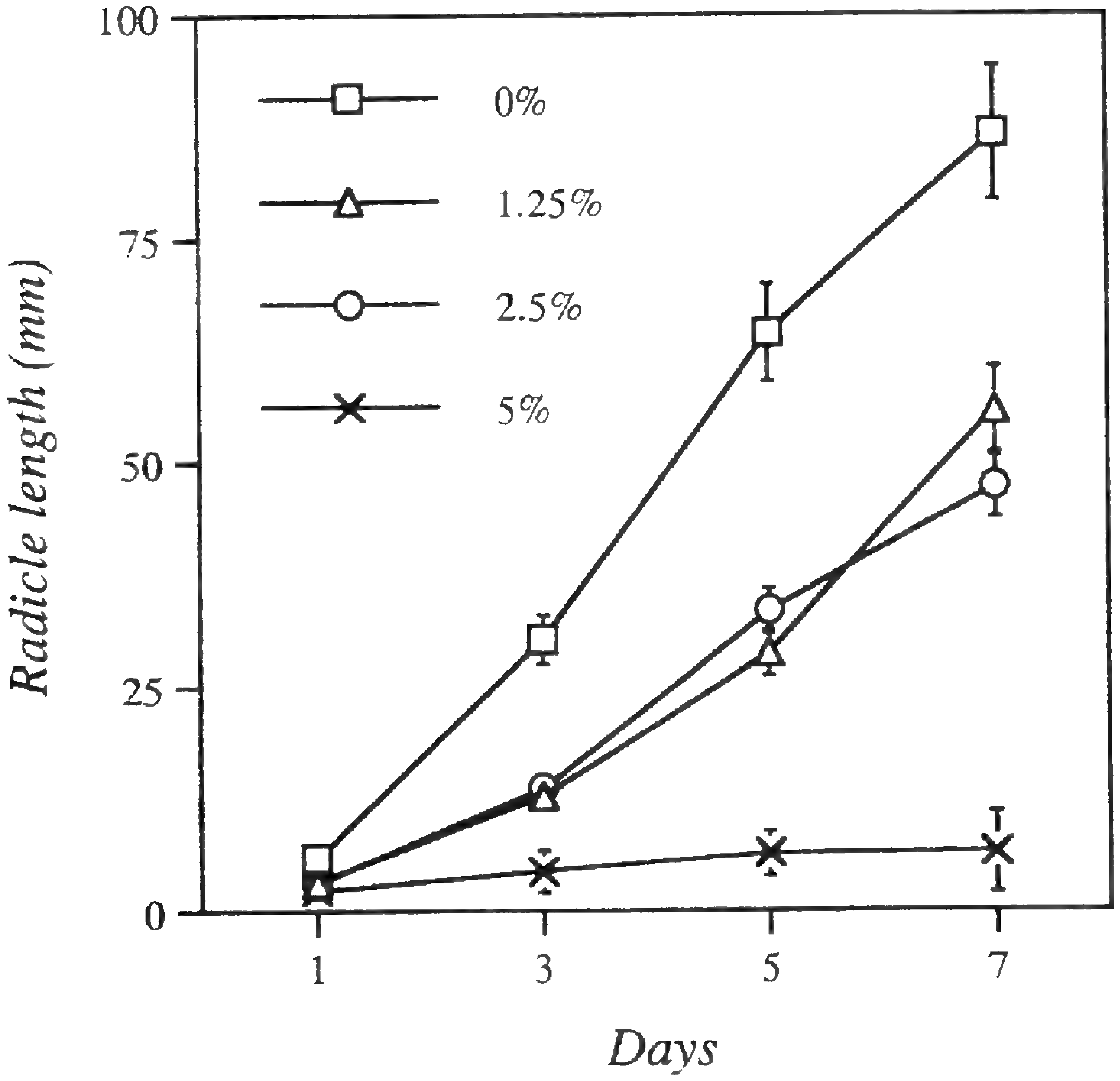

Figure 2. Length of *Ipomoea* radicles on seeds sprouting in aqueous *Lantana* extract (0–5%) over the course of one week. Each point represents the average of 30 radicles. In these petri dish assays, radicle growth was slowest in seeds soaked in the highest concentration (5%) of *Lantana* extract. Bars show ±1 SE; bars are absent when ±1 SE ≤ height of symbol.

control). They were kept at 25 ± 2°C under a 12h–12h light–dark cycle. Three replicate assays were performed, requiring a total of three petri dishes and thirty seeds for each of the four leaf extract preparations. Germination rate and percentages by seeds imbibing *Lantana* extract were examined using the methods of Liebl and Worsham (1983). Germination (root emergence), and radicle length were monitored over the course of seven days. Radicle lengths of seedlings in each concentration of *Lantana* extract were averaged (Figure 2).

Soil Assays

To expose *Ipomoea* seedlings to *Lantana* residue within a soil environment, five concentrations of leaf-amended soil were made. Each contained 300 g of sterilized commercial potting soil, then

12 g, 6 g, 3 g, 1.5 g, or 0 g (control) of dried and crushed *L. camara* leaves. Crushed leaf material was thoroughly mixed into the potting soil. The soils, now containing *Lantana* leaf residue, were watered and allowed to drain overnight before being planted with *Ipomoea* seeds. In each soil preparation, ten seeds (soaked in tap water, as above) were planted 2 cm deep and 2 cm apart. Three replicate assays were performed, requiring a total of three pots and thirty seeds for each amended soil preparation. Pots were kept in a greenhouse under 14h days with diurnal temperatures fluctuating between 10–30°C. Shoot emergence rate was monitored over 14 days (Figure 3). Seedlings were left to grow in the greenhouse, and total fresh biomass of root and of shoot systems was measured after seven weeks (Figure 4).

Analysis of variance (ANOVA) was used to test for significant differences between means, with a Scheffé posthoc multiple comparison test to determine whether means of the dependent variable differed significantly at *P* levels from 0.05 to 0.0001 (Data Desk 4.0, Data Description Inc. Ithaca, NY).

RESULTS

Petri Dish Assays

When exposed to *L. camara* extract, seeds of *Ipomoea* germinated at a rate similar to that of seeds in deionized water. Within 48 h of being placed on wetted filter paper, 90–100% of seeds germinated regardless of the concentration of *L. camara* extract used to wet the filter paper. After seven days, seedlings in all treatments showed distinct radicles. However, seedlings growing on paper soaked with 5% *L. camara* extract suffered up to 50% mortality apparently due to microbial activity fostered by nutrients in the extract. Seed putrifaction was common in 5% extract, but was never found in seeds soaked in water as a control. Only healthy seedlings with turgid white radicles were used in measuring radicle length. Thirty uncontaminated seedlings were measured from each treatment.

Once germinated, *Ipomoea* seedlings exposed to high concentrations of *L. camara* extract developed significantly ($P \leq 0.001$) shorter radicles than did control seedlings in deionized water (Figure 2). Though significant ($P \leq 0.01$) radicle inhibition occurred in seedlings growing in *L. camara* extract at 1.25% and at

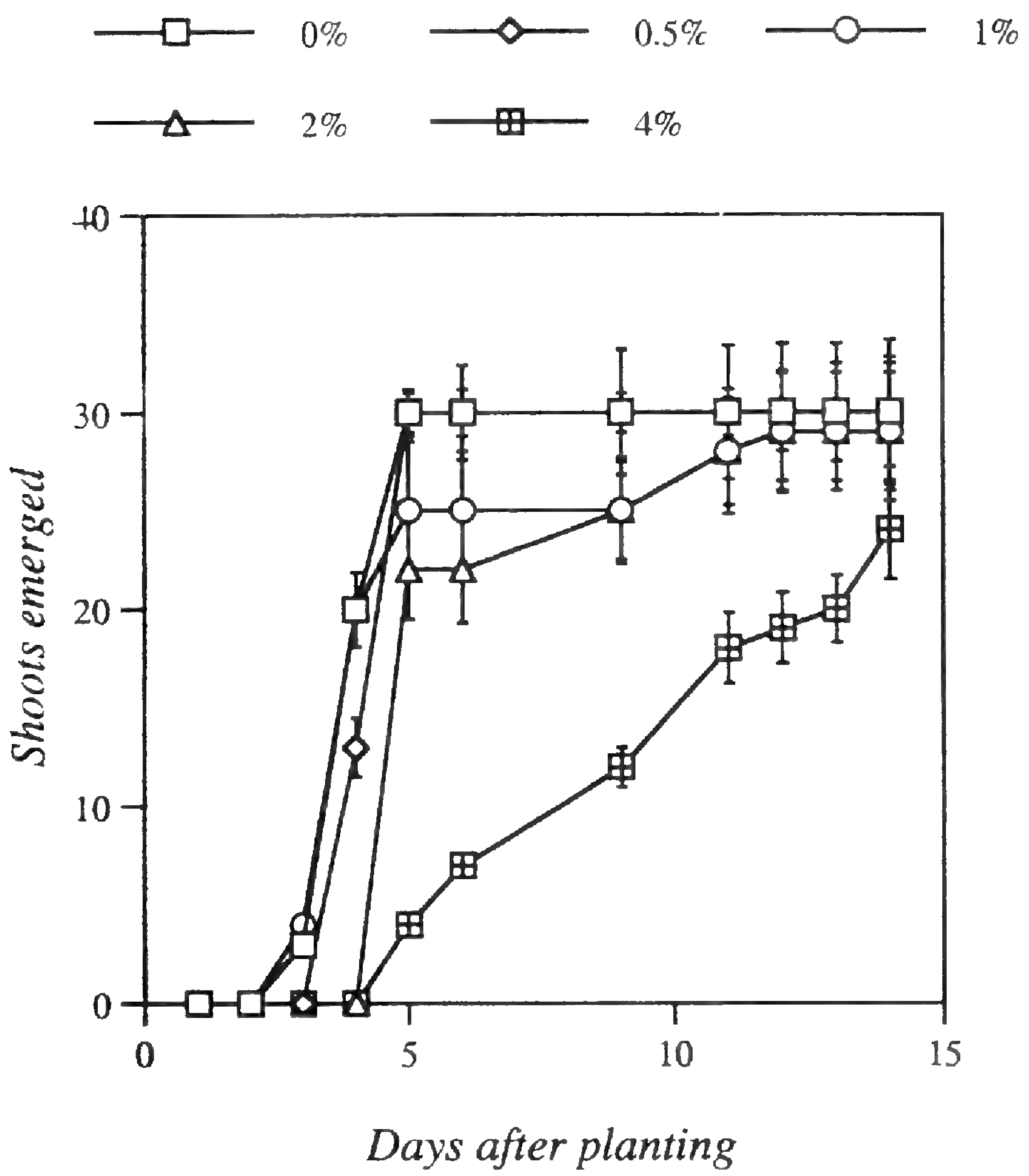

Figure 3. Rate of *Ipomoea* seedling emergence from soils laced with dried *Lantana* leaf material (0–4% by weight). Thirty seeds were planted in each of the five concentrations of *Lantana*-laced soil. Each point represents the average of 30 seedlings. A significant delay in seedling emergence occurred in *Ipomoea* growing in soil amended with 4% *Lantana* leaf material. Bars show ±1 SE; bars are absent when ±1 SE ≤ height of symbol.

2.5%, the most pronounced inhibition of seedling growth was caused by 5% extract. In that solution, radicles seldom reached more than a centimeter, while over the same amount of time, radicles of control seedlings in deionized water grew to ten times that length.

Soil Assays

The rate of *Ipomoea* shoot emergence from soil was slowed in the presence of *Lantana* leaf material (Figure 3). The most rapid

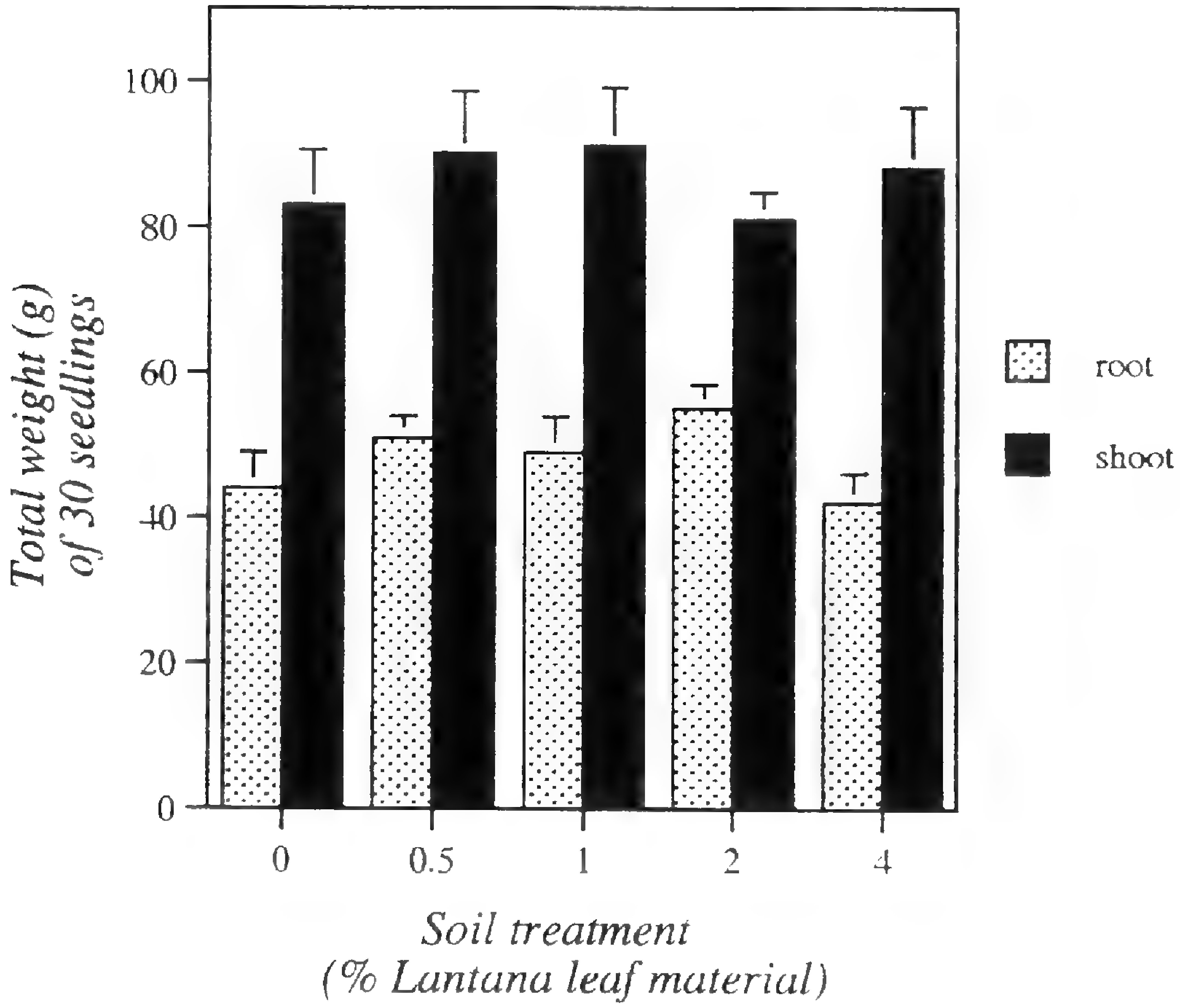

Figure 4. Total root and shoot biomass (fresh weight) of *Ipomoea* plants grown 50 days in soil laced with dried *Lantana* leaf material (0–4% by weight). Each bar represents the total fresh weight of roots or shoots from 30 plants. Error bars are +1 SE.

emergence was seen in control pots containing only potting soil, not amended with *Lantana*. In more than 90% of cases, cotyledons emerged from control soil within 4–5 days of being planted. In soil amended with dried *Lantana* leaves the rate of seedling emergence slowed with increasing concentrations of leaf material. Compared to control sets which had completely emerged after 4–5 days, seedlings in soil laced with 4% leaf material required significantly longer time ($P \leq 0.01$) to emerge, typically twice as long as did controls. Regardless of the time required for cotyledons to emerge, the appearance and subsequent development (leaf morphology, internode length, tendril activity) of *Ipomoea* seedlings was similar in amended and in control soils.

Two months after growing in the greenhouse, all 150 *Ipomoea* plants (10 plants for each of 5 *Lantana* leaf amendments to soil; 3 replicates) were removed from their pots, washed clean of soil particles, dabbed clear of water droplets and divided into root and shoot components. Total fresh weights of shoots and roots from three sets of plants (10/set) growing in each concentration of *L. camara* leaf amendment were determined (Figure 4). Within any given pot containing a set of ten plants, there was variation in plant size. Shoot systems weighed nearly twice as much as did root systems, and plants with smaller shoots had smaller root systems. There was no significant ($P \leq 0.05$) variation in shoot and root total fresh weight among sets of plants grown in the same or in different concentrations of *L. camara* leaf amendment. Plants in heavily contaminated soil (amended with 4% *L. camara* leaf material) grew as well as did control plants in uncontaminated soil. There was even a qualitative improvement in plants growing in soil laced with *L. camara.* After two months of growth, *Ipomoea* plants in soil containing 0% and 0.5% *Lantana* leaf material were yellowing, while those growing in heavily laced (4%) soil were still green.

DISCUSSION

The potentially allelopathic effect of *L. camara* against *I. tricolor* is expressed as a delay in early (underground) seedling growth, while post-emergence seedling and plant growth seem unaffected. In this study, I found growth of *I. tricolor* to be inhibited (delayed and reduced) by *L. camara* leaves, primarily when *Ipomoea* seeds were forced to imbibe aqueous extracts of *L. camara* in a petri dish (Figure 2). The effect of *Lantana* residue in soil appears to be less severe. After an initial delay in seedling emergence (Figure 3), *Ipomoea* plants growing in *Lantana*-laced soil show no ill effects, even after 50 days of growth (Figure 4). In fact, the greener appearance of plants in heavily laced soil is probably due to increased nutrients supplied by decaying *Lantana* leaf material, while plants growing in unamended potting soil develop nutrient deficiency symptoms such as chlorosis.

Results of this study differ from those reported by Achhireddy and Singh (1984). They used similar methodology to amend soil with dried leaves of *L. camara* and found that biomass of another vine, *Morrenia odorata* (Asclepiadaceae), was reduced by 33% when plants were grown in soil containing 4% *Lantana* leaf material. Growth inhibition was apparent after 30 days, whereas in the present study using *Ipomoea,* no biomass difference between control plants and those growing in *Lantana* laced soil appeared even after 50 days (Figure 4). Recent work by Inderjit and Dakshini (1994) suggests that leaf amendments in soils can change soil texture, and that test plants growing in amended soils could respond to textural as well as chemical changes caused by leaf amendments. The most significant inhibitory effects of *Lantana* material upon *Ipomoea* take place in the earliest phase of seedling growth. Radicle growth is delayed in germinating seeds confined to petri dishes (Figure 2) as is initial shoot emergence from soil (Figure 3). Under field conditions, delayed early growth can be fatal. Slow-growing seedlings are vulnerable to soil pathogens and herbivores, and require more time for roots to penetrate to soil levels with reliable moisture, several inches beneath the hot surface.

In situations where seeds are exposed to *Lantana* leachate in a confined environment, such as a petri dish, any inhibitory (allelopathic) compounds present in the growth medium will affect seedling growth. On the other hand, in open systems such as potted soil or disturbed sites populated by *Lantana* and *Ipomoea* in the field, potentially allelopathic material in *L. camara* may bind to organic molecules such as humic acid (Wang et al., 1971), soil colloids, or be broken down by bacteria or physical processes. This would decrease their potential to inhibit growth in the field (Rice, 1984). In a study of allelochemicals binding to organic matter in two Taiwanese agricultural soils (Wang et al., 1971) five phenolic acids, all of which are present in *L. camara* (Singh et al., 1989), were added to field soil. Between 60% to 80% of all added phenolics were bound to mudstone and latosol components of the soil. Ferulic acid, a phenolic in *L. camara* with strong inhibitory activity (Jain et al., 1989), was strongly bound by the soils, with the result that only 2–30% of applied ferulic acid remained free.

For *L. camara* to be functionally allelopathic against *Ipomoea* in the field, it must release inhibitors that are not inactivated by soil components. Strong inhibition occurs in petri dish assays (Figure 2) but *Lantana* material has less effect when delivered to seedlings in a soil medium. Inhibition is reduced (Figure 3) and dwindles to insignificant levels over the course of 50 days (Figure 4). It might still be possible for *Lantana* to allelopathically inhibit *Ipomoea* and other plants in the field but it would require constant replenishment of allelopathic compounds to soil through leaf drop or root exudates.

Given the remarkable success of *L. camara* as a pantropical weed and its wide distribution in Florida (Figure 1), the competitive strategies of this pest are worth exploring. Possible mechanisms leading to pure stands of *Lantana* include spatial and nutrient competition, coupled with the slight advantage of delay in germination of competing seedlings, as shown in this study with *Ipomoea.* Given the magnitude of damage and management costs caused by exotic pest plants (Gregg, 1994), understanding the means by which exotic weeds such as *L. camara* dominate local vegetation is needed to develop efficient and environmentally benign methods of exotic weed control (Heisey, 1996). That in turn will help sustain native flora in preserves, along with areas that have been repaired or restored (Kaufman and Franz, 1993).

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NEW ENGLAND NOTE

STUDIES ON NEW ENGLAND ALGAE II: A SECOND STATION IN MAINE FOR *NITELLA TENUISSIMA* (DESV.) KUETZING

L. C. COLT, JR.

Collections of algae from the shallow, rocky shores of Crawford Pond and the streams which drain into it in Union, Knox County, Maine have yielded some uncommon taxa. These and the area have been described previously (Colt, 1977, 1985, 1994a). This paper reports the second collection from Maine of *Nitella tenuissima* (Desv.) Kuetzing 48 years after it was reported by William Randolph Taylor in 1921.

On the south shore of the large central island in Crawford Pond are several large embayments characterized by waters mostly less than a meter in depth, and with very gently sloping subsurface cobble-like areas composed of small stones. Near the shore line the stones tend to be free of silt and debris as a result of small but constant waves formed by winds typically from the southwest. Silt accumulates as the water deepens away from the shoreline, becoming the primary substrate by filling the interstitial spaces between the stones and covering them. *Nitella* plants were collected from silt at a depth of approximately 10 cm in the easterly portion of the major embayment. The *Nitella* population was of low density, consisting of a few scattered clumps spread over 10–15 square meters.

Nitella tenuissima is one of the smaller charophytes (Wood and Imahori, 1965), and the plants have a minute, delicate appearance. The plants from Crawford Pond, collected on August 9, 1969, (partial upper portions) range from 2.2 to 3.1 centimeters in height, and have the distinctive beaded appearance which is one of the characteristics of this species. The "beads" are composed of repeated (3–4 times) furcations of branchlets at the nodes.

The morphological characteristics of the Maine plants fit the descriptions given by Prescott (1962) and Wood and Imahori (1965), and are summarized in Table 1. The collected plants (*L. Colt CP8969-1,-2,-3,-4,-5,-6,-7*) were not yet fully mature, judging by the morphology of the gametangia, yet fit within the range

Table 1. Species Data Summary, *Nitella tenuissima.*

	Wood & Imahori 1965	Prescott 1962	Colt
Axis, Diameter	160–500 μ	NR*	180 μ below 1st branchlets
Internodes	3/4–5 times as long as branchlets	NR	2–3 times as long as branchlets
Number of fertile branchlets	ca. 6 in whorl	6 in whorl	5–6 usual, occasionally 9–11
Branchlets, comparative appearance	upper usually more compact than lower	glomerules formed, compact	glomerules formed, upper branchlets more compact than lower
Furcation	2–4 times	3–4 times	3–4 times
Primary rays	single, 1/3–1/2 length of branchlet	NR	single, 1/3–1/2 length of branchlet
Secondary rays	5–7, 1 central	NR	5–7, 1 central
Tertiary rays	3–6	NR	5–6, 1 central
Quarternary rays	3–4, 1 may divide again	NR	3–4, see dactyls
Quinary rays	3–4	NR	none
Number of cells per dactyl	2-celled	2-celled	2-celled
Dactyl number	3–4	NR	3–4
Dactyl mucus	none	NR	none
Basal cell	cylindrical or tapering to base of end cell	NR	cylindrical, with slight taper to base of end cell
End cell	conical, acute, 42–105 μ long, 21–32 μ wide at base	NR	conical, acute, 62–107 μ long, 17–25 μ wide at base
Gametangia	monoecious, sejoined or conjoined at 2nd–3rd branchlet nodes	plant monoecious	monoecious, sejoined or conjoined at 2nd–3rd branchlet nodes
Oogonia color	light or reddish brown	NR	light brown
Oogonia number	solitary	NR	most often solitary, few paired
Oogonia size	270–550 μ long incl. coronula, 225–510 μ wide	400 μ long, 260 μ wide	320–340 μ long, including coronula, 240–329 μ wide
Coronula	10 cells in 2 tiers, 25–46 μ high, 40–58 μ wide at base	10 cells in 2 tiers	10 cells in 2 tiers, 9–45 μ high
Antheridia	90–175 μ in diameter, stipitate	175 μ in diameter, stipitate	106–195 μ in diameter, stipitate

* NR indicates that this information was not reported by Prescott (1962).

of measurements provided by both Wood and Imahori and Prescott.

On a worldwide basis, *Nitella tenuissima* is reported from Europe, North Africa, Madagascar, the Azores, India, Japan, and from North America where it is known to range from southern Canada to the West Indies (Wood and Imahori, 1965).

Wood and Imahori (1965) state that *Nitella tenuissima* is common throughout New England, although a search of the literature (Colt, 1994b) indicates that it has not often been collected or reported from the region. The species has been collected once in Maine from Echo Lake on Mt. Desert Island (Taylor, 1921) and once from Lake Chocorua in New Hampshire (Collins, in Wood and Imahori, 1965). More collections of *Nitella tenuissima* have been reported from Massachusetts than any other New England state. Faxon, Morong (as *Nitella gracilis* Smith, and as *Nitella tenussima, T. Morong 32, 37*), and Perkins are reported by Dame and Collins (1888) to have independently collected *Nitella tenuissima* from several ponds in Middlesex County, while Wood and Imahori (1965) report collections from Essex County by Collins (*Icon 308*) and by Robinson (as *Nitella transilis* Allen). Tindall and Sawa (1964) collected *Nitella tenuissima* in Morse Pond, Barnstable County, and Wood (in Wood and Imahori, 1965, *R. D. Wood 2015*) also collected it in Barnstable County. In Rhode Island Wood (*R. D. Wood 1081*), reports collecting this species from Larkins Pond in Washington County. It has also been collected by Faxon from Apponaug Pond and J. L. Bailey from Gorton Pond, both in Providence County, and by Wood and Palmatier from Newport County (Wood and Imahori, 1965). Robbins, and later Allen collected *Nitella tenuissima* in Rhode Island, but neither location is given by any of the authors (Halsted, 1878; Bennett, 1888; Wood and Imahori, 1965) listing the collections.

Whereas the Crawford Pond collection does not substantiate the comment by Wood that the plant is common throughout New England, it lends credence to the suggestion that *Nitella tenuissima* might be more widely distributed than has been reported heretofore. The more than 1600 articles known to report the collection of fresh water algae in New England (Colt, 1994b) suggest that such collections have tended to be primarily from scattered locations. Records of algal collections from Maine, New Hampshire, Vermont, Massachusetts and Rhode Island can only be described as geographically spotty and primarily a function of the interests and activities of collectors since the first published report of algae in New England by Hitchcock in 1829. The only systematic state-wide effort was in Connecticut, first by Conn (1905), Conn and Webster (1908), and then later by Hylander (1922a, 1922b, 1924, 1925, 1928). Neither Conn and Webster (1908) nor Hylander (1928) list any of the Characeae among the algae of Connecticut. Hylander notes the exclusion by suggesting that the Characeae belong in a separate group among the Thallophytes because of their "complicated and advanced types of reproductive structures." Furthermore, although *Nitella tenuissima* was occasionally assigned to *Nitella gracilis* or *Nitella transilis* by early workers (Wood and Imahori, 1965), neither of these species have been reported from Connecticut.

It is likely that because of the small size of *Nitella tenuissima* plants and its growth habit, "in silt with only the tips of the branches emergent," (Prescott, 1962), it would tend to escape notice by most collectors unless they were actively searching for it. Judging by the few plants at the site in Crawford Pond, *Nitella tenuissima* is probably relatively scarce even in suitable habitats. Then too, the Characeae have not enjoyed a great deal of attention among New England phycologists over the years, and many plants have, in all likelihood, been by-passed during searches for other algae.

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NEW ENGLAND NOTE

NEW BARNSTABLE COUNTY RECORDS

MARIO DIGREGORIO

During the field season in 1994, I documented two new records for Barnstable County along with one significant rediscovery:

Bidens laevis (L.) BSP. (Asteraceae)

Many hundreds of plants of *Bidens laevis* (L.) BSP. were found in the upper Mashpee River within the freshwater tidal zone just south of Route 28 in Mashpee, Massachusetts. Large or showy bur-marigold is a perennial characterized by 8–10 golden yellow ray flowers arranged around a flat disk, many measuring up to 3 cm long. The sharply serrate, sessile leaves are lanceolate and reach up to 15 cm. in length. In fruit the mature disk is 2–3 cm. broad and often nods; achenes are two to four-awned. Typical habitat for *B. laevis* is sluggish streams, either fresh or brackish, along the coastal plain of the eastern seaboard from Florida north to southern New Hampshire (Fernald, 1950; Gleason and Cronquist, 1991). Records have been documented for Plymouth County to the north and Bristol County to the west (Seymour, 1982). A check of the G. M. Gray Herbarium (SPWH) in Woods Hole and a literature search revealed no previous records documented for Barnstable County (Seymour, 1982; Svenson and Pyle, 1979).

Rumex pallidus Bigel. (Polygonaceae)

Six plants were discovered on August 26, 1994, in a barrier beach 'washover' area just east of Crosby Landing Beach in East Brewster, Massachusetts. Characterized by glaucous, narrowly lanceolate leaves, prostrate or depressed habit and whitish fruit arranged within a dense, spreading panicle, this taxon is typically found in the upper beach zone above normal high tide but within the stormtide washover area where beach profiles can change dramatically from season to season. Associated taxa include *Glaux maritima* L., *Lathyrus maritimus* (L.) Bigelow, *Xanthium strumarium* L., *Solidago sempervirens* L. and *Mertensia maritima* (L.) S. F. Gray (see next notation).

Pale or seabeach dock ranges from Newfoundland south to Nantucket (Fernald, 1950; Seymour, 1982); historically it was found as far south as Long Island (Seymour, 1982). Its present status in Massachusetts is classified as Threatened by the Massachusetts Natural Heritage and Endangered Species Program. This represents the first record ever for Barnstable County (P. Somers, MNHESP pers. comm.; Svenson and Pyle, 1979). A specimen was placed in the herbarium collection at the Garden in the Woods in Framingham; 35 mm. slides and an Element Occurrence form were filed with MNHESP.

Mertensia maritima (L.) S.F. Gray (Boraginaceae)

Due to its sporadic appearances and disappearances, seabeach lungwort or oysterplant has had a long history as a "phantom" or "fugitive" plant in Massachusetts (Bicknell, 1915; Svenson and Pyle, 1979). Cape Cod and Nantucket mark the southern limit of its range, which stretches north from Massachusetts to all the coastal counties of Maine (where it is fairly common) and to James Bay and Greenland (Fernald, 1950). It is classified as Endangered by the Massachusetts Natural Heritage and Endangered Species program.

From 1983 to 1988, Dr. Peter Dunwiddie of Nantucket noted the plant on the Coatue peninsula and Whale Island, a sandspit currently connected to Tuckernuck Island. These plants disappeared and no sign of the species was again noted until 1994, when Dr. Dunwiddie found 7 plants scattered along the eastern shore of the island (Dunwiddie, 1994, pers. comm.).

In Barnstable County, the plant was noted in the early 1970's in West Brewster by Don Schall but disappeared in 1974 (Schall, pers. comm.) and was not seen again on the Cape until 1992 when Kyle Jones of the Cape Cod National Seashore found populations in three lower Cape localities: 21 non-flowering plants on Jeremey Point in Wellfleet, one plant at Marconi Beach, and 104 non-flowering and three flowering plants at Race Point in Provincetown (Jones, pers. comm.; MNHESP data). It was seen again in 1993 and 1994, but by then all three populations were noted as being in 'severe decline' (Jones, pers. comm.).

The East Brewster population of twelve plants contained ten flowering and fruiting "rosettes"; two other non-flowering plants were depauperate and stressed due to their location in closer proximity to a heavily used bathing beach. The plant is quite distinctive, with sea-green, glaucous spatulate foliage which actually tastes of raw shellfish. The flowering branchlets radiate out from the central basal rosette in a spider-like configuration. As in most members of Boraginaceae, the small bluish-pink flowers are campanulate with fruits forming smooth, lustrous nutlets. The successful germination of their seeds amidst the "flotsam" of storm wrack detritus seems integral to the plant's habit of mysterious appearance and disappearance along the southern limit of its range. Vegetative reproduction from fragments may also occur but has not been documented (Dunwiddie, pers. comm.).

A follow up visit to the dramatically-changed winter beach in December 1994 revealed only one rosette partially buried in the overwash, all others having vanished out to sea or been buried deep beneath the newly deposited sand. By the late summer of 1995, the colony had diminished to five rosettes, with many desiccated flowering branches showing the stress of an unusually warm and dry growing season.

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BOOK REVIEW

Harris, James G. and Melinda W. Harris. 1994. *Plant Identification Terminology: An Illustrated Glossary.* 197 pp. Spring Lake Publishing, Spring Lake, UT. ($17.95).

Students of all ages find comfort in illustrations. Uncertainties about the meaning of technical terms often pose major impediments to correctly identifying a plant. Many plant enthusiasts resist graduation from the field guide stage to the technical manual because of a fear of terminology. Statements such as "There are at least 60 ways to say that a plant is not smooth," from the Peterson and McKenny Field Guide (1968) exacerbate the situation, not to mention do no service to botanical taxonomy. Even the thorough glossaries in most manuals don't seem to lessen the apprehensions of the neophyte. Merritt Lyndon Fernald's 8th Edition of Gray's Manual of Botany (1950) includes 1141 entries in the glossary (Peterson and McKenny, 1968). *Plant Identification Terminology* by James G. Harris and Melinda W. Harris is an illustrated glossary of terms used to identify plants that should help assuage such fears. In fact, at least one copy of *Plant Identification Terminology* aught to be in every classroom where floristics, plant taxonomy, or plant identification courses are taught.

Benjamin Daydon Jackson's comprehensive but difficult to use classic, *A Glossary of Botanic Terms,* was published in 1900. The fourth edition of 1928 has been reprinted and costs about twice the price of the Harris' book. Jackson's *Glossary* is hard to find and can usually be obtained only from dealers who handle more esoteric works in botany. *Plant Identification Terminology* will not replace Jackson's *Glossary* nor should it. It is, however, accessible, available, and reasonably priced. Its cost is not prohibitive, even for a student as a supplemental text for a plant identification course. Most importantly, it is copiously illustrated! That, alone, is worth the $17.95.

The book is divided into 2 parts, a general glossary (115 pages) and a section for specific terminology (67 pages) which is organized into 7 major categories (Roots, Stems, Leaves, Surfaces, Inflorescences, Flowers, and Fruits), some with further subdivisions (there are 10 subheadings under Flowers).

The most important feature of this book is its illustrations. Many of the definitions are supplemented with simple line drawings that more than suffice to make the point. Most of the illustrations are incorporated with the text in the general glossary. Some, however, are duplicated in the specialized terminology sections. These groups of illustrations comparing variations in leaf shape, inflorescence types, and fruits enhance the usefulness of the book.

Keys to help decide the term that best describes a condition such as leaf margin or inflorescence type are included in the Specific Terminology section. These are boxed in the text so that they clearly stand out. They will be especially useful to students who are familiarizing themselves with botanical terminology.

A very minor objection is that some illustrations used to define a term are used for more than one term. The same illustration occurs for climbing (figure 185), scandent (figures 927, 1363), and vine (figures 1253, 1324).

The proof of the versatility and value of *Plant Identification Terminology* will come when students use this book to aid them in identifying plants and the identification works. I am looking forward to trying this book with classes.

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RHODORA NEWS & NOTES

LISA A. STANDLEY

HIGHLIGHTS OF CLUB MEETINGS

May 1995 (909th Meeting). Dr. Walter Judd, of the University of Florida at Gainesville, spoke on "Angiosperm Temperate/Tropical Family Pairs." His research, based on cladistic analyses of representative genera and using conventional morphological characters, has tested the hypothesis that temperate families are derived from tropical families. He sped through a series of examples of temperate/tropical family pairs. Contrast of the temperate/tropical family pairs Apocynaceae/Asclepiaceae, Capparaceae/Brassicaceae, Moraceae/Urticaceae, Sapindaceae/Aceraceae shows that the temperate genera are simply the terminal members of a continuous clade, and that all of the characters that delimit the temperate family appear in the tropical group. Analysis of the Araliaceae/Apiaceae and Verbenaceae/Lamiaceae shows that these temperate families are polyphyletic, since each evolved from at least two distinct clades within the tropical family.

Dr. Judd concluded by summarizing that all tropical families appear to be paraphyletic (all members of the family share a common ancestor, but the family does not include all descendents of that ancestor). Temperate families comprise one or more advanced lineages within the larger clade of the tropical family. The greater number of species within temperate families is the result of rapid recent radiation, perhaps due to the shift from woody to herbaceous habit. His conclusion is that there are no temperate plant families, based on the philosophy that a family should be monophyletic (all members share a common ancestor, and the family contains all descendents of that ancestor). This conclusion is also supported by more traditional arguments which show that there are no clear phenetic (morphological) gaps between temperate families and members of their tropical ancestral families. Recent investigations using chloroplast DNA, and the fossil pollen record support this conclusion, although he cautioned that these results are preliminary, and based on a relatively small sample of genera.

June 1995 (910th Meeting). Dr. Ken Kimball, Director of the AMC's Research Department, spoke on "Recovery of an Alpine

Plant—*Potentilla robbinsiana.*" This Federally-listed Endangered species is endemic to New Hampshire's Presidential Range of the White Mountains. The successful implementation of a recovery program appears to have halted the decline of this plant, the only New England endemic species. It occurs primarily in Mt. Washington's Monroe Flats area, a windswept area of gravelly soils that is snow-free most of the winter and subject to blown abrasive ice and severe freeze-thaw cycles in the soil. However, plants also occur on a vertical cliff at another location. Like most arctic/alpine species, seed set is highly weather-dependent and rare, but seedlings do occur in nature. Chromosomal and isoenzyme data are limited, but suggest that there is virtually no genetic variation due to the apomictic (pseudogamous) reproduction. There are no adaptations to biotic or abiotic seed dispersal. The species appears to be derived from *Potentilla hyparctica,* a circumpolar species.

Potentilla robbinsiana has been studied at Monroe Flats for twenty years. Total counts of the population have been conducted at ten-year intervals, and show an increase of about 60% since the mid-1970's. Individual plants are mapped twice a year along permanent transects, providing a detailed account of about 10% of the population. Natural mortality is primarily due to winter conditions, particularly severe freeze-thaw cycles that lift plants out of the ground.

The recovery plan for this species has focused on eliminating human-caused mortality, primarily due to trampling by hikers and over-collection by botanists. This recovery has been achieved by rerouting the Crawford Path around the Flats, and by closing this area to hikers. Reintroduction and establishment of new populations by transplanting garden-grown seedlings, another feature of the recovery plan, has been successfully implemented. The sum of these efforts has been an increased understanding of the species, its demography, and recovery of the Mt. Washington population.

June 1995 (Field Trip). The first 1995 Field Trip was held on June 17th. Twenty-three Club members and guests visited the Alpine Gardens on Mt. Washington, guided by George Newman. Despite overcast and severely windy weather, participants enjoyed seeing *Rhododendron lapponicum, Diapensia lapponica, Loiseleuria procumbens, Houstonia caerulea* var. *Faxonorum,* and *Scirpus caespitosus* in full bloom. Other alpines (*Cassiope hypnoides, Phyllodoce caerulea, Geum peckii, Viburnum edule, Vac-*

cinium uliginosum, Arenaria groenlandica, Ledum groenlandicum, Carex bigelowii) were primarily observed in bud. Notable finds also included *Silene acaulis, Lycopodium selago* (*Huperzia selago* in Flora of North America (FNA)), *L. sitchense* (*Diphasiastrum sitchense* in FNA), *Arctostaphylos alpina* and *Salix uva-ursi.*

July 1995 (Field Trip). On July 22, 1995, Club members visited Snake Pond and East Mountain in Westfield, Massachusetts under the leadership of Dr. David Lovejoy of Westfield State College. The excursion was intended to explore unusual habitats in central Massachusetts and to contribute to the Club's herbarium, in which Hampden County is underrepresented. Participants renewed their acquaintance with *Toxicodendron vernix* while exploring the bog surrounding Snake Pond. The bog also yielded *Drosera rotundifolia, D. intermedia, Ilex glabra, Bartonia virginica, Habenaria psycodes, H. clavellata,* and a larch/black spruce thicket. *Rhododendron viscosum* at the bog margins appeared to be f. *glaucum.* Adjacent dry woods contained a large population of *Isotria verticillata,* with several fruiting plants. Along the talus slopes and dry ridgetop of East Mountain, trip participants observed *Sericocarpus asteroides, Hieracium paniculatum, Prunus pumila, Helianthus divaricatus, Lonicera dioica, Asplenium platyneuron,* and *Hystrix patula.*

OBITUARIES

Last August **Dorothy Waleka** of Ipswich, Massachusetts passed away at the age of 63. Although she was never a member of the Club, her handiwork will silently serve the Club as long as our organization exists. Ms. Waleka served as the mounter for the Club's herbarium from the 1960's into the mid-1980's, producing mounted specimens of the highest professional quality. As many as half of the folders presently in the vascular herbarium are labeled in her beautiful script. Ms. Waleka had a very warm and generous personality, and continued to be interested in news about the herbarium and Harvard University Herbarium staff after she discontinued her services due to health problems. Although her name does not appear on any of our herbarium sheets, her presence is there in as much measure as those collectors whose names do appear. Contributed by Ray Angelo, Curator of Vascular Plants.

NOTES

Invasive Alien Plants: Unlike Florida or Hawaii, New England is not generally considered to be severely affected by invasive alien plants. However, 29 percent of the New England flora is composed of alien species—and they're increasing. In Berkshire County, the proportion of aliens has grown from 17% of the flora in 1922 to 24% in 1990. As the number of exotic plants increases, they may compete for space with native species. While the total number of introduced plants growing without cultivation in New England exceeds 200 species, about 50 of these are considered highly aggressive and likely to invade natural areas. These include *Daucus carota, Coronilla varia, Rosa multiflora, Elaeagnus angustifolia, Cytisus scoparius, Celastrus orbiculatus, Lonicera japonica, Ampelopsis brevipedunculata, Berberis thunbergii, Euonymus alatus, Taxus cuspidata, Rhamnus frangula, R. cathartica,* and *Lythrum salicaria.* (Excerpted from an article by Faith Thompson Campbell, "Invasive Alien Plants," in the May 1995 issue of Columbine, the Conservation Newsletter of the National Council of State Garden Clubs). Contributed by Mary Walker.

THE NEW ENGLAND BOTANICAL CLUB

22 Divinity Avenue
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The New England Botanical Club is a non-profit organization that promotes the study of plants of North America, especially the flora of New England and adjacent areas. The Club holds regular meetings, has a large herbarium of New England plants, and a library. It publishes a quarterly journal, RHODORA, which is now in its 95th year and contains about 400 pages a volume.

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CONTRIBUTIONS TO THE FLORA OF VERMONT

Jerry Jenkins and Peter F. Zika

ABSTRACT

Recent herbarium and field studies have added 38 species and deleted 192 species from the flora of Vermont. The additions include 25 recently discovered species and 13 species based on older records that have been overlooked or misinterpreted. Ten additions are rare native species. Four of these are currently listed as state Threatened or Endangered species. The additions bring the total flora of Vermont to approximately 1933 species. The 192 deleted species, if included in the flora, would increase this number by 10%. The deletions include misidentified and misinterpreted species, cultivated plants incorrectly listed as naturalized, and many species that lack vouchers altogether. The geography of the added and deleted records suggests that many of the added species may be recent immigrants, and that many of the unvouchered species are highly unlikely in Vermont and are probably mistakes. A review of the number of species that have been deleted from the seven previous Vermont floras suggests that the apparent error rates of these floras have ranged from 0.3% to 5.4% of the species listed by each flora, with an average error rate of 2.4%.

Key Words: flora, additions, deletions, endangered species, discovery rate, error rate, immigration, Vermont

INTRODUCTION

In the last 150 years Vermont has had seven annotated floras and one checklist (Oakes, 1842; Torrey, 1853; Perkins, 1888; Brainerd et al., 1900; Eggleston et al., 1915; Dole, 1937; Seymour, 1969; Atwood et al., 1973), giving it the most extensively described flora of any state in the country. The authors are currently preparing a new checklist and flora. In the process we have compiled a number of recent unpublished additions to the flora and deleted a number of species credited to the flora in earlier works.

This paper lists those additions and deletions and, in the case of the deletions, gives our reasons for excluding them. The nomenclature follows that in Gleason and Cronquist (1991), except for a few cases in which we prefer the treatment of Kartesz (1994). Deleted species are listed under their current names[1]. When the names used in the original publications are different, these are placed in brackets. Common names for the species being added to the flora are taken from our forthcoming *Checklist of the Flora of Vermont*[2].

We used the standard acronyms from *Index Herbariorum* (Holmgren et al., 1990) when citing herbaria in the section that follows. The herbarium of the Vermont Institute of Natural Sciences (VINS) is not listed in Holmgren et al. (1990).

ADDITIONS TO THE FLORA

This section includes 38 taxa, 15 native to the northeastern U.S. and 23 aliens. Nineteen of these additions are recently discovered species that have never been listed for Vermont. Six are recent records for species that were listed previously, but for which the earlier records were unacceptable for various reasons, most commonly because they were unvouchered or based on misidentifications. Four are older records that either have never been cited or have been cited incorrectly. Six have been cited correctly in previous Vermont floras, but omitted from recent monographs or from the most recent Vermont flora (Seymour, 1969) and checklist (Atwood et al., 1973). And three are new identifications of specimens that were previously misidentified.

This list does not include taxa (e.g., *Spiranthes ochroleuca* (Rydb.

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[1] In most cases the contemporary equivalents of the historical names are well known or can be found in historical manuals. Thus, synonyms for many of the names used by Oakes (1842) and Torrey (1853) can be found in the Fourth Edition of *Gray's Manual* (Gray, 1857), and those for many of the names used by Perkins (1888) and Eggleston and Brainerd (1904) in the Seventh Edition of *Gray's Manual* (Robinson and Fernald, 1908). In a few cases the historical names are obscure or were used incorrectly by 19th century authors, and it is hard to know exactly what plant the authors thought they had or what contemporary species most closely fits their concept. In such cases (for example *Thaspium trifoliatum* Gray var. *apterum* Gray) we have indicated that the synonym is uncertain.

[2] The *Checklist of the Flora of Vermont* (Jenkins and Zika, in prep.) has been in preparation for ten years and is expected to be published in the near future.

ex Britt.) Rydb., or *Hudsonia ericoides* L. spp. *intermedia* (Peck) Nickerson & Skog) that have been added to the flora because of taxonomic and nomenclatural changes.

In addition to the species listed in this paper, at least 51 other recent additions to the state flora have been published since the last checklist (Atwood et al., 1973). These may be found in Countryman (1978), Hellquist and Crow (1980), Wagner and Wagner (1982), Hellquist and Hilton (1983), Zika et al. (1983), Zika and Thompson (1986), Zika (1986B, 1987, 1988, 1990, 1991A, 1991B, 1992), Angelo (1989, 1990), Rothrock (1991), Zika and Marshall (1991), Paris (1991), Haufler and Windham (1991), Beitel and Mickel (1992), Farrar (1992), Reznicek and Oldham (1993), and Gilman (1993).

Ten of the taxa added here are rare native species with extant populations (*Asplenium montanum* Willd., *Carex atlantica* L. Bailey var. *atlantica, C. capillaris* L., *C. cumulata* (L. Bailey) Mack., *Dracocephalum parviflorum* Nutt., *Eleocharis robbinsii* Oakes, *Myrica pensylvanica* Mirbel., *Panicum flexile* (Gattinger) Scribn., *Potentilla pensylvanica* L., and *Vaccinium stamineum* L.). Four of these (*Asplenium montanum, Carex capillaris, Dracocephalum parviflorum,* and *Panicum flexile*) are currently listed as state Threatened or Endangered species (10 V.S.A., Chapter 123). We have recommended to the Vermont Endangered Species Committee that all of these species, with the exception of *Myrica pensylvanica,* be listed as state Threatened or Endangered species.

Recently Discovered or Authenticated Species

Ajuga reptans L., Lamiaceae, carpet-bugle. **Windsor Co.**: roadside, South Woodstock, 1967 (*Ahles 68243* MASS); **Orleans Co.**: under raspberries, Lake Willoughby, Westmore, 1980 (*Zika 1354* MASS, VT).

Alyssum saxatile L., Brassicaceae, golden-tuft. **Chittenden Co.**: escape from cultivation, Shelburne, 1979 (*Zika 1291,* VT); **Addison Co.**: naturalized and common on limy ledges, Gardiners Island, Ferrisburg, 1980 (*Zika 1639* MASS, VT); 1981 (*Zika 4048* NEBC).

Asplenium montanum Willd., Aspleniaceae, mountain spleenwort. **Bennington Co.**: about 30 plants in cracks, dry sunny quartzite ledges, cliffs above Rattlesnake Brook, elev. 1000 feet, Pownal, 1974 (*Jenkins s.n.* VT).

Cardamine impatiens L., Brassicaceae, European bittercress. **Bennington Co.**: old railroad grade south of golf course, Bennington, 1979 (*Zika & Jenkins 1332* VT); edge of a footpath, Bennington, 1985 (*Jenkins & Thompson s.n.* VT). Known since 1981 from two localities in adjacent White Creek, Washington Co., New York (*Zika & Jenkins 8024* VT).

Carex atlantica L. Bailey var. *atlantica,* Cyperaceae, Atlantic sedge. **Franklin Co.**: Franklin Bog, Franklin, 1965 (*Seymour s.n.* VT); deep water of lag and central pools, with *Carex comosa* F. Boott and *C. interior* L. Bailey, several places, S. end of Franklin Bog, Franklin, 1982 (*Jenkins 82-176* VT); ten clumps, N. end of Franklin Bog, Franklin, 1982 (*Zika 6115* VT); **Bennington Co.**: sedge-alder swamp, with *Carex stricta* Lam. and *C. stipata* Muhl., near a sandy field, N. Pownal, 1982 (*Jenkins 82-155* VT). Determinations based on keys in Reznicek and Ball (1980).

Carex capillaris L., Cyperaceae, hair-like sedge. **Caledonia Co.**: limy seepage area near Route 2, with *Equisetum variegatum* Schleich., and *Eleocharis tenuis* (Willd.) Schultes var. *borealis* (Svenson) Gleason, Danville, 1985 (*Zika 9040* VT). Discovered here by T. Rawinski in 1984. Reported from northern Vermont by Fernald (1950), but vouchers never located.

Carex cumulata (L. Bailey) Mack., Cyperaceae, sedge. **Windham Co.**: sandy bluff, eroding bank of Connecticut River, with *Leptoloma cognatum* (Schultes) Chase, *Paspalum setaceum* Michx. var. *ciliatifolium* (Michx.) Vasey, *Cyperus filiculmis* Vahl, and weeds, Rockingham, 1989 (*Thompson & Rawinski 2307* VT, Det. A. A. Reznicek, 1990); among granite boulders in steep oak woods, with *Pinus rigida* Miller, Black Mountain, Dummerston, 1991 (*Jenkins s.n.* VT).

Carex spicata Huds., Cyperaceae, sedge. **Rutland Co.**: rough limy meadow west of the south end of Shaw Mt., West Haven, 1990 (*Thompson 90-52* VT); limy meadow by Catfish Cove, Mt. Independence, Orwell, 1990 (*Jenkins s.n.* VT). The two colonies are within 10 miles of each other and both consist of a few clumps of the sedge within a few square meters.

Eleocharis robbinsii Oakes, Cyperaceae, Robbin's spike-rush. **Rutland Co.**: locally abundant, shallow water adjacent to boggy shore, with *Nuphar, Utricularia gibba* L. and *Potamogeton epihydrus* Raf., east shore of Little Lake, Wells, 1989 (*Jenkins s.n.* VT).

Erucastrum gallicum (Willd.) O. E. Schulz, Brassicaceae, dog mustard. **Orleans Co.**: lower slope of Mt. Pisgah, Westmore, 1973 (*Hodgdon et al. 19983* NHA). Vouchers for stations reported by Dole (1937) have not been found.

Hieraceum flagellare Willd., Asteraceae, whiplash hawkweed. **Windham Co.**: roadside, junction of Routes 103 and Interstate 91, Rockingham, 1979 (*Ahles 86816* MASS, VT); **Windsor Co.**: roadside, Route 103, Chester, 1979 (*Ahles 86783* MASS).

Iris sibirica L., Iridaceae, Siberian iris. **Windham Co.**: roadside, Rockingham, 1979 (*Ahles 86823* MASS); **Chittenden Co.**: naturalized in a damp meadow, Shelburne, 1981 (*Zika 4013* VT); sandy lot by airport, South Burlington, 1985 (*Zika 9062* VT).

Kolkwitzia amabilis Graebn., Caprifoliaceae, beauty-bush. **Chittenden Co.**: apparently spreading from cultivation into thickets, Rock Point, Burlington, 1981 (*Zika 4706* VT).

Lavandula angustifolia Mill. [*L. officinalis* Chaix., *L. spica* L., *L. vera* DC.], Lamiaceae, lavender. **Windham Co.**: escaped in field, Guilford, 1982 (*Zika 6547* VT). Earlier reports of *L. spica* (Atwood et al., 1973) are based on collections from cultivated plants.

Lysimachia vulgaris L., Primulaceae, garden loosestrife. **Bennington Co.**: roadsides, Pownal, 1967 (*Ahles 67959* MASS); **Windsor Co.**: naturalized, Connecticut River shore, near mouth of Lulls Brook, Hartland, 1982 (*Zika 6220* VT); **Washington Co.**: roadside weed, Plainfield, 1980 (*Zika 1654* VT); **Windham Co.**: common on Connecticut River shore, two miles south of Bellows Falls, Westminster, 1982 (*Zika 6269* VT).

Mentha ×*villosa* Hudson [*M. alopecuroides* Hull], Lamiaceae, foxtail mint. **Washington Co.**: railroad yard, Montpelier, 1975 (*Ahles 81496* MASS); **Windham Co.**: weed, sandy dump, Brattleboro, 1982 (*Zika 6461* NEBC, VT).

Myosotis micrantha Pallas [*M. stricta* Link], Boraginaceae, blue scorpion-grass. **Chittenden Co.**: lawn weed, North Beach Campground and Lakeview Cemetery, Burlington, 1980 (*Zika 1330 & 1370* VT); weed, Horsford Nursery, Charlotte, 1984 (*Zika 7988* VT). An earlier record for Burlington (*Seymour 23094* MO), cited in Seymour (1982), is based on a specimen of *M. arvensis* (L.) Hill.

Myrica pensylvanica Mirbel., Myricaceae, bayberry. **Chittenden Co.**: five clones, ca. 120 ramets, overgrown hillside pasture north of Rt. 2, with *Acer rubrum* L., *Berberis, Crataegus, Pinus strobus* L., *Rubus,* Richmond, 1992 (*Marshall 2446* VT). First observed in 1989 by Everett J. Marshall.

Panicum flexile (Gattinger) Scribn., Poaceae, panic grass. **Rutland Co.**: common, sunny limestone ledges, Shaw Mountain, West Haven, 1983 (*Jenkins & Zika 7665* NEBC, VT). Previous reports for Grand Isle are based on a sheet of *P. capillare* L. (*Hunnewell 13908* NEBC). *Panicum flexile* has long been known from Skene Mountain, in Whitehall, N. Y., about 10 miles south of Shaw Mountain, where a small population still persisted in 1987 (Jenkins and Zaremba, pers. obs.).

Pimpinella saxifraga L., Apiaceae, burnet saxifrage. **Bennington Co.**: along abandoned railroad grade, Bennington, 1975 (*Jenkins s.n.* VT). First discovered at this site by Barbara Beecher in 1975. Apparently not extant in August 1985.

Polygonum sachalinense F. W. Schmidt, Polygonaceae, giant knotweed. **Addison Co.**: Granville, 1983 (*Zika 7189* VT); **Lamoille Co.**: roadsides of Route 108 near Mt. Mansfield, Stowe, 1980 (*Zika 2224, 4752* MASS, NEBC, VT); Stowe, 1981 (*Angelo et al., s.n.* NEBC); Wolcott, 1983 (*Zika 7486A* VT); **Washington Co.**: railroad yard, Roxbury, 1982 (*Zika 6760* VT); **Windsor Co.**: railroad yard, White River Junction, 1981 (*Zika 5336* NEBC, VT).

Potentilla pensylvanica L., Rosaceae, Pennsylvania cinquefoil. **Washington Co.**: hilltop pasture, Plainfield, 1968 (*Jenkins s.n.* VT). Colony extant but very small in September 1987.

Setaria faberi R. Herrm., Poaceae, giant foxtail. **Addison Co.**: New Haven Junction, 1981 (*Zika 5258* VT); Middlebury, 1981 (*Zika 5263* VT); Ferrisburg, 1981 (*Zika 5292* VT); **Bennington Co.**: Bennington, 1984 (*Zika 8263* VT); **Chittenden Co.**: Burlington, 1980 (*Zika 1913* VT); Jericho, 1981 (*Zika 5185* VT); **Franklin Co.**: St. Albans, 1981 (*Zika 5177* VT); **Rutland Co.**: Rutland, 1981 (*Zika 5270* VT); **Washington Co.**: Waterbury, 1979 (*Zika 1228* VT); **Windham Co.**: Brattleboro, 1981 (*Zika 5339* VT); **Windsor Co.**: White River Junction, 1981 (*Zika 5132* VT). This species apparently has increased rapidly in New York since 1940 (Smith, 1965) and has been spreading rapidly in Vermont since about 1970 (W. D. Countryman, pers. comm.). At present it is a widespread pest on railroad easements, agricultural lands, and roadsides, where it is frequently associated with *Setaria glauca* (L.) P. Beauv., *S. viridis* (L.) P. Beauv., *Aristida* spp., *Panicum dichotomiflorum* Michx., or *Kochia scoparia* (L.) Schrader.

Vaccinium stamineum L., Ericaceae, deerberry. **Bennington Co.**: one bush in rocky woods above River Road, North Pownal, 1986 (*Jenkins s.n.* VT). Brainerd et al. (1900) noted in the appendix to their flora that *V. stamineum* was known from Mt. Greylock in Williamstown, Massachusetts, and should be sought in Vermont. A record from Wells River, Vermont, in Dole (1937) was not supported by a herbarium specimen.

Verbena stricta Vent., Verbenaceae, hoary vervain. **Chittenden Co.**: weed in cracks in asphalt, Troy Ave., Colchester, 1981 (*Zika 4234* VT).

Older Records, Not Previously Cited

Asclepias verticillata L., Asclepiadaceae, whorled milkweed. **Windsor Co.**: Windsor, undated (*Alphonso Wood s.n.* NY). Although the Windsor collection lacks a date and was not cited in any previous Vermont flora, we accept the record because the specimen is correctly identified and geographically plausible. A collection by C. C. Frost from Brattleboro cited in early floras has not been found.

Dioscorea batatas Decne., Dioscoreaceae, Chinese yam. **Windham Co.**: Townshend, 1922 (*L. A. Wheeler s.n.* NEBC). Marginal addition, probably short-lived, as Wheeler's label reads: "temporary escape."

Hieracium murorum L., Asteraceae, golden lungwort. **Rutland Co.**: Center Rutland, 1947 (*Kirk s.n.* TUFT).

Rhododendron periclymenoides (Michx.) Shinners [*Rhododendron nudiflorum* (L.) Torr.], Ericaceae, pinkster-flower. **Caledonia Co.**: Peacham, 1891 (*F. Blanchard s.n.* NY). All records of this species cited in previous floras are based on specimens of *R. prinophyllum* (Small) Millais [*R. roseum* (Loisel.) Rehd.].

Older Records, Cited by Previous Floras, But Omitted From Recent Floras or Monographs

Carex atlantica L. Bailey var. *capillacea* (L. Bailey) Cronq. [*C. howei* Mackenzie], Cyperaceae, Howe's sedge. **Chittenden Co.**: Colchester, 1899 and 1907 (*Flynn s.n.* VT); S. Burlington, 1896 (*Flynn s.n.* VT). Not cited for Vermont by Reznicek and Ball (1980).

Carex wiegandii Mackenzie, Cyperaceae, Wiegand's sedge. **Windham Co.**: Torrey Meadow, Stratton, 1895 (*Grout s.n.* VT); **Chittenden Co.**: Star Farm, Burlington, 1906 (*Flynn s.n.* VT). Listed in Seymour (1969) and Atwood et al. (1973), but not cited for Vermont by Reznicek and Ball (1980).

Dracocephalum parviflorum Nutt., Lamiaceae, American dragonhead. **Windsor Co.**: potato field, Billings Farm, Woodstock, 1921 (*Kittredge s.n.* VINS); **Rutland Co.**: West Clarendon, 1915 (*Potter s.n.* TUFT); dry rocky slope in full sun, Twin Mountain, West Rutland, 1983 (Jenkins, pers. obs.). Cited by Kittredge (1931) and Dole (1937), but not in subsequent works.

Geum vernum (Raf.) T. & G., Rosaceae, spring avens. "**Vermont**": undated collection (ex herb. *Torrey* VT); **Bennington Co.**: fertile ground among wrecked cars, 100 m. north of the North Bennington post office, with *G. canadense* Jacq., *Chenopodium gigantospermum* Aellen and weeds, Bennington, 1985 (*Zika 9087* VT). Torrey's sheet, presumed to have been made in the 1800's, was reported in Seymour (1967), but not in previous floras or Atwood et al. (1973). The North Bennington colony was discovered by J. Jenkins and had both flowers and fruits on 5 June 1985. The species is not otherwise known from New England, but occurs occasionally in eastern New York (Jenkins, pers. obs.).

Primula veris L., Primulaceae, primrose. **Chittenden Co.**: garden escape, Burlington, 1898 (*Jones s.n.* VT). Cited in Dole (1937), but omitted from recent floras.

Tagetes patula L., Asteraceae, French marigold. **Windsor Co.**: riverbank, Billings Farm, Woodstock, 1918 (*Kittredge s.n.* VINS). Cited by Dole (1937), but not in subsequent works.

Plants Incorrectly Determined in Previous Floras

Delphinium orientale J. Gay [*Consolida orientalis* (J. Gay) Schrödinger], Ranunculaceae, rocket larkspur. **Chittenden Co.**: roadside escape, Charlotte, 1903 (*Flynn s.n.* VT). Previously reported as *Delphinium ajacis* L.

Prunus cerasus L., Rosaceae, sour cherry. **Bennington Co.**: Manchester, 1898 (*Day 371* NEBC). The specimen was labelled as *P. avium* L. and was cited under this name in previous floras. Harry Ahles annotated it to *P. cerasus* in 1975. A Brainerd specimen of *P. cerasus* from Middlebury, cited in Dole (1937), has not been found.

Solanum sarrachoides Sendtner, Solanaceae, hairy nightshade. **Chittenden Co.**: garden weed, Westford, 1969 (*Meunier s.n.* VT). Previously reported as *S. villosum* Mill. (Seymour, 1969).

DELETIONS FROM THE FLORA

This section lists 192 species, credited to Vermont in publications or represented by herbarium specimens, that we have either proven to be erroneously credited to the state or have been unable to validate. These we are deleting from the flora. In doing so we are not asserting that the species has never occurred in Vermont, but only that the historical reports are apparently unverifiable or in error. The deletions do not include taxa (like *Antennaria brainerdi* Greene or *Aster pringlei* (Gray) Britton) that were formerly listed for Vermont but are now included in other species.

Species have been deleted for any of six reasons[3]. The commonest reason is that no specimen was found (NSF). For 130 of the deleted species we were unable to locate vouchers to support one or more of the published records. Ninety-six of these species lacked vouchers altogether and another 34 lacked vouchers for one or more of the reported stations.

Interestingly, only 19 of the species that lack vouchers for one or more sites are cited in the floras whose authors required vouchers for all the species they listed (Brainerd et al., 1900; Eggleston et al., 1915; Seymour, 1969; Atwood et al., 1973); in these cases

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[3] The claim that a species is or was present in Vermont is usually based on one or more published records, which may or may not cite individual specimens. We delete a species only after we have either looked for and found no corroborating specimens or have examined and rejected all the specimens we have found. The reasons for rejecting specimens vary: some can't be found; others are misidentified; others are rejected because they were cultivated, incorrectly cited, or otherwise dubious (see main text). Because the decision to reject a species usually rests on the rejection of several specimens or citations, a species may be deleted for a combination of reasons. Thus we say, for example, that some species lacked vouchers altogether, while others lacked vouchers for one or more stations. In the latter cases, the stations with vouchers would have been deleted for other reasons.

it is likely that the original specimens cited in these floras have since been lost or redetermined. The remaining 111 species which lack one or more vouchers were cited in works (Oakes, 1842; Torrey, 1853; Perkins, 1988; Dole, 1937) that included unvouchered records. In many of these cases we suspect that no specimen was ever seen by the authors of the floras.

The second most common reason for deleting species is that they are misidentified (MI). For 50 deleted species one or more vouchers were misidentified. These include 28 species for which all the published records were misidentifications and another 22 species for which all the vouchers we could locate were misidentified.

A third group of deletions are cultivated species that are not provably naturalized. To list a cultivated species in the flora, we require evidence that it has spread (though not necessarily persisted) beyond the immediate area where it was cultivated. Many collectors made specimens of cultivated plants; and, in the absence of information about where a specimen was collected, the mere presence of a specimen of a cultivar in a herbarium does not prove that the plant was naturalized. A total of 31 deleted species fall in this category. Twenty of these are based on specimens that are almost certainly from cultivated plants (CULT), and another 11 are based on specimens whose labels lack habitat information and so are not definitely naturalized (NDN).

A fourth group of deletions includes 15 records based wholly or partly on specimens that were correctly determined by their collectors, but incorrectly cited or attributed to Vermont in subsequent floras (IC). Examples include a specimen of *Erigeron acris* L. from the St. Johns River in Maine which was relabeled and credited to the St. Johnsbury Railroad in Vermont and, less dramatically, a number of cases where the old and new names for a plant were listed in the same work as two separate species. When one name is obsolete, this causes no real problems. But in cases (e.g., *Cardamine flexuosa* With., *Amelanchier canadensis* (L.) Medikus, or *Carex saxatilis* L.) where one of the names is now used for a species that doesn't occur in Vermont, this practice can lead to significant errors, particularly when these records are cited in regional floristic works.

A fifth group of deletions includes five species for which some or all of the specimens are inadequate (IS) because they are immature, sterile, fragmentary, or otherwise undeterminable. These are mostly species that closely resemble a common Vermont species. Examples are *Lepidium ruderale* L., sterile plants of which resemble the common *L. densiflorum* Schrader, and *Salix serrissima* (L. H. Bailey) Fern., whose immature leaves closely resemble those of the common *Salix lucida* Muhl.

The last group of deletions includes five species in which one or more specimens are correctly determined, but not provably from Vermont, that is, the collection data is not convincing. We call these specimens of doubtful provenance (DP). Our reasons for rejecting them—which are inferential and not conclusive—are different in each case and are summarized in the entries for those species.

Each of the following entries gives a) the species deleted; b) the publications (if any) that cited the record; c) in bold type, the locality to which the plant was credited, or NL if no locality was given, or an abundance in quotation marks if that is the only distributional information in the original publication; d) the collector of the specimen on which the record is based (or NCC when no collector was cited in the publication) and the herbarium holding that specimen (both in parentheses); and e) our reason for deleting the record. When the current name differs from that used in the original publication, we give the older name in square brackets. When no herbarium is listed, it means that we found no specimen and are listing the locality and collector credited in the original publication. For readability, we use the following abbreviations.

Publications: A, Atwood et al. (1973); AM, Ames (1910); B, Brown (1964); BR, Brainerd et al. (1900); C, Countryman (1978); CR, Crow (1982); D, Dole (1937); E, Eggleston et al. (1915); EB, Eggleston and Brainerd (1904); F, Fernald (1950); FL, Flynn (1911); G, Gleason and Cronquist (1991); I, Cronquist et al. (1977); J, James (1823); JE, Jesup (1891); K, Kennedy (1904); KI, Kittredge (1931); KS, Kittredge (1939); LI, Little (1977); O, Oakes (1842); P, Perkins (1888); PE, Pennell (1935); S, Seymour (1969); T, Torrey (1853); W, Watson and Coulter (1890).

Reasons for deletions: CULT, cultivated; DP, doubtful provenance; IC, incorrectly cited; IS, inadequate specimen; MI, misidentified; NDN, not definitely naturalized; NSF, no specimen found.

Allium porrum L. [*A. fistulosum* sensu Dole (1937), not L.], A, S, **Manchester,** (*Day* NEBC, GH), MI = *A. cepa L.* or *A. fistulosum L.*

Amaranthus cannabinus (L.) Sauer [*Acnida cannabina* L.], D, **Woodstock,** (*Kittredge*), MI = *Amaranthus rudis* Sauer ?; **NL** (ex herb. *Torrey,* VT), MI = *Amaranthus tuberculatus* (Moq.) Sauer [*Acnida altissima* (Riddell) Moq. ex Standl.].

Amaranthus powellii S. Wats., D, **Woodstock,** (*Kittredge*), NSF.

Amelanchier canadensis (L.) Medikus, A, S, **14 sites,** (*several collectors,* VT), IC = *A. arborea* (Michx. f.) Fern. The name *A. canadensis,* which formerly included the Vermont plants now attributed to *A. arborea,* is restricted to plants of the coastal plain.

Anchusa arvensis (L.) M. Bieb. [*Lycopsis arvensis* L.], P, "**not common,**" (*NCC*), NSF; O, **Pownal,** (*Reed*), NSF; **Middlebury,** (*Dodge* VT), MI = *Lithospermum officinale* L.

Antennaria virginica Stebbins, D, **Middlebury,** (*Brainerd*), NSF; A, **North Dorset,** (*Flynn* VT), MI = *A. neglecta* Greene var. *neodioica* (Greene) Cronq.; A, **Vernon,** (*NCC* VT), NSF. See Bayer and Stebbins (1982).

Aronia arbutifolia (L.) Elliott [*Pyrus arbutifolia* (L.) L. f. var. *erythrocarpa* Gray], O, P, **NL,** (*NCC*), NSF; D, "**occasional,**" (*NCC*), NSF.

Asclepias purpurascens L., T, **Brattleboro,** (*Frost*), NSF; P, "**common,**" (*NCC*), NSF; D, KI, **Woodstock,** (*Kittredge* NY, *Billings & Kittredge* VINS), both MI = *A. syriaca* L.; C, S, **Essex,** (*Carpenter* VT), MI = *A. syriaca*; **Burlington,** (*Ayer & Sullivan* VT), MI = *A. syriaca.*

Aster ciliolatus Lindley [*A. lindleyanus* T. & G.], D, S, **Ripton,** (*NCC*), NSF; A, D, E, **South Bellows Falls,** (*Blanchard*), NSF; D, **Burlington,** (*Dole*), NSF; A, D, **Middletown Springs,** (*Carpenter* VT), MI = *A. cordifolius* L.; **Bellows Falls,** (*Potter* VT), MI = *A. cordifolius.*

Aster dumosus L., D, **Hartland,** (*Eggleston*), NSF; D, **Westminster,** (*Blanchard* VT), MI = *A. racemosus* Elliot [*A. vimineus* L. of Vermont authors]; D, **Wells River,** (*Smith*), NSF; **Vernon,** (*Blanchard* VT), MI = *A. racemosus*; **Rutland,** (*Eggleston* HNH), MI = *A. cordifolius* L. × ? *A. pilosus* Willd.

Aster foliaceus Lindley ex DC., A, S, **West R. & Connecticut R.,** (*several collectors,* HNH, NEBC, VT), MI = *Aster novi-belgii* L. Large populations of a plant related to *Aster novi-belgii* occur along the West and upper Connecticut Rivers. The plants have the slightly enlarged and veiny outer bracts of the boreal species *A. foliaceus,* but resemble *Aster novi-belgii* in other features and differ in leaf shape and bract width from Canadian and cordilleran material of *A. foliaceus.* Measurements from 50 West River collections (Jenkins, unpubl. data) show that the plants with broader bracts that have been called *A. foliaceus* grow mixed with typical *A. novi-belgii,* and that intermediates occur. On the basis of this evidence, we refer all Vermont collections of *A. foliaceus* to *A. novi-belgii,* noting that *A. novi-belgii,* which is known to be quite variable, can have outer involucral bracts to 2.0 mm wide which are more or less reticulately veined. This conclusion agrees with that of a brief study of specimens from the upper Hudson River (Jenkins, 1990, unpubl. report to the Adirondack Nature Conservancy, Keene) and an extensive study of plants from Quebec (Jacques Labrecque, pers. comm.).

Aster infirmus Michx., D, **Danville,** (*Drake*), NSF.

Aster patens Aiton, P, **NL,** (*Barrows*), NSF.

Aster praealtus Poiret, O, **Bellows Falls,** (*Carey*), NSF.

Aster prenanthoides Muhl., BR, E, **Newfane,** (*Grout*), MI = *A. novi-belgii* L. var. *tardiflorus* (L.) A. G. Jones; E, D, **Taftsville,** (*Darling*), NSF.

Aster solidagineus Michx. [*Sericocarpus solidagineus* Nees], P, "**not common,**" (*NCC*), NSF.

Atropa belladona L., D, **Wells River,** (*Smith*), NSF. Besides *Atropa belladona,* Dole (1937) reported *Gaylussacia frondosa* (L.) T. & G., *Vaccinium stamineum* L., and *Silene pensylvanica* Michx. from Wells River on the authority of W. P. Smith. All are native species and, excepting *Vaccineum stamineum* which was recently discovered in extreme southwestern Vermont (100 miles from Wells River), all are otherwise unknown in Vermont, geographically unlikely, and unsupported by vouchers or citations in other floras.

Avena sterilis L., A, **Charlotte,** (*Pringle* VT), CULT.

Bidens comosa (A. Gray) Wieg., D, **Middlebury** (*Brainerd*), NSF; A, S, **Vernon,** (*Eaton* NEBC), IS.

Bidens laevis (L.) BSP. [*B. chrysanthemoides* Michx.], P, "**wet places,**" (*NCC*), NSF; E, "**common,**" (*NCC*), NSF; D, **Middlebury,** (*Brainerd*), NSF; D, **Danville,** (*Drake*), NSF; **East Dorset,** (*Grout* VT), MI = *B. cernua* L.; **Middletown Springs,** (*Carpenter* VT), MI = *B. cernua*; **Rutland,** (*Kirk* VT), MI =

B. cernua. Bidens laevis, a rare species barely reaching our area, closely resembles the common *B. cernua* and probably was the species Perkins and Eggleston had in mind.

Bromus arvensis L., D, **Windham,** (*Blanchard*), NSF; **Brattleboro,** (*Ahles* MASS), MI = *B. japonicus* Thunb.

Bromus hordaceus L. [*B. mollis* L.], P, **NL,** (*NCC*), NSF.

Calamagrostis cinnoides (Muhl.) Bart. [*Deyeuxia nuttaliana* St., *C. nuttalliana* Steud.], D, JE, P, **Windsor,** (*Leland*), NSF.

Calystegia hederacea Wallich [*C. pubescens* Lindl., *Convolvulus japonicus* Thunb.], E, D, **NL,** (*NCC*), NSF.

Cardamine flexuosa With., D, **Wallingford,** (*Brainerd*), IC = *C. pensylvanica* Muhl.; D, **Smugglers Notch,** (*Brainerd*), IC = *C. pensylvanica*; KI, **Woodstock,** (*Kittredge*), NSF. See Kittredge (1936). The name *C. flexuosa,* which is now restricted to a plant of the southern U.S., was formerly used for broad-leaved forms of *C. pensylvanica.*

Cardamine rotundifolia Michx., T, **Vermont,** (*Robbins*), NSF.

Carex adusta F. Boott, P, **Fairlee,** (*Blanchard*), NSF; P, **Middlebury,** (*Blanchard*), NSF.

Carex atrata L., I, **Vermont,** IC = *C. atratiformis* Britton.

Carex bullata Schk., D, **Sharon,** (*Dutton*), NSF; **Whitingham,** (*Ahles* MASS), MI = *C. vesicaria* L.

Carex collinsii Nutt., A, S, **Essex Co.,** (*NCC* NEBC), NSF; A, S, **Walden,** (*NCC* NEBC), NSF.

Carex crawei Dewey, P, **Charlotte,** (*Pringle*), NSF.

Carex dioica L. var. *gynocrates* (Wormsk.) Ostenf. [*C. gynocrates* Wormsk.], P, T, **Burlington,** (*Torrey*), NSF.

Carex flaccosperma Dewey [*C. glaucodea* Tuckerm.], D, **Leicester,** (*Dutton*), NSF; D, **Middlebury,** (*Brainerd*), NSF; D, **Middletown Springs,** (*Carpenter*), NSF.

Carex saxatilis L., O, **Mt. Mansfield,** (*Robbins et al.*), NSF; O, **Camel's Hump,** (*Tuckerman* GH), IC = *C. bigelowii. Carex saxatilis* and *Carex bigelowii* are somewhat similar in appearance, though only distantly related. Some 19th-century authors (i.e., Gray, 1857) treated them, incorrectly, as synonyms.

Carex shortiana Dewey, P, **Burlington, "doubtful,"** (ex herb. *Torrey*), NSF.

Carex sterilis Willd., A, C, N, S, **Concord,** (*Pease* NEBC), IC = *Carex echinata* Murray; **"Vermont,"** (*Kent* NEBC), IC = *Carex echinata.* Robinson and Fernald (1908) defined *C. sterilis* broadly, including much of what is now called *C. echinata.* Our more restrictive use of *C. sterilis* is for a rare coastal and boreal species that does not occur in Vermont, according to Reznicek and Ball (1980) and Fernald (1950).

Carex striata Michx. [*C. walteriana* Bailey], T, **Burlington,** (*Torrey*), NSF. According to House (1924, p. 193), records of *C. striata* in Torrey's *Flora of New York* probably refer to *Carex houghtoniana* Torr. *ex* Dewey.

Carex styloflexa Buckley, A, C, S, **Middlebury,** (*Brainerd* VT), MI = *Carex laxiflora* Lam. or *C. gracilescens* Steudel.

Carex tetanica Schk., P, **Burlington,** (ex herb. *Torrey*), NSF.

Carex vestita Willd., O, **Middlebury,** (*James*), NSF.

Carya tomentosa (Poiret) Nutt. [*C. alba* (Mill.) K. Koch, not Nutt.], FL, D, **Williston, West Haven,** (*Blake*), NSF; FL, D, **Burlington,** (*Burns*), IC = *C. ovata* (Mill.) K. Koch. The historical synonymy of the common hickories is complex, the Linnean epithet *alba* having been used in different ways by different 19th-century authors. Some early Vermont collectors, following Gray (1857, 1874) used *C. alba* sensu Nutt. for the shagbark *C. ovata*; this apparently created confusion with the mockernut, *C. tomentosa,* which Robinson and Fernald (1908) incorrectly called *C. alba* (L.) K. Koch. Mockernuts occur in eastern N.Y., but are apparently unknown in Vermont.

Centaurea americana Nutt., D, **St. Johnsbury,** (*Howe*), NSF.

Cerastium viscosum L. [*C. glomeratum* Thuill.], D, **Wells River,** (*Eastman*), NSF.

Chelone lyonii Pursh, D, **Woodstock,** (*Kittredge*), NSF.

Chenopodium berlandieri Moq. var. *berlandieri,* D, **Vergennes, Middlebury,** (*Dutton*), NSF.

Chenopodium berlandieri Moq. var. *macrocalycium* (Aellen) Cronq. [*C. macrocalycium* Aellen], A, **Colchester,** (*Flynn* VT), MI = *C. berlandieri* var. *bushianum* (Aellen) Cronq. The specimen was originally determined as *C. album* L. and annotated to *C. macrocalycium* by Wahl during his study of the genus (Wahl, 1952-3). We refer it to *C. berlandieri* var. *bushianum,* noting that Wahl determined several other Flynn specimens from this locality, including one collected on the same day, as *C. bushianum* Aellen.

Cimicifuga racemosa (L.) Nutt., J, O, **Middlebury,** (*James*), NSF; O, **Mansfield Mountain,** (*NCC*), NSF; O, **Shelburne &**

Sharpshin Points near Burlington, (*Macrae*), NSF; D, "**Vermont,**" (ex herb. *Torrey* VT), DP; "**Vermont,**" (*Dike* VT), DP. The records from Middlebury, Burlington, and Mt. Mansfield are in the northern half of Vermont and are disjunct by over 100 miles from known stations of the species in other states. The Dike collection has a printed label saying "Flora of Vermont" but the collection data is handwritten and says only "*Cimicifuga racemosa* Rich Woods, 20th July, A.C. Dike." The collection from the Torrey Herbarium says only "*Actaea racemosa* Nutt. Vermont." The species is reported from within 20 miles of the southern Vermont border and could easily have occurred here; but, given the lack of detailed collection information and the possibility that the specimens may have come from cultivated plants, we cannot accept the records.

Cirsium altissimum (L.) Sprengel, D, **Wells River,** (*Eastman*), NSF. *C. altissimum,* a species of the southern U.S., closely resembles our *C. discolor* (Muhl.) Sprengel, which may have been the species Eastman saw.

Cirsium canum (L.) Bieb., D, **Castleton,** (*Higby*), NSF.

Cirsium horridulum Michx., P, T, **Brattleboro,** (*Frost*), NSF.

Cirsium palustre (L.) Scop., D, **Wells River,** (*Eastman*), NSF.

Cirsium undulatum (Nutt.) Sprengel, D, **Wells River,** (*Eastman*), NSF.

Clematis viorna L., P, T, **Castleton,** (*Carr*), NSF.

Crataegus laevigata (Poiret) DC. [*C. oxyacantha* L., misapplied], A, **Ryegate,** (*Blanchard* HNH), IC = *C. monogyna* Jacq.; A, **Fairlee,** (*Eggleston* HNH), IC = *C. monogyna*; A, S, **Burlington,** (*NCC* VT), CULT. Atwood (1973) lists both *C. oxyacantha* (now a rejected name) and *C. monogyna* for Vermont; earlier Vermont authors treated these names as synonyms, and the Blanchard and Eggleston specimens are in fact all *C. monogyna.*

Crepis setosa Haller f., EB, E, **Townshend,** (*Blanchard*), NSF; D, **Townshend,** (*Wheeler*), NSF.

Cyperus polystachos Rottb. [*Cyperus filicinus* Vahl], A, **many counties,** (*several collectors* VT, MO, NEBC), IC = *C. lupulinus* (Sprengel) Marcks [*C. filiculmis* Vahl var. *macilentus* Fern.). This was probably an orthographic error, substituting *C. filicinus* (a coastal species not known inland) for *C. filiculmis,* a common Vermont plant.

Datura metel L., D, **Middlebury,** (*Brainerd* VT), CULT.

Desmodium canescens (L.) DC., O, P, **Pownal,** (*Robbins*), NSF.

Desmodium obtusum (Muhl.) DC. [*Desmodium rigidum* (Ell.) DC.], E, D, **North Pownal,** (*Eggleston*), NSF; E, D, **Vernon,** (*W.H. Blanchard*), NSF.

Dianthus chinensis L., A, **Middlebury,** (*Brainerd* VT), CULT.

Elaeagnus angustifolia L., A, **Westmore,** (*Dole* VT), NDN.

Eleocharis parvula (R. & S.) Link [*E. pygmaea* Torr.], BR, K, **Willoughby,** (*Dean* HNH), MI = *E. intermedia* (Muhl.) Schultes.

Eleocharis rostellata (Torr.) Torr., P, W, **Willoughby Mt.,** (*Tuckerman* NEBC), MI = *E. pauciflora* (Lightf.) Link.

Erigeron acris L. [*E. angulosus* Gaudin], D, **Royalton,** (*Drake*), NSF; **St. Johnsbury,** (*Pringle* VT), IC, collection from Maine. The nearest known stations are in Aroostock County, Maine. A Pringle specimen with a typed label at VT says "barren places by the St. Johnsbury RR." The label is a later addition; other, apparently identical, collections have handwritten labels which read "barren places by the St. Johns River, Me."

Eriocaulon decangulare L., P, **Willoughby,** (*Wood*), NSF.

Erodium moschatum (L.) L'Her., A, S, D, **Burlington,** (*Brainerd* VT), MI = *E. cicutarium* (L.) L'Her.; D, **Woodstock,** (*Kittredge*), NSF.

Eubotrys racemosa (L.) Nutt. [*Leucothoe racemosa* (L.) Gray], P, **NL,** (*NCC*), NSF.

Eupatorium dubium Willd., A, S, **many counties,** (*several collectors* VT, NEBC), MI = *E. purpureum* L. and *E. maculatum* L. All of the Vermont records for *E. dubium* are annotations of specimens originally determined as *E. purpureum* or *E. maculatum.* None of the annotated specimens agree with typical coastal *E. dubium* and we refer them all to their original determinations.

Eupatorium fistulosum Barratt, A, S, **many localities,** (*several collectors* LSC, NEBC, VT), MI = *E. maculatum* L. *Eupatorium fistulosum* is normally differentiated from *E. maculatum* by a hollow stem, fewer flowers per head, and a more convex inflorescence. Hollow-stemmed plants definitely occur in Vermont, but field and museum study (Jenkins, unpubl. data) has shown that such plants are neither more convex nor fewer-flowered than adjacent solid-stemmed plants. In addition, the hollowness of the stem is far from being a clear-cut character. It varies in different sections of the stem and in different stems in a colony and is often mimicked by boring beetles. At present we are unable to recognize two species in our material and consider all the hollow-stemmed plants from Vermont to be forms of *E. maculatum.*

Euphorbia geyeri Engelm., D, **North Hero,** (*Brainerd* VT), MI = *E. nutans* Lag.

Euphorbia humistrata Engelm., D, **St. Johnsbury,** (*Howe*), NSF.

Euphorbia marginata Pursh, A, C, D, **Brandon,** (*Dutton* VT), CULT; A, **Windsor,** (*Leland* NEBC), CULT; **Burlington,** (*Flynn* VT), CULT.

Euphorbia serpyllifolia Pers., D, **Middlebury,** (*Brainerd*), NSF.

Forsythia suspensa (Thunb.) Vahl, A, **Brattleboro,** (*Wheeler* NEBC), CULT. The specimen is from Retreat Park, which has a formal garden with extensive ornamental plantings; we assume it was cultivated.

Fragaria ×*ananassa* Duchesne [*F. grandiflora* Ehrh.], D, **Burlington,** (*Blake*), NSF.

Galium pumilum Murray [*Galium sylvestre* Poll.], E, D, **Charlotte,** (*Pringle* MO), MI = *G. mollugo* L.; **Charlotte,** (ex herb. *Horsford* MO), MI = *G. mollugo.*

Gaylussacia frondosa (L.) T. & G., D, **Wells River,** (*Smith*), NSF.

Gentiana rubricaulis Schwein., C, S, **Stowe,** (*Straw* VT), NSF = *G. linearis* Froelich. Dr. James Pringle (pers. comm.), who monographed the section Pneumonanthae of *Gentiana* (Pringle, 1967), saw the specimen at VT and annotated it to *G. linearis* Froel. The specimen is now missing.

Geranium dissectum L., O, **Castleton,** (*Carr*), NSF.

Gilia tricolor Benth., D, **Stratton,** (*Blanchard*), NSF.

Glyceria fluitans (L.) R. Br., D, **11 sites,** (*several collectors* VT), IC = *G. borealis* (Nash) Batch. Early Vermont botanists used the names *G. fluitans,* which is now restricted to a species of Europe and eastern Canada, and *G. septentrionalis* A. Hitchc., now restricted to a species occuring from Massachusetts south, for the common plants now referred to *G. borealis.*

Glyceria obtusa (Muhl.) Trin. [*Poa obtusa* Muhl.], O, P, **Bellows Falls,** (*Carey*), NSF.

Glyceria septentrionalis A. Hitchc., E, D, **Hartland,** (*Ruggles*), NSF; D, **North Hero,** (*Brainerd*), IC = *G. borealis* Batch.; D, **Weston,** (*Carpenter*), IC = *G. borealis*; D, **Colchester,** (*Dole*), NSF; D, "**Vermont,**" (*Pringle*), NSF; **East Wallingford,** (*Kent*), IC = *G. borealis.* See notes on *Glyceria fluitans* above.

Goodyera oblongifolia Raf. [*Goodyera menziesii* Lindl., *Epipactis decipiens* Ames], D, **St. Johnsbury,** (*Balch & Howe* SJFM), MI = *G. tesselata* Lodd.; KI, D, **Woodstock,** (*Kittredge* VINS), IS. The Woodstock collection at VINS lacks a locality or date but has a collection number matching one written in Kittredge's copy of her 1931 flora. The plant is missing from the sheet, but from the outline of the leaves remaining on the paper we believe it was *G. tesselata* or *G. repens* (L.) R. Br.

Habenaria ciliaris (L.) R. Br., J, O, P, **Middlebury,** (*James*), NSF; AM, **Troy,** (*Carey* MO), NSF; D, E, **Bellows Falls,** (*Carey*), NSF; A, **Troy,** (*Carey* VT), DP, MI = *H. blephariglottis* (Willd.) Hook.? *Habenaria ciliaris* was originally credited to the Vermont flora in an early list of the plants of Middlebury (James, 1823). Perkins (1888) noted, on the authority of Ezra Brainerd, that James prepared the list "in his earlier manhood and before he had acquired the botanical skill to which he afterwards attained," and that "although of great value, it nevertheless must be used with care as it contains undoubted errors." The collection cited at MO by Ames (1910) is missing. The Carey specimen at VT is labeled "*Habenaria blephariglottis,* Troy, Vt., John Carey, 1861." We reject this record for two reasons. First, *Habenaria blephariglottis* (Willd.) Hook. and *H. ciliaris,* while easily separated by color in the field, are hard to tell apart accurately when dry (Voss, 1972, p. 442). Herbarium identification rests on the length of the fringe on the lip, a character which we have found to vary considerably in other Vermont collections of *H. blephariglottis.* Because of this variability we cannot determine the specimen with certainty, but think it is probably *H. blephariglottis.* In addition, we find it hard to believe that if Carey had found a yellow-flowered *Habenaria* he would have used the name of a common white species. Second, the specimen has been remounted and the current sheet consists of portions of two older herbarium sheets, one of which bears the specimen, and the other the label data. The original papers differ in texture and composition, suggesting they are of different ages and that an error occurred when the plant was being remounted. Thus, both the identification of the specimen and the accuracy of the label are questionable.

Habenaria leucophaea (Nutt.) A. Gray, D, **St. Johnsbury,** (*Howe* SJFM), MI = *H. lacera* (Michx.) Lodd.; D, **Danville,** (*Howe & Balch* TUFT), MI = *H. psycodes* (L.) Sprengel.

Hieracium gronovii L., T, **Colchester,** (*Torrey* VT), MI = *H. scabrum* Michx.; T, **Brattleboro,** (*Frost*), NSF; D, **Woodstock,** (*Kittredge*), NSF.

Hydrangea arborescens L., D, **Burlington,** (*Dole*), NSF.

Iberis amara L., A, **Peacham,** (*Blanchard* HNH), NDN.

Ilex laevigata (Pursh) A. Gray, T, **mouth of Winooski River,** (*NCC*), NSF; C, LI, **Rutland Co.,** (*NCC*), NSF; **Charlotte,** (*Eggleston* HNH), MI = *I. verticillata* (L.) A. Gray.

Ipomoea coccinea L., D, **Burlington,** (*Mrs. Zottman*), NSF.

Ipomoea quamoclit L. [*Quamoclit vulgaris* Chosey], A, **Windsor,** (*Leland* NEBC), CULT. The specimen has two labels. The original label says "habitat gardens"; a second label, covering the first, says "garden escape."

Isatis tinctoria L., P, **Burlington,** (*NCC*), NSF.

Juglans nigra L., D, **Leicester,** (*Dutton*), NSF; A, C, S, **West Dover,** (*Eaton* NEBC), MI = *J. cinerea* L.; **"Railroad Street,"** (*Roony* SJFM), NDN.

Juncus brachycarpus Engelm., A, **Caledonia Co.,** (*Seymour*), NSF.

Lamium album L., D, **St. Johnsbury,** (*Howe*), NSF; D, **Burlington,** (*Flynn* VT), MI = *L. maculatum* L.

Lappula redowskii (Hornem.) Greene, A, **Williston,** (*Bates* GH), MI = *L. squarrosa* (Retz.) Dumort [*L. echinata* Gilib.].

Lechea maritima Leggett, A, C, S, **Burlington,** (*Flynn* VT), MI = *L. intermedia* Leggett; A, C, S, **Burlington,** (*Charette,* det. A. R. Hodgdon, MO, HNH), MI = *L. intermedia*; A, C, S, **Essex,** (*Charette* VT), MI = *L. intermedia*; A, C, S, **Essex,** (*Brainerd* VT), MI = *L. intermedia. Lechea maritima* is, to us, a poorly delimited species. The characteristic pubesence of coastal plants is not present on inland material that we have seen, making *L. maritima* difficult to separate from *L. intermedia* without mature seeds. The inland range of *L. maritima* is, correspondingly, uncertain. When Hodgdon reviewed the genus (Hodgdon, 1938) he found no valid records from Vermont, though subsequently he identified Charette's 1969 Burlington collection as *L. maritima.* This specimen appears to us to fall within the range of variation of the Vermont specimens of *L. intermedia* and we refer it to that species.

Lepidium ruderale L., P, **Rutland,** (*Pringle*), NSF; D, **Leicester Junction,** (*Brainerd*), NSF; **Lyndonville,** (*Bahosh* LSC), MI = *L. virginicum* L.; **Brighton,** (*Trafan* LSC), IS; **Burlington,** (*Cook, Grout* VT), MI = *L. densiflorum* Schrader.

Lespedeza procumbens Michx., D, "**Vermont,**" (*NCC*), NSF.

Ligustrum obtusifolium Siebold & Zucc., A, **Burlington,** (*Dole* VT), NDN. The sheets are labeled: "*in series sepium*" (in hedge rows), but this does not make it clear whether they are cultivated or escaped.

Linum grandiflorum Desf., D, **Brandon,** (*Dutton* VT), CULT; D, **Middlebury,** (*Brainerd* VT), CULT.

Lithospermum latifolium Michx., D, **Colchester,** (*D.B. Griffin*), NSF.

Luzula confusa Lindeberg, C, S, **Rutland,** (*Eggleston* CONN), IC. The label on the specimen reads: "Mt. Washington, N.H., ex herb. W. W. Eggleston of Rutland."

Lycopus europaeus L., P, "**not very common,**" (*NCC*), NSF.

Lycopus rubellus Moench, D, **Bennington,** (*Ridlon*), NSF; A, D, **Burlington,** (*Dole*), NSF; A, S, **Lyndon,** (*Pease* NEBC), MI = *L. americanus* Muhl.; A, S, D, **Willoughby,** (*Kennedy* NEBC), MI = *L. americanus*; A, **Colchester,** (*Dole* VT), MI = *L. americanus*; A, **Benson,** (*Atwood* VT), MI = *L. americanus.* A range map in a review of this species by Henderson (1962) shows no Vermont occurrences.

Macleaya cordata (Willd.) R. Br., D, **Proctor,** (*Kittredge*), NSF.

Matricaria recutita L. [*M. chamomilla* L.], D, **St. Johnsbury,** (*Howe*), NSF.

Matthiola incana (L.) R. Br., A, **Peacham,** (*Blanchard* HNH), CULT.

Melothria pendula L., D, **Burlington,** (*Flynn* VT), CULT.

Mertensia virginica (L.) Pers., E, D, **Burlington,** (*Gifford*), NSF; D, **Fair Haven,** (*Carpenter*), NSF; S, **Burlington,** (*Jones* VT), NDN. This is a common cultivar. The Jones collection says "old cellar hole" and provides no evidence that the plant has spread beyond the area where it was cultivated.

Mimulus alatus Aiton, D, **Wells River,** (*Smith*), NSF.

Mimulus guttatus DC. [*M. langsdorfii* Donn], D, **Reading,** (*Whiting*), NSF.

Muhlenbergia racemosa (Michx.) BSP., A, S, **Westmore,** (*Stevens* HNH), MI = *M. mexicana* (L.) Trin.; A, S, **Westmore,** (*Dean* HNH), IC = *M. glomerata* (Willd.) Trin.; A, S, **Norwich,** (*Jesup* HNH), IC = *M. glomerata*; KS, **Hartland,** (*Ruggles* HNH), IC = *M. glomerata.* The name *M. racemosa,* which formerly included the Vermont plants now referred to *M. glomerata,* is now restricted to a western species.

Muscari botryoides (L.) Miller, D, "**occasional,**" (*NCC*), NSF; A, S, **Peacham,** (*Blanchard* HNH), CULT; A, S, **Charlotte,** (*Pringle* VT), CULT; **North Street,** (*Carpenter* VT), DP, NDN. This is a common cultivar which, although naturalized elsewhere in the northeast, has not been found wild in Vermont. The Carpenter specimen lacks a town or a state and was not cited in any floras; it may well be a Vermont collection, but cannot be accepted without corroborating evidence.

Myriophyllum heterophyllum Michx., P, **NL,** (*NCC*), NSF.

Nelumbo lutea (Willd.) Pers., D, **Champlain Valley,** (*Brainerd*), NSF.

Oenothera biennis L. var. *canescens* T. & G. [*O. canescens* Torr. & Frem.], D, **Woodstock,** (*Kittredge*), MI = *O. parviflora* L. var. *oakesiana* (Robbins) Fern.

Oenothera fruticosa L., T, **Willoughby,** (*Frost*), NSF; S, **Danville,** (*NNC* VT), NSF.

Panicum amarum Elliott, P, **Brattleboro,** (*Barrett, Robbins & Pringle*), NSF.

Panicum polyanthes Schultes, D, **Leicester,** (*Dutton*), NSF.

Panicum spretum Schultes, A, S, **Townshend,** (*Dobbin* MO), MI = *P. lanuginosum* Ell.

Papaver dubium L., P, **NL,** (*NCC*), NSF; **Charlotte,** (*Pringle* VT), CULT.

Papaver intermedium Becker, EB, **Townshend,** (*Blanchard*), NSF. This name, taken from the original publication, is apparently no longer in use. We have been unable able to determine its modern equivalent.

Penstemon laevigatus Aiton [*Penstemon calycosus* Small], A, S, **five counties,** (*several collectors* VT, NEBC), MI = *P. digitalis* Nutt.; PE, **near Poultney,** (*Drushel* PH), MI = *P. digitalis.*

Petrorhagia saxifraga (L.) Link [*Tunica saxifraga* (L.) Scop.], D, **Morrisville,** (*Bentley*), NSF.

Petroselinum crispum (Miller) Mansf., A, **Townshend,** (*Wheeler* NEBC), CULT; A, **Caledonia Co.,** (*NCC* NEBC), NSF.

Phlox drummondii Hook., A, **Peacham,** (*Blanchard* HNH), NDN.

Physalis peruviana L., E, D, **Burlington,** (*Jones* VT), MI = *P. pubescens* L.; D, **Hinesburg,** (*Roy* VT), MI = *P. heterophylla* Nees.

Plantago virginica L., T, **Brattleboro,** (*Frost*), NSF.

Poa alpina L., O, **Mt. Mansfield summit,** (*Robbins*), NSF. *Poa alpina,* a species of the subarctic, closely resembles our *Poa fernaldiana* Nannf. The latter occurs on Mt. Mansfield and may be the species that Robbins saw.

Polygonum ramosissimum Michx., A, **Manchester,** (*Day* VT), MI = *P. aviculare* L.; BR, "**frequent,**" (*NCC*), MI = *P. aviculare* (Eggleston and Brainerd, 1904).

Potamogeton pulcher Tuckerman, P, **Brattleboro,** (*Frost*), NSF.

Prenanthes nana (Bigel.) Torr. [*P. trifoliolata* (Cass.) Fern. var. *nana* (Bigel.) Fern.], E, **Willoughby Mt.,** (*Rusby*), NSF.

Prenanthes racemosa Michx., D, F, **Swanton,** (*Blake*), NSF.

Primula veris L. [*P. officinalis* (L.) Hill], D, S, **Burlington,** (*Jones*), NSF.

Prunus avium L., A, S, D, **Manchester,** (*Day* NEBC), MI = *P. cerasus* L.

Prunus cerasifera Ehrh., A, **Franklin Co.,** (*NCC* NEBC), NSF.

Prunus persica (L.) Batsch., A, **Jamaica,** (*Wheeler* NEBC), CULT.

Pycnanthemum setosum Nutt. [*P. aristatum* Michx.], P, **Southern Vermont,** (*NCC*), NSF.

Pyrus baccata L., D, **St. Johnsbury,** (*Miss Howe*), NSF.

Pyrus prunifolia Willd., A, S, **Worcester,** (*Blanchard* NEBC), NDN.

Quercus palustris Muenchh., D, **Pittsford,** (*Dutton*), NSF.

Quercus prinoides Willd., BR, D, E, **Pownal,** (*several collectors* VT, NEBC, HNH, NCU), MI = *Q. muehlenbergii* Engelm.; A, S, **Addison,** (*Brainerd* VT), MI = *Q. muehlenbergii* and hybrids. The leaves of *Q. prinoides,* a species of sandplains in southern and central New England, are very similar to those of *Q. muehlenbergii,* a species of limy hills and ledges that is uncommon but widely distributed in western Vermont (Zika, 1986A). Well-developed leaves of *Q. muehlenbergii* are typically larger and have more teeth than those of *Q. prinoides.* Leaves of intermediate form are common in both species, and some authors (i.e., Gleason, 1952) consider *Q. muehlenbergii* an arborescent variety of *Q. prinoides.* Collections of *Q. prinoides* from Quarry Hill in Pownal lack bark and habit notes. They cannot be determined with certainty, though many suggest *Q. muehlenbergii* more strongly than *Q. prinoides.* Quarry Hill is a limestone hill, and has an extant population of *Q. muehlenbergii*; hence we refer all the historical collections from Quarry Hill to that species. Specimens from Snake Mountain in Addison also lack notes and are likewise undeterminable. The plants there, which were recently relocated, are in a calcareous site and are typically low and multi-stemmed but occasionally have strong single trunks several meters high. Their leaves are exceptionally variable, some suggesting *Q. prinoides,* some *Q. muehlenbergii,* and some seemingly hybrids with *Q. prinus* L., which occurs nearby. Given the variability we are reluctant to name this population. But we do not think that the Snake Mountain plants, viewed as a group, are sufficiently distinct from the typical *Q. muehlenbergii* of the Champlain Valley, or sufficiently similar to the typical *Q. prinoides* of southern New England, to be the basis of a new state record and northward range extension for *Q. prinoides.*

Ranunculus micranthus Nutt., A, D, E, **Coventry,** (*Cushman* HNH), MI = *R. abortivus* L.

Reseda odorata L., S, **Windsor,** (*Leland* NEBC), CULT. As with *Ipomoea quamoclit,* the original label (now covered by a second label) says "garden plant."

Ribes nigrum L., A, S, D, **Townshend,** (*Wheeler* VT), CULT; **Dummerston,** (*Wheeler* NEBC), IS; **Wallingford,** (*Kent* NEBC), IS; **Newport,** (*Knowlton* NEBC), IS (sterile). Good flowering material is needed to distinguish this species from *R. americanum* Miller.

Rosa ×alba L., D, **Townshend,** (*Wheeler*), NSF; D, **Stratton,** (*Underwood*), NSF; D, **Leicester,** (*Dutton*), CULT.

Rosa canina L., D, **Woodstock,** (*Wright*), NSF; D, **Johnson,** (*Grout* VT), IC = *R. pimpinellifolia* L. [*R. spinossisima* L.]. The specimen was originally determined as *R. canina,* then annotated, correctly, to *R. spinossisima.* Later it was cited, incorrectly, as *R. canina.*

Rosa damascena P. Mill., D, **Norwich,** (*Loveland*), NSF; D, **Leicester,** (*Dutton*), CULT.

Rosa johannensis Fern., A, S, **North Hero,** (*Knowlton* NEBC), MI = *R. blanda* Ait.; A, S, **Gardiner Island,** (ex herb. *Faxon* NEBC), MI = *R. blanda*; A, S, **Royalton,** (*Eggleston* NY), MI = *R. blanda*; A, S, **Ferrisburg,** (*Faxon et al.* NY), MI = *R. blanda. Rosa johannensis* is a species of uncertain status that may eventually be included in *R. blanda.* Whatever its final disposition, all the Vermont specimens seem to be typical *R. blanda.*

Rosa tomentosa J. E. Smith, D, **Woodstock,** (*Kittredge*), NSF; D, **Pomfret,** (*Kittredge*), NSF.

Rumex altissimus Wood, A, **Windham Co.,** (*NCC* VT), NSF.

Rumex aquaticus L., P, **near summit of Mt. Mansfield,** (*NCC*), NSF. *Rumex longifolius* DC. was found as a weed near the summit of Mt. Mansfield before 1900, and handwritten notes in the copy of Perkins (1888) used to prepare the Brainerd et al. (1900) flora suggest that this is the species to which Perkins was referring.

Rumex arifolius All. [*Rumex montanus* Desf.], D, **Burlington,** (*Ross* VT), MI = *R. acetosa* L.

Rumex patientia L., A, **5 counties,** (*several collectors* HNH, VT), IC = *R. longifolius* DC. [*R. domesticus* Hartm.]. Early Vermont botanists, following the Seventh Edition of *Gray's Manual* (Robinson and Fernald, 1908), used the name *R. patientia* for the plants we now call *R. longifolius.* True *R. patientia* occurs in the northeastern U.S., but apparently not in Vermont.

Sagittaria lancifolia L. [*S. falcata* Pursh], T, **Brattleboro,** (*Frost*), NSF; P, **Mallets Bay, Colchester,** (*NCC*), MI (see Brainerd et al., 1900). A review by Bogin (1955) lists no occurrences of this species north of Delaware.

Sagittaria subulata (L.) Buch. [*S. natans* Michx.], P, T, **Brattleboro,** (*Frost*), NSF.

Salix pentandra L., D, **Burlington,** (*Dole*), NSF.

Salix serissima (L. H. Bailey) Fern., A, D, S, **Arlington,** (*Knowlton* NEBC), IS; A, S, **Corinth,** (*Anderson* NEBC), NSF; A, **Franklin Co.,** (*NCC* HNH), MI = *S. lucida* Muhl.; **Westmore,** (*Churchill* HNH), MI = *S. lucida* Muhl. Young sterile shoots of *Salix serissima* are hard to distinguish from *S. lucida* and cannot be determined with certainty. We expect that *S. serissima* will eventually be found in Vermont, but, as yet, do not have confirming specimens.

Saururus cernuus L., **Bristol,** (*Dike* VT). The specimen is correctly identified but is uncorroborated by written citations or other collections from Vermont and is probably mislabeled. Geographically, *Saururus cernuus* is a southern species that reaches its northern range limits in southern Massachusetts and western New York. Bristol is ca. 150 miles from the nearest stations in western New York and 200 miles from the nearest colonies in southern New England and the Hudson Valley. This is a substantial disjunction: out of ca. 250 species which reach their northern range limits in Vermont, only six are disjunct by more than 75 miles from the nearest colonies in other states, and only three of these by ca. 100–125 miles (Jenkins, in prep.). The wetlands in Bristol—which are only 20 miles from Burlington—were a famous botanical site and received the attention of all the prominent Vermont botanists of Dike's day, especially Pringle and Brainerd. In addition, Dike traded specimens with Pringle and others. It seems likely to us that the discovery of a conspicuous and exceedingly rare species would have been noted and verified by other botanists and would have been cited in print. Given the geographic implausibility and the absence of any corroborating citations or specimens, we consider it likely that the specimen was mislabeled.

Sedum telephioides Michx., D, **Colchester,** (*Flynn* VT), MI = *S. telephium* L.; D, **Burlington,** (*Dole*), NSF.

Silene caroliniana Walter [*S. pensylvanica* Michx.], D, **Wells River,** (*Smith*), NSF.

Sisyrinchium albidum Raf., P, **NL,** (*NCC*), NSF.

Smilax glauca Walter, D, **Clifton,** (*Britton* VT), DP. There is no Clifton in Vermont. Britton made a number of collections from Clifton, N. Y., on Staten Island.

Smilax rotundifolia L., O, P, **NL,** (*NCC*), NSF.

Solanum tuberosum L., A, **Newfane,** (*Wheeler* NEBC), NDN.

Solanum villosum Miller, S, **Westford,** (*Munier* VT), MI = *S. sarrachoides* Sendtner.

Solidago calcicola Fern., C, CR, S, **Mt. Killington,** (*Dutton et al.* VT, GH, NEBC), MI = *S. macrophylla* Pursh × *rugosa* Aiton. The specimens were probably from a single plant. The original collectors took them to Fernald who first determined them as *S. calcicola* (Kirk, 1912A, 1912B), then compared them to the northern material he was calling *S. calcicola* and changed his mind (Anonymous, 1915).

Solidago rigida L., T, **Burlington,** (*Torrey*), NSF.

Solidago stricta Aiton, T, **Burlington,** (*Torrey*), NSF.

Spartina alterniflora Loisel, D, **Vermont,** (*Pringle*), NSF. Given the lack of any citations in other floras we regard it as improbable that Dole ever saw a Pringle sheet of either this or the next.

Spartina patens (Aiton) Muhl., D, **Vermont,** (*Pringle*), NSF.

Sphenopholis pensylvanica (L.) A. Hitchc. [*S. palustris* Scribn., *Trisetum pensylvanicum* (L.) Beauv.], A, S, **Wells River,** (*Jones* VT), NSF. References to *Avena pensylvanica* L. or *Eatonia pensylvanica* A. Gray in early floras (i.e., Brainerd et al., 1900) refer to *S. intermedia* (Rydb.) Rydb. and not *S. pensylvanica.*

Spiraea japonica L. f., D, **Woodstock,** (*Kittredge*), NDN; **Peacham,** (*Blanchard* NY), NDN, MI = *Astilbe japonica* (Morren & Decne.) A. Gray.

Spiraea prunifolia Siebold & Zucc., A, **Middlebury,** (*Brainerd* VT), NDN. Brainerd collected this species in 1898 but did not list it in his flora (Brainerd et al., 1900), suggesting that the collection was from a cultivated plant.

Stellaria longipes Goldie [*Stellaria strictiflora* (Rydb.) J. M. Macoun], D, **Woodstock,** (*Porter*), MI = *S. graminea* L.; D, **Plymouth,** (*Heselton*), NSF; D, **Passumpsic,** (*Howe*), NSF; D, **Weston,** (*Carpenter*), NSF.

Thalictrum revolutum DC. [*T. purpurascens* L. of Robinson and Fernald (1908) in part], KI, D, **Woodstock,** (*Kittredge* VINS), MI = *T. dioicum* L.; D, **Clarendon,** (*Hitchcock* NY), MI = *T. pubescens* Pursh.

Thaspium trifoliatum (L.) A. Gray [*T. aureum* Nutt., misapplied; *Thaspium aureum* var. *aptera* A. Gray], P, "**common in damp fields,**" (*NCC*), NSF. The treatments of *Thaspium* and *Zizia* are extremely confused in 19th-century manuals (i.e., Gray, 1874). Perkins was probably referring to *Zizia aurea* (L.) Koch.

Tipularia discolor (Pursh) Nutt., P, **Brattleboro,** (*Frost*), NSF; P, "**Vermont,**" (*Beck*), NSF; D, **Bradford,** (*Bacon*), NSF. Perkins (1888) called the early records doubtful. Despite the lack of a specimen or corroborating documentation, *Tipularia* was put on the official Vermont list of protected plants (13 V. S. A., Chapter 79) in the 1930's.

Tradescantia subaspera Ker Gawler, A, S, D, **Hartland,** (*Carpenter* VT), MI = *T. virginiana* L.

Trifolium medium L., D, **Wells River,** (*Eastman*), NSF; D, **Burlington,** (*Jones*), NSF.

Trifolium stoloniferum Muhl., P, **Bellows Falls,** (*Brown*), NSF. See Brooks (1983).

Viburnum prunifolium L., D, **Ferrisburg,** (*Kittredge*), NSF.

Viola brittoniana Pollard, D, **Vermont,** (*Dutton*), NSF.

Viola elatior Fries., D, **Wells River,** (*Eastman*), NSF, NDN.

Viola odorata L., A, S, **Jamaica,** (*Wheeler* NEBC), NDN; **Middlebury,** (*Brainerd* HNH), CULT; **Norwich,** (*Richardson* HNH), NDN.

Viola pedata L., T, **Brattleboro,** (*Frost*), NSF.

Viola striata Aiton, A, S, **Middlebury,** (*Brainerd* VT), NSF.

Vitis vulpina L. [*V. cordifolia* Michx.], P, **NL,** (*NCC*), NSF.

Woodsia oregana D.C. Eaton, B, G, **Charlotte,** (*Pringle* IA), CULT.

Zizia aptera (Gray) Fern. [*Zizia cordata* (Walt.) DC., *Thaspium trifoliatum* Gray var. *apterum* Gray, ? *T. cordatum* T. & G.], P, **NL,** (*NCC*), NSF; O, **Middlebury,** (*James*), NSF. The treatments of *Thaspium* and *Zizia* are extremely confused in 19th-century manuals (i.e., Gray, 1874), and we are not sure what species Perkins and Oakes had in mind.

DISCUSSION

The rate of additions

How fast are species being added to the Vermont flora? Our manuscript checklist (Jenkins and Zika, in prep.) lists 1933 species for Vermont, of which 1310 (68%) are believed to be native. In the last 19 years approximately 19 native species and 58 aliens have been added to the flora, or roughly three aliens for every native species. These numbers give a growth rate of 0.2% per year for the whole flora, 0.08% for the native species, and 0.5% per year for the alien species, with the pool of aliens growing six times faster than the pool of native species.

These numbers show that there are still discoveries to be made in a flora which, by United States standards, is very well-known. If the present discovery rate continues, the number of native species reported will grow by nearly 10% in the next century, the number of aliens by a remarkable 50%, and the whole flora by approximately 20%.

The continuing discovery of new species, after 150 years of botanical effort, raises the question of whether the newly discovered plants are recent immigrants or resident species that have been overlooked. This is an impossible question to answer factually, but we can advance three indirect arguments that support the hypothesis that many of the newly discovered species are new arrivals.

(1) Approximately 620 species of aliens have immigrated to Vermont in about 230 years of European settlement. The average

immigration rate was 2.7 species per year and the peak immigration rate has to have been larger than this. The current discovery rate (about 3.0 alien species per year) is roughly the same as the average immigration rate and so it is at least possible that many discoveries are recent immigrants.

(2) The discovery rate for all species declined six-fold from about 20 species per year in the late 1800's to a rate of two to three species per year by the middle of this century. If we were exhausting a fixed pool of undiscovered species, we would expect the decline would have continued and that the current discovery rate would be lower than the mid-century rate. But instead, it has increased slightly to about four species per year (Jenkins and Zika, in prep.). This suggests either that the depletion of the pool of undiscovered species is being offset by increased botanical effort or that the pool is being replenished through immigration.

(3) Many of the newly discovered species, both natives and aliens, are colonizing species found in successional or human-disturbed habitats. In such habitats, individual populations of rare species are almost always transient; we have only a few documented examples (e.g., *Lygodium palmatum* (Bernh.) Swartz, *Ceanothus herbaceus* Raf.) of rare species that have persisted for more than a decade or two in successional habitats. Probably many of the newly arrived species in such habitats neither persist nor establish elsewhere (Pimm, 1991; Muhlenbach, 1979). The remainder spread, often rapidly, as *Puccinellia distans* (Jacq.) Parl. and *Panicum dichotomiflorum* Michx. have recently done (Zika, 1990) or as *Cardamine impatiens* L. and *Carex praegracilis* W. Boott appear to be doing (Jenkins, pers. obs.; Reznicek and Oldham, 1993). This suggests that it is likely that many of the species that are both rare and restricted to transient habitats are fairly recent arrivals.

None of the above arguments proves that the newly discovered species are recent immigrants, but, taken together, they at least make it plausible.

The plausibility of unvouchered records

We have deleted 130 unvouchered taxa from the flora. It is likely that some of these excluded taxa (for example, *Carex crawei* Dewey, which Perkins reports on the basis of a collection by C. G. Pringle from Charlotte (Perkins, 1888)) are valid records. Given that Pringle knew sedges well and was a scrupulous collector, that good habitat for the species exists in Charlotte, and that the species occurs on the New York side of Lake Champlain within 20 miles of Charlotte, it seems quite likely to us that a specimen once existed and has since been lost.

With equal certainty, some of the unvouchered records are invalid. The record of *Erigeron acris* L. from Royalton, Vermont, 300 miles south of the nearest vouchered colony and mentioned only in a flora (Dole, 1937) whose compilers did not require specimens, is almost certainly a mistake.

By rejecting unvouchered records, we thus guard against mistakes; but, at the same time, we exclude some authentic records for which the validating specimens have been lost. This is common botanical practice and is amply justified if our chief purpose is to avoid mistakes or, for that matter, to tabulate as accurately as possible the current holdings of botanical museums. But if our purpose is to make the most accurate possible list of the historical flora of the state and if, on the average, more of the unvouchered records are right than wrong, we will improve our overall accuracy by including them, albeit at the cost of including some mistakes as well. But are more of the unvouchered records right than wrong?

A review of the geography of the unvouchered records strongly suggests that they are not. Of the 85 native species with one or more unvouchered records, only 15 are known from sites within 100 miles of their reported Vermont locality. The remaining 70 (82%) are long disjuncts. This contrasts with an overall frequency of less than 3% for long disjuncts among the 1310 native species that we currently list for Vermont (Jenkins and Zika, in prep.). Thus, the frequency of long disjunctions is 27 times higher among unvouchered than vouchered records, suggesting that many of them are geographically suspect.

The geographic plausibility of the 45 species of unvouchered aliens is more difficult to evaluate. Since long disjunctions are common in weedy species and since most cultivars are potentially able to escape, any alien species occurring or cultivated in the northeast U.S. might conceivably occur in Vermont. With this interpretation of what is geographically possible, 21 of the unvouchered aliens are regarded as possible because they are cultivars, 16 are regarded as possible because they have occurred as introductions in the northeast, and 8 are neither cultivated nor escaped regionally and so unlikely on geographic grounds.

Table 1. Approximate error rates in previous Vermont floras relative to current knowledge

	Date of Flora						
	1853	**1888**	**1900**	**1915**	**1937**	**1969**	**1973**
Total Species[a]	1034	1360	1563	1694	1861	1927	1990
Species we delete[b]	27	33	4	15	101	40	58
Possible error rate (%)[c]	2.6	2.4	0.3	0.9	5.4	2.1	2.9

Notes: [a] Number of species in flora, not corrected to current taxonomy. [b] Number of species from that flora we have deleted in this article. [c] Number of species deleted divided by number species in flora, in percent.

Combining natives and aliens, 78 of the 130 unvouchered records (60%) are geographically unlikely. Fifteen (12%) are geographically plausible native species and 37 (28%) are cultivars or rare weeds which we also consider geographically plausible. Thus at least three-fifths of the unvouchered records are geographically unlikely and most probably based on misidentifications. This suggests that the inclusion of unvouchered records would add a substantial number of misidentifications (at least 78 and possibly as many as 130) to the Vermont flora and substantially decrease the overall accuracy of the flora.

This conclusion is strengthened by the observation that in the last 14 years of field work Vermont botanists rediscovered about 100 of the 200 vouchered native species that were considered missing in 1980 (50%), but only two out of the 83 missing unvouchered natives (2.4%). This means that either unvouchered native species are about 20 times harder to relocate than vouchered ones, or that 20 times more unvouchered native species have gone extinct than vouchered ones, or that many of the unvouchered species have never been here at all.

The completeness and accuracy of historical floras

Every flora has errors and omissions. The existence of seven previous Vermont floras gives us a rare opportunity to examine these quantitatively (Table 1). By using our manuscript checklist (Jenkins and Zika, in prep.) as a benchmark, we can calculate the percentage of the species we accept that are included in each previous flora, and also the ratio of the records we would delete from a previous flora to the total number of species in it (possible error rate). Note that we do not count changes in taxonomic rank as omissions or errors. We call the ratio a *possible* error rate because we may have erred in some of our re-determinations of historical specimens and because some percentage of the unvouchered records we are deleting may be valid. It is thus an estimate of the upper bound of the percentage of species erroneously credited to the flora.

Table 1 presents the results. The most interesting thing to note is that while the percentage of the 1992 flora included has increased with each successive flora, the possible error rate has sometimes increased and sometimes decreased. Newer is not necessarily better. The nineteenth century floras had a respectable possible error rate of about 2.5%, largely the result of misidentifications and taxonomic uncertainties, but included approximately 52% and 68% of our checklist flora (Jenkins and Zika, in prep.[4]). The two floras early in this century, which were based entirely on vouchers and prepared with great attention to taxonomic detail, included approximately 83% of our checklist flora and had impressively low possible error rates of 0.3% and 0.9%. The 1937 flora included 85% of the species we currently recognize; but it mixed vouchered and unvouchered records and so had a possible error rate of 5.4%, the highest of any Vermont flora. The 1969 flora and 1973 checklist, following a period of relative botanical inactivity, still increased the known Vermont flora to approximately 93% of our checklist flora total and improved the accuracy of the flora by eliminating many unvouchered records that had been reported in 1937. But in many cases the compilers of these works transcribed rather than verified label data and so introduced a number of misidentifications, nomenclatural errors, and inaccurate citations. In consequence, the 1969 flora and 1973 checklist have possible error rates of 2.1% and 2.9%, roughly half those of the 1937 flora, but several times higher than those of the more scrupulous 1900 and 1915 floras.

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[4] Estimates of the percent of our checklist flora included in an historical flora are made by taking the number of species in that flora (top line of Table 1), subtracting the number of species we are deleting (second line of Table 1), and then correcting for differences in taxonomic concepts. For example, the 1937 flora had 1861 species. We delete 102 of these, then subtract 125 species that we do not recognize, and add three species formerly considered varieties. The result is 1637 species, or 84.6% of our checklist total of 1933 species.

We close with several comments about floristic practice. First, Table 1 confirms what many botanists have long suspected: attempting to base a flora on unvouchered field records is a risky business. The Vermont floras that included unvouchered records (1853, 1888, 1937) had apparent error rates of 2.4% to 5.4%, meaning that anywhere from one species in 42 to one species in 19 in these works might be erroneously attributed to the flora. Second, owing to nomenclatural changes and the inevitable misidentifications found in all herbaria, attempting to do a flora by compiling herbarium records without verifying the nomenclature and the identifications is likewise risky. The recent Vermont floras that did this (1969, 1973) had apparent error rates of 2.1% and 2.9%, lower on average than those that accepted unvouchered records, but still suggesting that one species in 34 to one in 48 was erroneously attributed to the flora.

And finally, as has been forcefully stated by E. Voss (1972, p. 3, 7–8), given the inaccuracies in previous floras, it follows that any attempt to compile a state or regional checklist by combining several previous floras without examining primary records is likely to be highly inaccurate. If we were to compile a checklist of the flora of Vermont in this way, it would contain about 2125 species. One hundred ninety-two of these would rest on unvouchered or otherwise unacceptable records, for a possible error rate of nine percent, or one species in 11.

Thus, our conclusion, which is hardly radical, is that the practice of basing floristic work on the critical examination of vouchers seems amply justified. Such work in Vermont has produced error rates six to eighteen times lower than those of less critical works and approximately thirty times lower than what might be produced by compiling printed records.

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OCCURRENCE OF THE RED ALGA *THOREA VIOLACEA* (BATRACHOSPERMALES: THOREACEAE) IN THE HUDSON RIVER, NEW YORK STATE

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ABSTRACT

We discovered a population of *Thorea violacea* in the upper Hudson River of New York State during September 1994. The same site was barren of *Thorea* the following June, but two and a half months later—a year after the initial collection—a large population of thalli, some over a meter in length, was again present. This seasonality may account in part for the seeming rarity of this large, conspicuous alga. Thalli presumed to represent the Chantransia phase of the *Thorea* life cycle occurred on rocks at the same location with the same phenology. The Hudson River site represents the first confirmed North American locality of *T. violacea* north of Texas and the most northerly North American locality of the family Thoreaceae. Characterization of the chemical and physical conditions at the study site suggests broader environmental tolerances (lower specific conductance, greater water flow, colder water regimes) of this group than previously known.

Key Words: Chantransia stage, freshwater algae, Hudson River, Rhodophyta, *Thorea violacea*

INTRODUCTION

The Thoreaceae (Batrachospermales) is a family of multiaxial red algae, whose members, *Thorea* and *Nemalionopsis,* are among the largest red algae found in freshwater; *Thorea* may be up to 2 m long (Bischoff, 1965). The branched, cylindrical axes of these algae consist of an unpigmented, filamentous medulla surrounded by laterally disposed, highly pigmented filaments. Thallus color is generally blue-green or red.

Life cycles in the three families of the Batrachospermales typically involve alternation of morphologically dissimilar phases. Taxonomic diagnoses are based principally on the more conspicuous and anatomically complex gametophyte phase. This phase bears the generic epithet, e.g., *Thorea* phase. The sexual life cycle known for representatives of the Batrachospermaceae and Lemaneaceae involves an inconspicuous, freely branching, diploid phase, called Chantransia, that produces sessile, haploid gametophytes directly from apical cells following somatic meiosis (Sheath, 1984). Female gametes (carpogonia) and zygotes are retained on the gametophyte, which results in the growth of diploid, spore-producing filaments, collectively termed the carposporophyte, on the female gametophyte. Diploid carpospores, released by the carposporophyte, grow into the Chantransia phase (Sheath, 1984).

Life histories of the Thoreaceae are poorly known. Sexual structures have been described for some representatives of *Thorea* (Yoshizaki, 1986; Necchi, 1987), but the location of meiosis in the life history has not yet been documented. Asexual reproduction is common and conspicuous in this family (Swale, 1963) and involves the differentiation of spores, termed monospores, from terminal cells of lateral filaments. Although the morphology of the asexually reproducing *Thorea* phase thalli resembles that of gametophytes, monospores rather than gametes are produced (Swale, 1963). Monospores are also produced by Chantransia phase thalli. Regardless of the phase that generates the monospores, all monospores grow into thalli of the Chantransia morphology (Swale, 1962). Presumably, *Thorea* phase thalli that produce monospores rather than gametes are part of an apomictic life cycle, but chromosome counts are not available to evaluate this hypothesis. Generic phase thalli of *Nemalionopsis* produce monosporangia terminally on long lateral filaments (Sheath et al., 1993). Generic phase thalli of *Thorea* produce monosporangia on short, branching, lateral filaments, and the long lateral filaments are entirely vegetative (Sheath et al., 1993).

Sheath et al. (1993) recently revised the taxonomy of the Thoreaceae, reducing the number of recognized species of *Thorea* from thirteen to four. Two of these occur in North America, most commonly in the southern United States and Mexico (Sheath et al., 1993). *Thorea hispida* (Thore) Desvaux (as *T. ramosissima* Bory and *T. andina* Lagerheim et Möbius) has been reported from Nebraska (Hedgcock and Hunter, 1899), Illinois (Tiffany and Britten, 1952), and Ohio (Hirsch and Palmer, 1958), but the most northerly confirmed site for *T. violacea* Bory de Saint-Vincent (as *T. riekei* Bischoff) in North America, until our discovery of this species in the Hudson River, was southern Texas (Bischoff, 1965; Sheath et al., 1993). We also found in the field the presumptive alternate life history (Chantransia) phase of this alga. Based on environmental conditions present at the New York site, a greater ecological and geographical range for this species and for the genus is indicated.

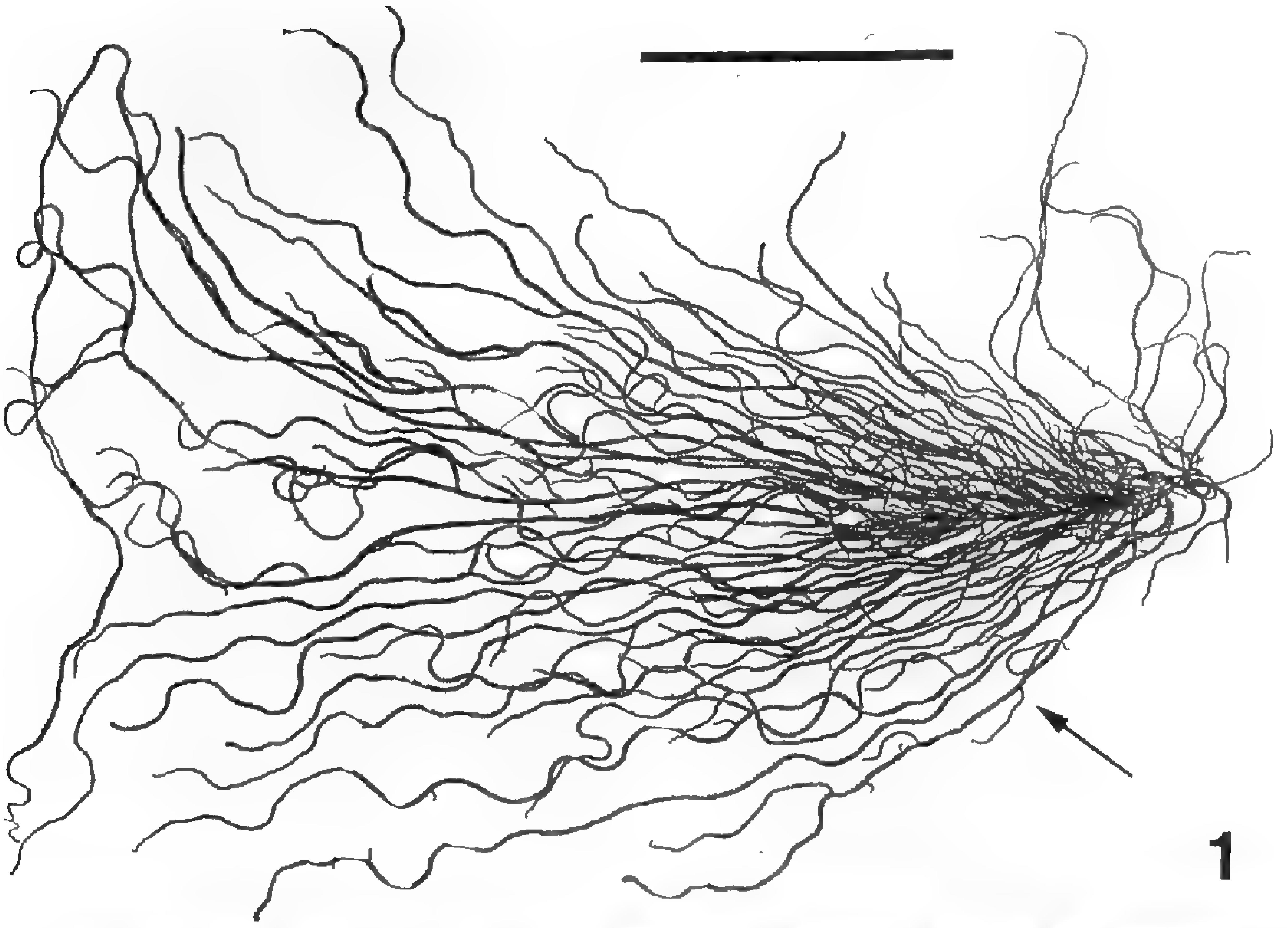
STUDY SITE

Thorea violacea was found growing attached to pebbles and small rocks at depths of ca. 30–70 cm in the Hudson River (73°35′W, 43°11′23″N), Saratoga County, Northumberland Township, New York State. The site is near the eastern shore of Thompson Island, downstream of a low head dam. The area containing *Thorea* was less than 1000 m^2. A portion of the site was shaded late in the day by trees onshore. *Thorea* grew in open areas between patches of vascular macrophytes, and only where the river bed consisted of pebbles and small rocks. Farther from shore, vascular macrophytes completely occupied the substratum; farther downstream, the river bed was mud rather than pebbles. *Thorea* was first discovered on 15 September 1994. Additional collections were made and environmental parameters were measured on 29 September 1994. Surface current velocity over the *Thorea* patch was 63 cm sec^{-1}. Specific conductance was 119 μS cm^{-1}; pH was 6.9; alkalinity was 0.39 meq l^{-1}. The site was revisited 30 June 1995, but no *Thorea* was detected. However, large thalli again were abundant when the site was visited 10 September 1995. Attempts to locate *Thorea* at three other relatively high-flow sites in the Hudson River and six selected tributaries in the area were unsuccessful.

Our measurements of conductivity and pH fell within the ranges recorded in unpublished US Geological Survey (USGS) data collected at Fort Edward, located 9 km upstream of our study site: conductance there was 44–136 μS cm^{-1}, and pH was 6.6–7.7. Total P was 0.1–0.5 mg l^{-1}, and NO_3^- was 0.2–0.9 mg l^{-1}. During a nine-year period, mean annual discharge ranged from 110–203 m^3 sec^{-1}, with a nine-year mean of 143 m^3 sec^{-1}. Water temperature ranged from 0–26°C; all twenty readings from November to March were less than 10°C. Five readings of water temperature during September, the month during which *Thorea* was collected, ranged from 15–19°C.

RESULTS AND DISCUSSION

Thalli of the *Thorea* phase of *T. violacea* varied considerably in the amount of macroscopically visible branching present. Most thalli were profusely branched near the base, resulting in many long axes without a distinct main axis (Figure 1); other thalli had



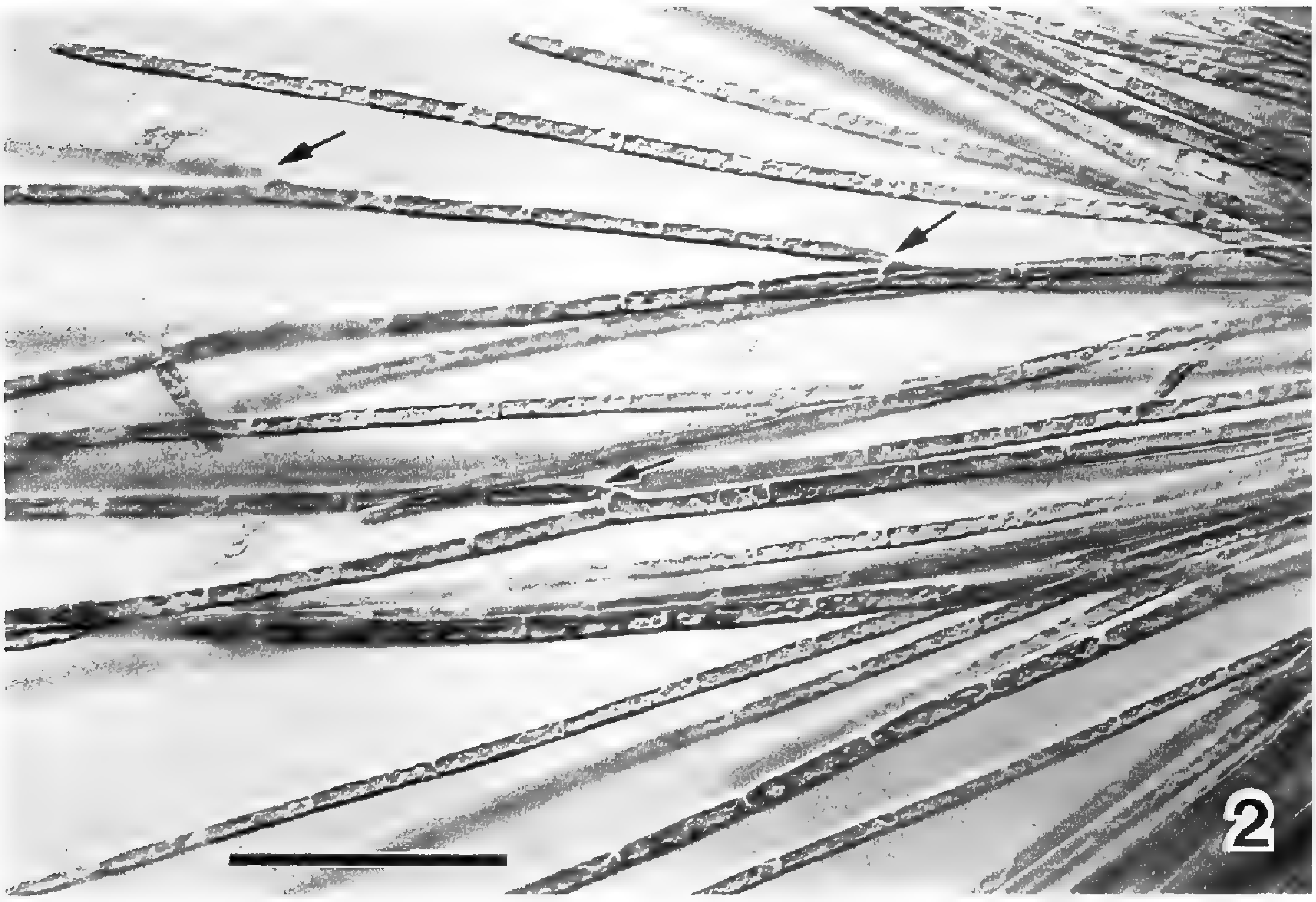


Figure 1. Herbarium specimen of monospore-bearing *Thorea* phase of *Thorea violacea* from the Hudson River. Branching is extensive near the base of the thallus, but few branches (arrow) emerge along the length of the long axes. Scale bar equals 0.1 m.

Figure 2. Light micrograph of a section of one long axis showing the distal portion of assimilatory filaments that radiate from the axis (axis not shown, but see Figure 3). Note that assimilatory filaments have non-clavate apical cells and occasional branches (arrows). Scale bar equals 100 μm.

only one or a few long axes. Secondary branching, which was initiated below the growing apices, occurred sparsely along the length of the long axes (Figure 1).

Each long axis was composed of numerous filaments whose branching was visible only by microscopic examination (Figures 2, 3). The core of the axis was composed of highly branched, interwoven, unpigmented filaments encased in a common mucilaginous matrix (Figure 3). At the outer edge of this colorless medullary zone, medullary filaments produced branches, not encased in mucilage, that were highly pigmented, occasionally branched (Figure 2), and oriented perpendicular to the axis (Figure 3). This fringe of lateral, determinate, assimilatory filaments surrounding the medulla formed a photosynthetic cortex. Monosporangia were produced on short filaments interspersed among the bases of the lateral assimilatory filaments (Figure 3).

The identity of our specimens as *T. violacea* was determined using key criteria proposed by Sheath et al. (1993): generally sparse secondary branching of long axes (Figure 1) and assimilatory filaments occasionally branched and with non-clavate apical cells (Figure 2). This identification was confirmed by Sheath (pers. comm.). Some thalli exceeded 1 m in length, but most were between 0.5–0.9 m long. Measurements of thallus features described below were made on living thalli. Long axes were 2–3 mm in diameter. Most of the diameter consisted of the lateral assimilatory filaments that arose from the tough, resilient, colorless, medullary zone, 0.5 mm in diameter. Cells of assimilatory filaments were 8–10 μm in diameter (Figure 2). Basal cells of the assimilatory filaments were 20–30 μm long (Figure 3). Within a filament, cell length increased progressively over a span of several cells, until cells attained a relatively uniform length of 42–50 μm. Although many assimilatory filaments were unbranched, a single branch was common. Lateral branches emerged from the distal portion of the cell bearing the branch, just below the crosswall (Figure 2). Filaments with as many as four branches were found. Apical cells of assimilatory filaments were cylindrical except for their rounded tips; they did not taper and were not markedly longer than other cells (Figure 2).

The only reproductive structures observed were sporangia (Figure 3), each producing a single spore. All thalli examined microscopically bore a profusion of such sporangia. These were presumed to be monosporangia, because they were borne terminally

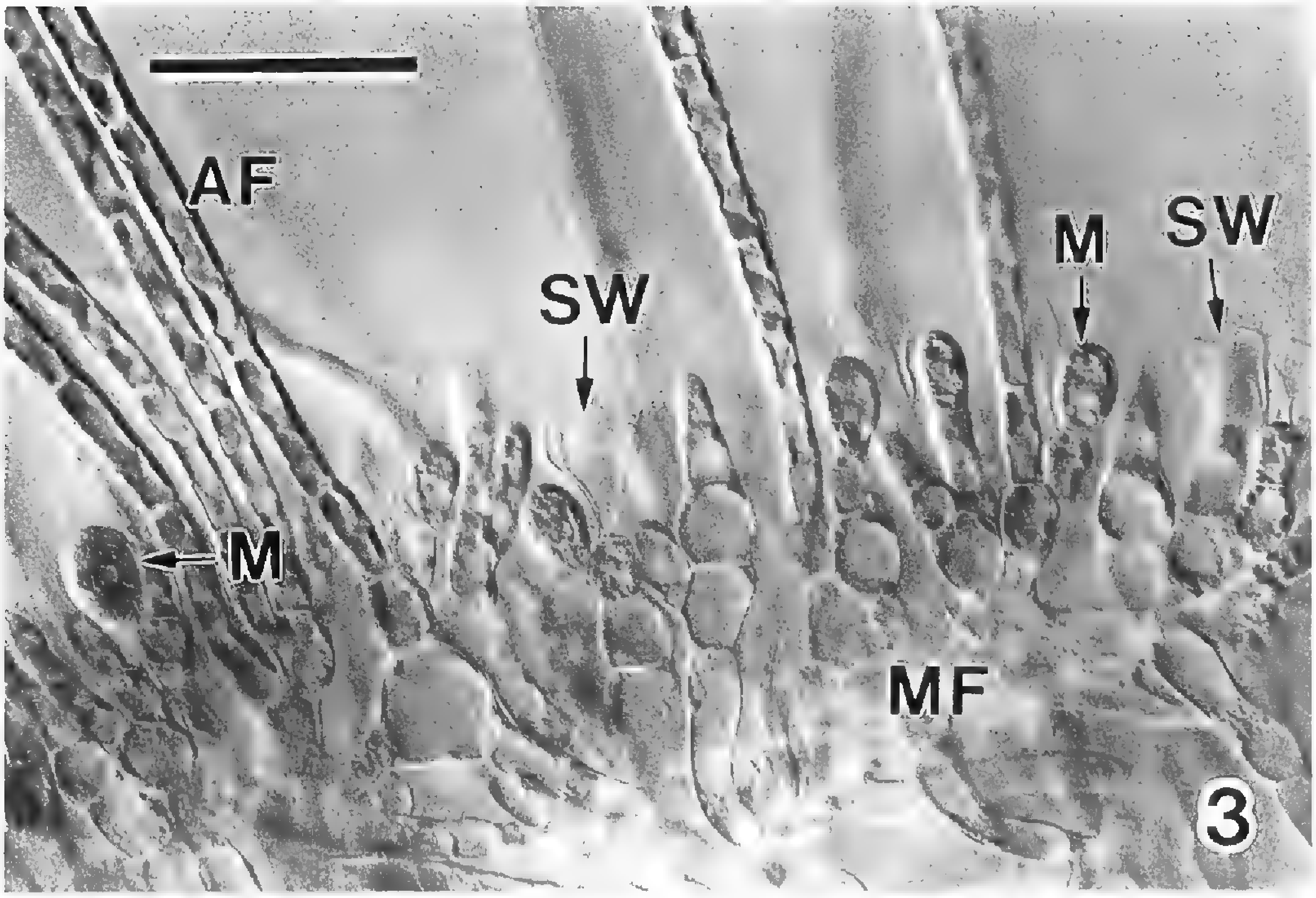


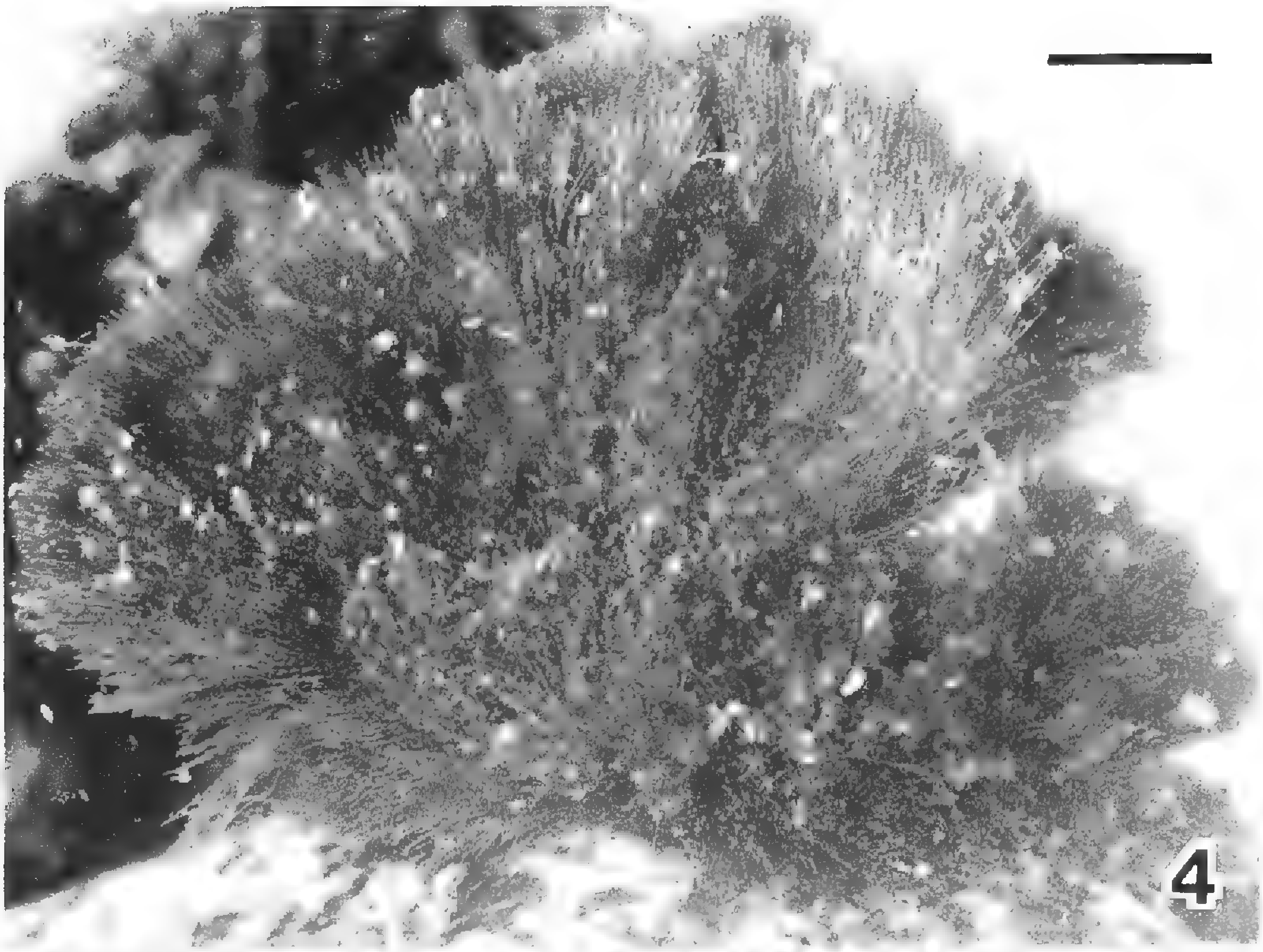
Figure 3. Light micrograph of a section of one long axis showing the outermost portion of the medullary zone and the proximal portion of the zone of pigmented cells. Branches of medullary filaments (MF) give rise to long assimilatory filaments (AF) and short filaments that produce monosporangia (M). Note empty sporangial walls (SW) of discharged monosporangia. Scale bar equals 50 μm.

or laterally on short filaments, a few cells long, that formed a pigmented layer around the medulla (Figure 3). By contrast, carposporangia of *Thorea* (not observed) are produced on branching, multicellular filaments that originate from carpogonia, which in turn are borne on short filaments (Yoshizaki, 1986; Necchi, 1987). The total length of monosporangial filaments in our specimens was about 50–60 μm. Mature sporangia were 15–18 μm in diameter and about 25 μm long. The walls of discharged sporangia persisted (Figure 3), and thus served as a marker of post-discharge development of the subtending filament. In some filaments, the cell subtending a discharged sporangium divided to produce a new sporangium that developed within the loose confines of the old wall. Alternatively, the new apical cell was vegetative and, one or two cell divisions later, a terminal sporangium was again formed.

Specimens from the Hudson River had several features that differed from Bischoff's (1965) descriptions of *T. riekei,* which Sheath et al. (1993) placed in synonymy with *T. violacea.* Our alga was blue-green in color, and it maintained this color upon drying. The long assimilatory filaments moved freely, and they were not encased in mucilage. Bischoff (1965) reported that the Texas specimens were generally rust-colored, and he demonstrated that the assimilatory filaments were embedded in mucilage. However, these features may be environmentally variable; Sheath (1984) noted that mucilage was not abundant in his specimens from the same location in Texas. Bischoff (1965) also reported that assimilatory filaments were unbranched and that apical cells were tapered and twice as long as other cells. Tapered apical cells of *Thorea* specimens from Texas were also noted by Hedgcock and Hunter (1899), whereas branching assimilatory filaments and cylindrical apical cells (Figure 2) were present in thalli from the Hudson River. Further study is needed to establish whether these differences are taxonomically significant.

Red algal thalli of considerably different morphology were present on rocks in the same part of the river bed. These were presumed to represent the Chantransia stage of the *Thorea* life history. Some thalli were visible only by microscopic examination of the rock surface, but a few formed grey tufts up to 9 mm in length (Figure 4). When viewed by light microscopy, chloroplast color and morphology were identical to that of the *Thorea*-phase thalli, and the pattern of lateral branch emergence was the same (Figure 5). Cells were 13–16 μm in diameter and 32–40 μm in length. Small thalli were sparsely branched, but larger ones had increasingly frequent branching towards the apices of the filaments and bore monosporangia. Two species of bluish-green *Audouinella* are recognized to occur in freshwaters of North America, and it is possible that one or both might represent life-history stages of the Batrachospermales (Necchi et al., 1993), but neither of these closely resembles the presumptive Chantransia stage present at our site.

Ours is the first report of field-collected Chantransia stage of *Thorea* in North America. As in other Batrachospermales (Sheath, 1984), thalli of the gametophyte morphology of *Thorea* are known to arise directly from the Chantransia phase (Swale, 1962; Bischoff, 1965). Monospores from both Chantransia and *Thorea* phases are known to grow into Chantransia (Swale, 1962), and carpospores produced on the *Thorea* phase are presumed to grow into Chantransia (Necchi, 1987). However, none of these links



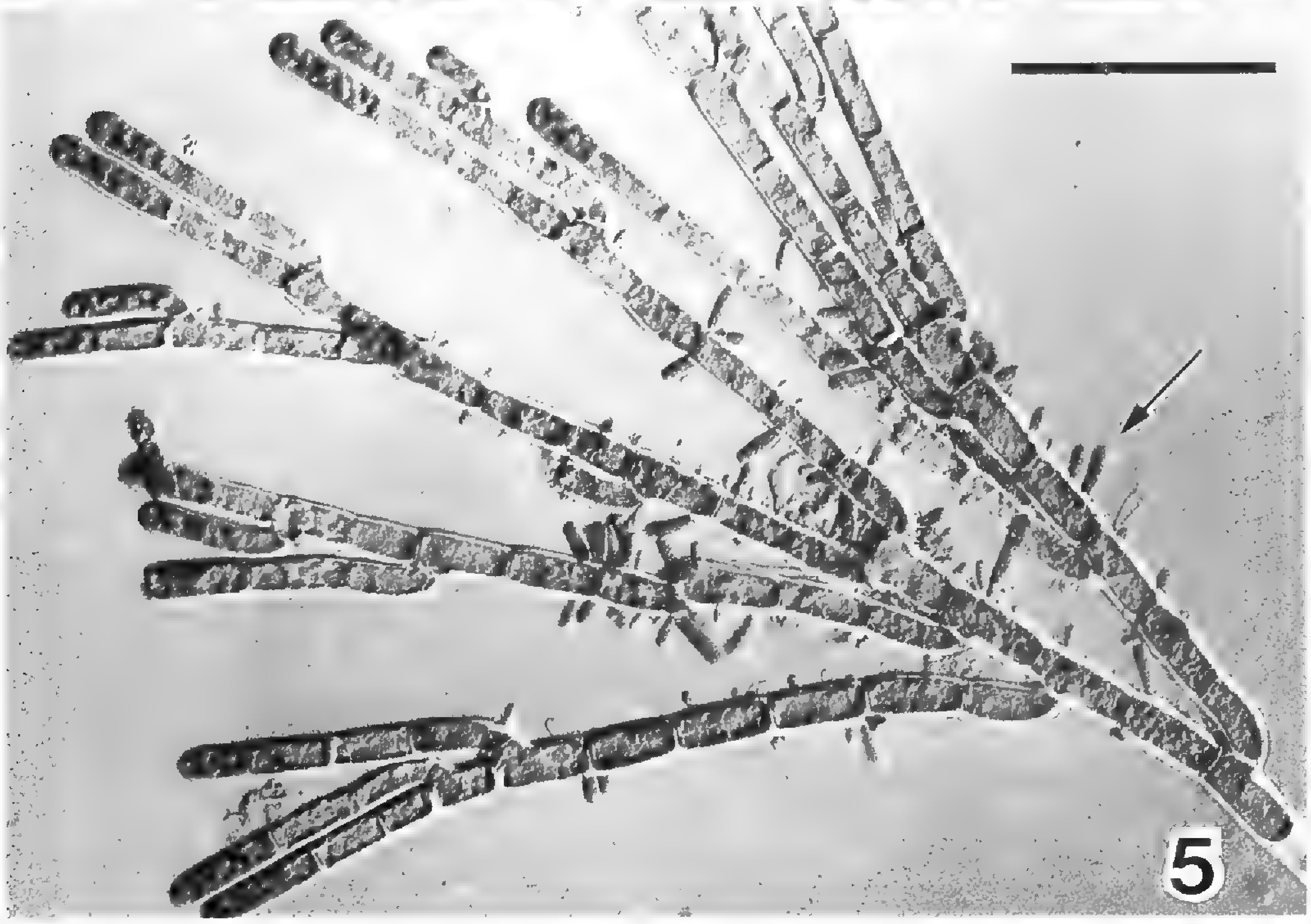


Figure 4. Putative Chantransia stage of *Thorea violacea* showing extensive branching. Scale bar equals 2 mm.

Figure 5. Light micrograph showing branching of putative Chantransia stage. Small lateral appendages (arrow) are epiphytic, unicellular blue-green algae. Scale bar equals 100 μm.

between the presumed stages of *T. violacea* in the Hudson River has been established.

In addition to the significant extension of the geographic range of *Thorea* in North America, the presence of this alga in the Hudson River represents a considerable extension of environmental conditions under which members of this family are known to grow. As summarized by Sheath et al. (1993), the Thoreaceae are found in streams with mean specific conductance of approximately 300 μS cm^{-1} (range 180–500 μS cm^{-1}), pH of 8.0 (range 7.5–8.3), current velocity of 30 cm sec^{-1} (range 9–99 cm sec^{-1}), width of 6.5 m (range 1.5–12 m), and temperature of 20°C (range 15–24°C). Our data and that of the USGS show significantly lower conductance (44–136 μS cm^{-1}), lower pH (6.6–7.7), greater than average current velocity (63 cm sec^{-1}), lower than average temperature during the month of collection (16.8°C), and larger stream size (the Hudson River dam just upstream of the *Thorea* patch is 120 m wide).

Unlike many freshwater algae, the red algae do not form thick-walled spores capable of surviving adverse conditions for long periods (Sheath and Hambrook, 1990). Therefore, annual extremes in environmental conditions, and not just the conditions during the time at which the macroscopic phase develops, must have an effect on the range of distribution of freshwater red algae. Although *Thorea* occurs at higher latitudes in England (Swale, 1962, 1963) and Germany (Schmidle, 1896; Schnepf, 1992), the Hudson River site undoubtedly experiences lower temperatures for longer periods. Water temperature measured by the USGS near the *Thorea* site was below 10°C from November to March.

The absence of *T. violacea* at our site during early summer is interesting, because *Thorea* typically grows in geographic regions of generally higher water temperatures and greater light intensity than occur in the Hudson River during early summer. Although the Chantransia stage was not detected during the early summer collection, it could have escaped detection if present as creeping filaments. The Chantransia stage is believed to be perennial (Sheath and Hambrook, 1990). Alternatively, this *Thorea* patch may be repopulated by spores from upstream populations of either phase. Spores would give rise to Chantransia, which in turn would produce the *Thorea* phase directly. The growth of *T. violacea* must have occurred in the interval between the end of June, at which time it was not detected, and mid-September, by which time some achieved 1 m in length. Rapid growth is typical of *Thorea.* Swale (1962) found that *T. hispida* (as *T. ramosissima*) grew as much as 44 cm in one week.

It remains to be determined how far north *Thorea* may grow. The proximity of the Hudson River site to the St. Lawrence River watershed, and the connection of the Hudson River to this watershed through the Lake Champlain Canal, provides opportunity for *Thorea* to range considerably farther north. The newly recognized broader range of *Thorea*'s environmental tolerances requires rethinking of the apparent warm-temperate distribution of the Thoreaceae in North America. The more common presence of the Thoreaceae in southern locales might simply reflect slow post-glacial recolonization of former ranges from small populations in southern refugia, as was suggested by Sheath and Hambrook (1990). Three reported localities of *T. hispida* are of similar latitude and near the southern limits of glaciation (Hedgcock and Hunter, 1899; Tiffany and Britten, 1952; Hirsch and Palmer, 1958), but the specimens of *T. violacea* in the Hudson River are the first members of this family discovered deep within the glaciated region of North America.

ACKNOWLEDGMENTS

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DISTRIBUTION AND CONSERVATION OF NANTUCKET SHADBUSH, *AMELANCHIER NANTUCKETENSIS* (ROSACEAE)

Alison C. Dibble and Christopher S. Campbell

ABSTRACT

Amelanchier nantucketensis, Nantucket shadbush, thought to be restricted to coastal Massachusetts and Long Island, New York, is now also known from Maine, Maryland, inland Massachusetts, New Hampshire, and Nova Scotia. Distribution is greater in part due to a wider circumscription of the species; *A. nantucketensis* intergrades with and therefore includes *A. stolonifera* f. *micropetala.* The 41 extant populations reported here each consist of up to 13 individuals, grow in early successional sites, and almost always occur with other *Amelanchier* species. Conservation at the state level is recommended for *A. nantucketensis,* which should be included in administrative rare plant lists. Protection of local populations would be best effected by controlling vegetation to maintain an early successional stage.

Key Words: *Amelanchier nantucketensis,* endemism, Maine, Nantucket, Nova Scotia, shadbush

INTRODUCTION

Setting priorities for conservation is problematic in clonal plants, yet conservation at some level is appropriate for a recognizable morph that is apparently stable (Holsinger, 1992). This is especially so if the morph has small, isolated populations and a clearly bounded geographic range, requires specialized habitat, depends on rare pollinators or dispersers, or supports a rare or unusually diverse fauna. Data regarding number and size of populations and ecology of species can be useful in determining whether a species is worthy of special consideration.

Amelanchier, the shadbushes, contains as many as 17 species and three named hybrids of shrubs and trees in eastern North America (Phipps et al., 1990). Most of these are widespread and poorly defined due in part to facultative agamospermy (asexual seed production), polyploidy, and hybridization (Campbell and Dickinson, 1990; Campbell and Wright, in press). A northeastern North American species of *Amelanchier* that has been characterized as a narrow endemic is *A. nantucketensis* Bickn., Nantucket shadbush, originally known only from Massachusetts coastal islands (Bicknell, 1911; Sorrie, 1987) and later from Long Island, New York. *Amelanchier nantucketensis* was in Category 2 of the

Federal Register of Endangered and Threatened Plant Species, indicating that formal listing required more knowledge about taxonomic status, geographic distribution, or threats. On February 28, 1996, the U.S. Department of the Interior Fish and Wildlife Service dropped Category 2 (Office of the Federal Register, 1996 February 28) because of uneven data quality and insufficient resources. Thus *Amelanchier nantucketensis* no longer has Federal status. *Amelanchier nantucketensis* was considered to be a hybrid by Gleason and Cronquist (1991). Standley (1992) noted the lack of information regarding the biology of this taxon.

Amelanchier nantucketensis has an unusual feature, andropetaly; this is a term we propose for the condition of petals bearing one or usually two microsporangia. Andropetals replace normal, sterile petals, are often narrower and shorter than sterile petals, and are ivory rather than white (Dibble, 1995). Andropetaly is evident in at least some flowers on an individual; however, not all petals on a plant bear pollen. This condition is also found in *A. stolonifera* Wieg. f. *micropetala* (Robins.) Rehd. (Fernald, 1950), where it was termed "staminody" by Weatherby (1916). Tiny, pollen-bearing petals are found also, though rarely, in *A. obovalis* (Michx.) Ashe, coastal shadbush. Andropetaly in *Amelanchier* is associated with a floral syndrome which is characterized by dense inflorescences, short pedicels, and small petals. A distinct component of the pollinator guild of solitary bees is attracted to andropetalous plants when compared to sympatric *Amelanchier* with normal petals. Possibly, the attraction to bees is not andropetaly so much as overall floral display in *A. nantucketensis* (Dibble, 1995).

Amelanchier nantucketensis and *A. stolonifera* f. *micropetala* were thought to differ in the amount of pubsecence on the ovary summit (Fernald, 1950), but this distinction is not consistent. *Amelanchier stolonifera* f. *micropetala* has therefore been merged into *A. nantucketensis* on the basis of six morphological characters (Dibble, 1995).

Historic collections of this more broadly defined species indicate that its range extends mostly along the coastal plain from northern Virginia to Maine. The Massachusetts Natural Heritage Endangered Species Program (MNHESP) has records for an estimated 30–40 small populations of *Amelanchier nantucketensis* on Nantucket, 12 on Martha's Vineyard, and 11 populations in five counties of inland Massachusetts and Cape Cod. Most of these populations have been field-checked within the past 20 years. In Connecticut, four populations in three counties are recorded, but none are known to be extant. On Long Island, New York, at least three extant populations are known. Therefore, status as a narrow endemic is no longer appropriate for a species with such a large distribution, especially given nonspecificity of habitat in known locales.

Our objectives were to document geographic distribution and population size for *A. nantucketensis.* We also sought habitat features and ecological links or associations with rare pollinators that might be important to consider in planning a conservation strategy.

MATERIALS AND METHODS

This study involved a wide-ranging field survey of northeastern North American *Amelanchier* and included three visits to the type locality of *A. nantucketensis.* We collected and pressed specimens from 565 permanently marked plants including 62 individuals of *A. nantucketensis* from 38 populations. Field surveys in New England, Maryland, New Jersey, New Brunswick, Nova Scotia, the Gaspé Peninsula of Quebec, and the west coast of Newfoundland from 1990–94 concentrated on roadsides, watercourses, meadows, and other disturbed habitats. We regard a population to be an aggregation of individuals separated from any other aggregation by at least 0.5 km. Because *Amelanchier* plants are clonal and therefore often occur in clumps of stems, we made the assumption that one clump represents one individual. We counted clumps per population and number of stems per clump, estimated or measured plant height, and noted habitat features. Identification of an assumed genetic individual was based on at least 2 m physical separation between clumps of stems; we have not found rhizomes to exceed a length of 50 cm. This 2 m criterion does not account for the possibility that several genotypes may grow intermingled within a clump or that some "individuals" could be multicloned from agamospermy or fragments of former large clumps.

We located *Amelanchier* plants in flower and returned to the same stems to collect mature leaves and developing or mature fruits. At each population of *A. nantucketensis* we collected samples from all accessible sympatric *Amelanchier* morphs and identified them using several treatments of the genus (Wiegand, 1912; Jones, 1946; Fernald, 1950; Hinds, 1986; Gleason and Conquist, 1991). To assess recruitment, we searched for seedlings among mature ramets of *A. nantucketensis.* We noted evidence of herbivory, fungal infection, insect visits to flowers, and activity of dispersers where present.

We examined herbarium specimens at ACAD, BH, GH, NEBC, and NSAC (herbarium acronyms follow Holmgren et al., 1990) for *A. nantucketensis* from the type locality and elsewhere. Dibble (1995) reported additional information regarding morphology, cytology, megasporogenesis, and pollination ecology.

RESULTS AND DISCUSSION

Distribution and endemism

The geographic range of *A. nantucketensis* is greater than previously recognized; this increase is due to concerted effort in field surveys and to lumping *A. stolonifera* f. *micropetala* into *A. nantucketensis.* The range extends from Great Falls, Maryland (Ashe, 1944), along the coastal plain to Nova Scotia, with inland populations in northwestern Massachusetts and New Hampshire (both are montane habitats), and northwestern Maine on a high gravelly bank on the St. John River (Table 1, Figure 1). *Amelanchier* taxa exhibiting andropetaly were previously unknown in Canada (Scoggan, 1987). *Amelanchier nantucketensis* is apparently not limited to coastal plain communities.

North American *Amelanchier* contains numerous taxa of narrow geographic distribution. *Amelanchier lucida* Fern., for example, is limited to Nova Scotia (Fernald, 1948; Roland and Smith, 1969). Others include *A. amabilis* Wieg. (Fernald, 1950), *A. fernaldii* Wieg. (Wiegand, 1912), *A. huronensis* Wieg., *A. mucronata* Nielsen, *A. interior* Nielsen (Nielsen, 1939), *A. gaspensis* (Wieg.) Fern. & Weatherby, *A. florida* Lindl., *A. cusickii* Fern., and *A. basalticola* Piper (Jones, 1946). In addition, we have identified several series of populations that are morphologically discrete and narrowly distributed in Maine or in Maine and New Brunswick (Dibble, 1995).

Some of these narrowly distributed taxa may be the product of

Table 1. Extant and historic (known prior to 1976) populations of *Amelanchier nantucketensis* that were visited for this study or reported to the authors, and estimated population size for each within about 50 m radius. Records for additional sites are kept at the Massachusetts Natural Heritage Endangered Species Program.

State/Province	**County**	**Town**	**Number of populations**		**Population size (no. of individuals[a])**	**Year last seen**
			Historic	**Extant**		
Connecticut	New London	Waterford	1	0	0	ca. 1975
Maine	Penobscot	Bangor		1	13	1994
Maine	Penobscot	Bradley		1	2	1993
Maine	Penobscot	Eddington		1	1	1993
Maine	Penobscot	Milford		1	1	1996
Maine	Penobscot	Old Town		1	6	1995
Maine	Penobscot	Orono		3	11	1994
Maine	Hancock	Ellsworth		3	5	1994
Maine	Hancock	Bar Harbor		1	9	1993
Maine	Aroostook	T12 R16 WELS	1	1	1	1995
Maine	Lincoln	Wiscasset		1	1	1991
Maryland	Montgomery	Great Falls	1	1	3	1993
Massachusetts	Nantucket	Nantucket	1	18	44	most: 1993
Massachusetts	Barnstable	Harwich		1	1	1990
Massachusetts	Barnstable	Hyannis		1	1	1991
Massachusetts	Berkshire	N. Adams[b]		1	1	1987
Massachusetts	Dukes	Edgartown		1	9	1992
New Hampshire	Carroll	N. Conway		1	10	1996
New York	Nassau	Montauk		1	9	1992
New York	Nassau	Shinnecock		1	4	1992
Nova Scotia	Shelburne	Jordan Bay	—	1	9	1992
	Totals	21	4	41	141	

[a] An "individual" may consist of one or more genotypes and is considered a discrete clump of stems separated by >2 m from other clumps.

[b] Specimens identified as *A. stolonifera* f. *micropetala*, Pamela B. Weatherbee, Williamstown, Berkshire Co., MA, 9 May 1987 No. 772 and 8 July 1987 No. 998; Summit, Pine Cobble Mt.—elev. ca. 800 m).

the interplay between hybridization and agamospermy. *Amelanchier* hybrids with at least one agamospermous parent are also agamospermous in the two cases that have been studied (Weber and Campbell, 1989; Campbell and Wright, in press). Agamospermy perpetuates hybrids and thus generates microspecies, se-

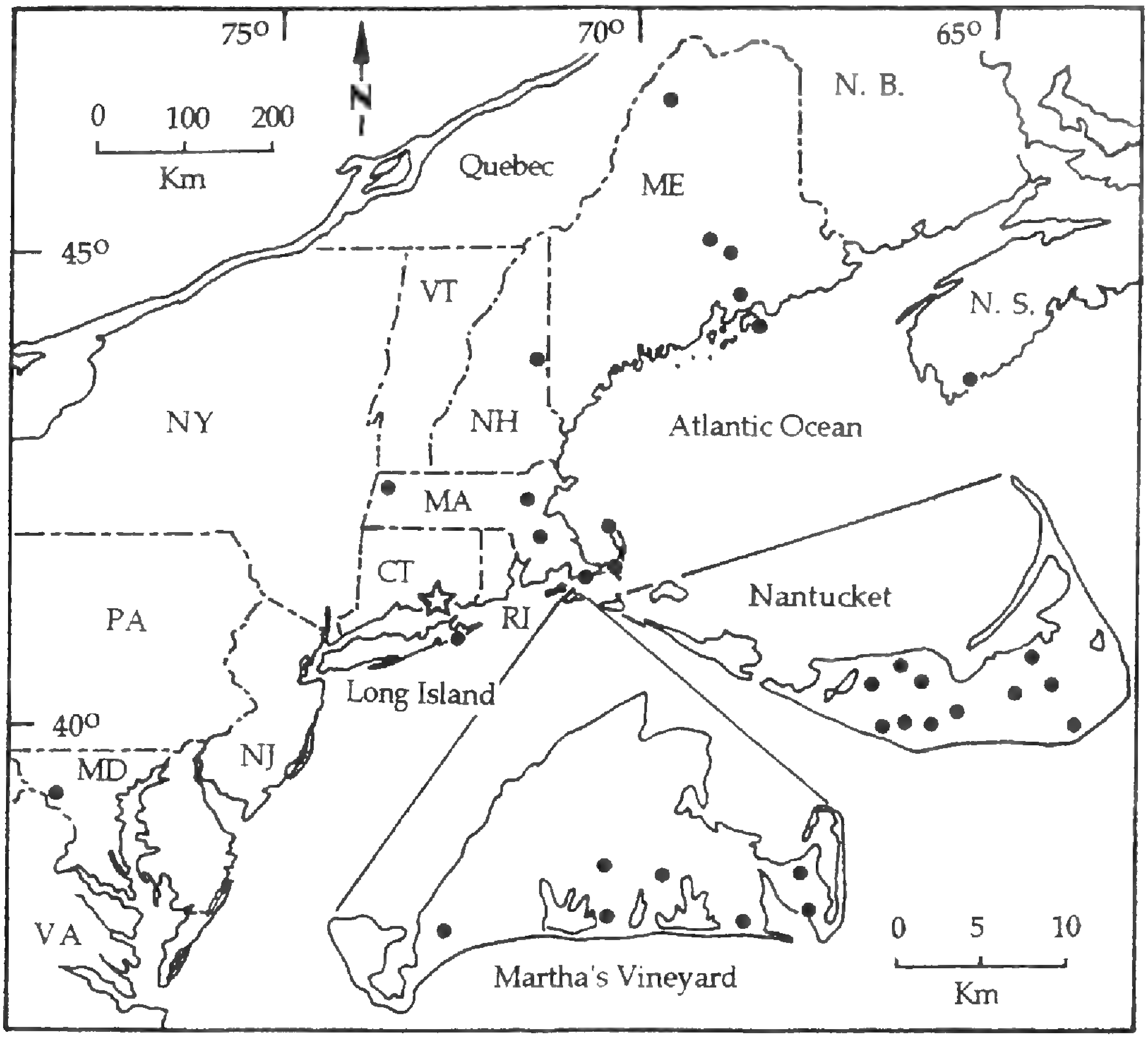

Figure 1. Geographic distribution of *Amelanchier nantucketensis*, with approximate extant (dots) and historic but presumed extirpated (star) locations. Multiple populations are represented by a single dot in some cases.

ries of populations derived from uniparental reproduction (Grant, 1981).

As a tetraploid agamosperm, *Amelanchier nantucketensis* (Dibble, 1995) may itself be of hybrid origin, as suggested by Gleason and Cronquist (1991); however, unambiguous identification of parental taxa has not been made. *Amelanchier nantucketensis* may participate in microspecies formation because it frequently grows with other *Amelanchier*, and in most cases there is overlap in flowering times. *Amelanchier* species and hybrids that grow with *A. nantucketensis* include *A. canadensis, A. stolonifera, A. laevis* Wieg., *A.* cf. *humilis* Wieg., and less commonly, *A. arborea* (Michx. f.) Fern., *A. bartramiana* (Tausch) M. Roemer, *A.* × *neglecta* Egglest., *A.* × *intermedia* Spach, and a morph we tentatively identify as *A.* cf. *humilis* × *A. laevis*. The above list includes the first record of *A. stolonifera* on Nantucket. We have observed apparent morphological intermediates between *A. nantucketensis* and *A. stolonifera* in some populations on Nantucket and in Orono, Maine (Dibble, 1995). The Orono population of *A. stolonifera* includes tetraploid agamosperms.

For most of the supposed narrowly distributed endemic *Amelanchier* species, taxonomic status and geographic distribution are uncertain and, in our experience, not fully determinable from herbarium specimens. Ideally, the status of these entities will be ascertained from detailed study of morphological and molecular variation, hybridization, ploidy, and reproductive biology. To date, extensive study of supposed rare *Amelanchier* taxa other than *A. nantucketensis* is lacking.

Population number and size

We visited 38 populations of *A. nantucketensis* for this study; locations of three others were brought to our attention (Table 1). Fourteen of these were unknown prior to 1990. Based on records kept by MNHESP, the total number of extant populations could exceed 80; the actual total depends on whether one considers occurrences within gene flow (i.e., pollen and seed dispersal) distance of others, as on Nantucket, to be populations or subpopulations. Determining the number of individuals at these populations is difficult in this rhizomatous shrub. Numerous stems (or apparent ramets) arise within 10–50 cm of each other, and presumed genets may be up to 10 m across. All populations we visited are small, usually with one or a few individuals each consisting of numerous stems. Populations with up to 13 individuals are known from Maine and Nantucket. One Maine population has since been extirpated by a construction project.

We found no small seedlings among the densely arranged mature ramets of *A. nantucketensis*. However, we observed young ramets growing at the center as well as near the edges of large clumps. These young ramets usually have large leaves compared to older ramets, suggesting they are sprouts from rhizomes rather than seedlings.

Habitat

The diversity of habitats occupied by *A. nantucketensis* is much greater than previously known. It grows in sand or loam or on ledges, along roadsides, river and stream shores, in coastal heaths, and under powerlines. Rarely, it grows in early- to mid-successional forests dominated by *Quercus rubra* L., *Populus* spp., *Betula* spp., *Pinus strobus* L., and *Picea* spp., always within about 10 m of an opening. Occurrence in such habitats could depend on succession of the site. As with many *Amelanchier* species, *A. nantucketensis* has the greatest density of stems and the most prolific flowering and fruiting in sunny sites. Soil drainage may influence plant height, with mesic soils supporting taller plants.

Conservation aspects

Because *A. nantucketensis* is associated with ecotones and such habitats are often occupied by a higher diversity of organisms than are adjacent areas under closed canopies, the potential for ecological links between this colonizing plant and various opportunistic animals is relatively high. We found no rare arthropods associated with *A. nantucketensis,* but a multitude of invertebrates use this species as forage, breeding habitat, or as a domicile. We did not find any obligately species-specific invertebrates, and we observed similar associations among these animals and various other *Amelanchier* species (Dibble, 1995).

Examples of some animals associated with *Amelanchier nantucketensis* include more than 40 species of generalist solitary bees, which are probably the primary pollinators of this species (Dibble, 1995). Flowers are also visited by sawflies (Tenthredinidae), bee flies (Bombyliidae), flower flies (Syrphidae), moths and butterflies (Lepidoptera), and various beetles including dermestids (Dermestidae). Insect herbivores include leaf cutter bees (*Megachile* spp.), which use circular pieces of leaf to line their nests; weevils (Curculionidae); scale insects (Coccidae); aphids (Aphididae); and leaf miners (Agromyzidae). Ants (Formicidae), perhaps attracted by nectar, are ubiquitous on flowers and developing fruits; they eat styles, stamens, petals, sepals, and carpels. Crab spiders (Thomisidae) are camouflaged on flowers and capture visiting, small, solitary bees. Weevils mate on the plants during anthesis; then the females oviposit into the hypanthium; later the larvae consume developing *Amelanchier* embryos. Wounds created by weevils provide one entry for *Gymnosporangium* rust, the alternate host for which is *Juniperus.* This rust disfigures the fruits so that birds avoid these when foraging on the plants, but viable seeds can develop within spermogonia-laden fruits (Dibble, unpubl. data). The fruits probably fall to the ground near the parent plant, which would allow seeds to germinate in a microsite to which the genotype is well-adapted. Dispersal is by birds and various mammals, and there is potential that seeds consumed on different but nearby species could be deposited together, germinate, and grow intermingled, adding to confusion of field observers.

All these associations are integral parts of a fully functioning ecosystem and represent a microcosm of ecological interactions in and around a host plant species. For conservation purposes, no link is dispensable given that we do not fully understand relationships between organisms. Although these associates of *A. nantucketensis* are mostly common, widely-distributed generalists, it is unknown whether this shadbush species would be adversely affected by loss or reduction in numbers of any of these animal and fungal species.

Listing at the state rather than Federal level is recommended for *A. nantucketensis* because it has more than 60 recently verified populations and a broad geographic range compared with narrow endemics listed as Federally Endangered. Although some state lists, such as Maine's (Dibble et al., 1989), provide no regulatory protection, recognition of rarity within the state could increase the likelihood that some *A. nantucketensis* populations will be protected voluntarily. Small populations and occurrence in habitats subject to frequent human disturbance or succession make *A. nantucketensis* susceptible to population extinction if development destroys habitat or if forests succeed open areas. In protected populations, woody vegetation should be monitored every 2–5 years and controlled by mowing or burning to maintain the early successional habitat conducive to persistence of *A. nantucketensis.*

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A line drawing of *Amelanchier nantucketensis* appears on the cover of Rhodora 95, 1993.

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ERIOGONUM CODIUM (POLYGONACEAE: ERIOGONOIDEAE), A NEW SPECIES FROM SOUTHCENTRAL WASHINGTON

JAMES L. REVEAL, FLORENCE CAPLOW,
AND KATHRYN BECK

ABSTRACT

Eriogonum codium (Polygonaceae: Eriogonoideae), a low, matted, cespitose perennial with tomentose flowers and achenes found on the Hanford Nuclear Reservation (the Hanford Site), Benton Co., Washington, U.S.A., is described as a new species. It belongs to the same group of matted perennials in the subgenus *Eucycla* as *E. chrysops* but has a cymose-umbellate inflorescence similar to *E. cusickii*. The tomentose flowers and achenes readily distinguish the new species from all of its near relatives.

Key Words: Polygonaceae, Eriogonoideae, *Eriogonum codium*, floristics, rare plants, Hanford Nuclear Reservation

The genus *Eriogonum* Michx. (Polygonaceae Juss.: Eriogonoideae Arn.), a taxon of more than 240 species widely distributed in temperate North America, is divided into eight subgenera (Reveal, 1989). The most speciose is subg. *Eucycla* (Nutt.) Post & Kuntze, containing nearly half of the known species. The majority of cespitose to pulvinate-matted perennials with captitate or cymose-umbellate inflorescences belong to the sect. *Capitata* Torr. & A. Gray. The type of this section is *E. pauciflorum* Pursh, an atypical member in the sense that it has densely tomentose flowers whereas all other species have glabrous or glandular pubescent flowers. Related to this section is another group of species that have villous or pilose flowers; and, in one of these, *E. shockleyi* S. Wats., the ovaries and achenes are densely tomentose. Prior to the discovery of *E. codium*, this was the only cespitose species of the subg. *Eucycla* with this latter condition.

Eriogonum codium Reveal, Caplow & K. Beck, sp. nov. (Figure 1). A *E. cusickii* floribus et achenis pubescentibus differt.

Low, cespitose, herbaceous perennials, the aboveground woody caudex system forming highly branched mats (1) 2–7 (9) dm across, arising from a stout, woody taproot; **leaves** basal, persistent, the leaf-blades oblanceolate to elliptic, (5) 6–12 mm long, 3–6 mm wide, densely white-tomentose on both surfaces, only slightly less so above in some, the apex mostly acute, the base cuneate, the margin entire and plane, the petiole short, 2–8 (10) mm long, tomentose, the petiole-base elongate-triangular, 1.5–3 (4) mm long, 0.8–1.6 (2) mm wide, densely tomentose abaxially, sparsely so to glabrous adaxially; **flowering stems** scapose, erect, 2–9 cm long, tomentose, often brittle; **inflorescences** cymose-umbellate to cymose, divided 2–3 times, up to 2 cm high and 4 cm across, tomentose, each typically with a centrally positioned, pedunculate involucre and two lateral, short, dichotomous branches; **bracts** scale-like, ternate, triangular, 1–2.5 mm long, 1–2 mm wide, tomentose without, glabrous within, connate at the base; **peduncles** restricted to the lower node, (1.5) 2–5 (7) mm long, glabrous, faintly winged; **involucres** solitary, appearing congested in early anthesis, turbinate-campanulate, membranaceous, 2.5–4 mm long, 2–2.5 mm wide, tomentose to floccose without, glabrous within, the 5 sharply acute teeth 0.8–1.2 (1.5) mm long, the bractlets linear, 2–3 mm long, with marginal glands and scattered teeth, the pedicels 2–3.5 mm long, glabrous; **flowers** lemon-yellow with greenish midribs and yellowish-green bases, 2–3 mm long, moderately (at anthesis) to thinly (in fruit) tomentose without, sparsely so and minutely glandular along the midrib within, the tepals essentially similar, broadly oblong often with the apex emarginate, 1.2–1.5 mm wide, those of the inner whorl narrower (0.9–1.2 mm) than those of the outer whorl and with rounded apices, united about ½ the length of the flower; **stamens** slightly exserted, 2.5–3.5 mm long, the filaments sparsely hairy at the very base, the anthers yellow, 0.5–0.6 mm long, oblong; **achenes** trigonous, light brown, 2.5–3 mm long, sparsely tomentose, the globose base tapering to a long, 3-angled beak.

TYPE: U.S.A. Washington: U.S. Department of Energy's Hanford Site, on the northern edge of Umtanum Ridge west of Washington Highway 24 overlooking the Columbia River about 38 air miles northwest of Richland, Benton Co., on volcanic soil associated with *Grayia spinosa* (Hook.) Moq., *Artemisia tridentata* Nutt., *Salvia dorrii* (Kellogg) Abrams, *Hesperostipa comata* (Trin. & Rupr.) Barkworth, and *Pseudoroegneria spicata* (Pursh) A. Löve at about 350 m elev. in sec. 13, T.13N., R.24E., 27 Jun 1995, *Reveal, Caplow & Sackschewsky 7484*. (Holotype: US; Isotypes: BM, BRY, CAS, COLO, GH, K, MARY, MO, NY, RM, RSA, TEX, UC, WS, WTU, and elsewhere).

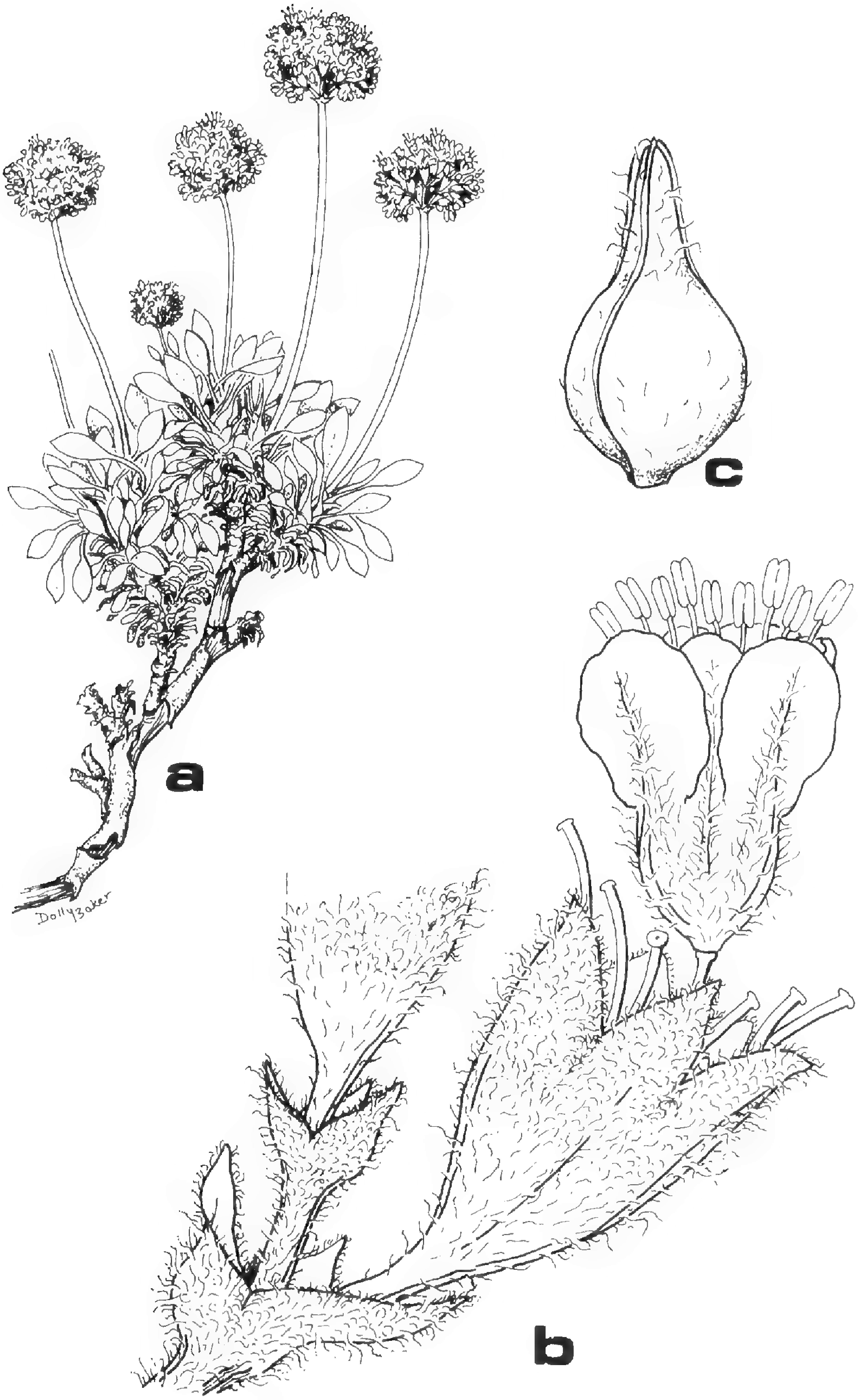

Figure 1. *Eriogonum codium* showing (a) general habit (× 0.75) with details of the (b) cymose inflorescences showing the pedunculate, centrally positioned

ETYMOLOGY: From *kodion* Gr., the diminutive of *koas,* fleece, referring to the woolly nature of the flowers and achenes.

The basalt desert buckwheat, *Eriogonum codium,* was found on the Hanford Nuclear Reservation (the Hanford Site) during the botanical survey portion of the Hanford Biodiversity Project sponsored by the U.S. Department of Energy and the Washington State Chapter of The Nature Conservancy. The new species is related to those of sect. *Capitata* noted for their highly restricted distributions and generally minor morphological differences. The majority of these species occur in the Intermountain West and are differentiated into two major groups, those with distinctly rigid involucres (e.g., *E. ochrocephalum* S. Wats.) and those with membranaceous involucres (e.g., *E. kingii* Torr. & A. Gray). The vast majority of plants in these two groups have capitate inflorescences with the involucres in clusters atop a short scape (e.g., *E. chrysops* Rydb. and *E. capistratum* Reveal). Only a few have a branched inflorescence (e.g., *E. novonudum* M. E. Peck and *E. cusickii* M. E. Jones of Oregon, and the Sierra Nevada endemic, *E. breedlovei* (J. T. Howell) Reveal). Nonetheless, none of these plants has tomentose flowers or achenes. The cymose-umbellate inflorescences of the new species readily differentiate it from the capitate Great Plains species, *E. pauciflorum,* and the sparsely tomentose flowers and achenes of *E. codium* are unlike the more densely pilose flowers and densely tomentose achenes found in *E. shockleyi.* As currently understood, *Eriogonum codium* does not appear to be closely related to any of the known species in and related to those of section *Capitata,* except that it belongs with those species related to *E. chrysops* found mainly in Oregon, Idaho, and Nevada.

Eriogonum codium is highly restricted in its distribution. The only known population occurs at elevations ranging between 340 and 400 m on flat to gently sloping substrates at the top edge of the steep, north-facing basalt cliffs of Umtanum Ridge overlooking the Columbia River. Approximately 5000 plants grow interruptedly in a narrow band 2.5 km long and generally less than 30 m wide. The plants occur only on the ridge which is subject to

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involucre on a short branch with three bracts (left) and an entire involucre with numerous pedicels, one of which bears a flower, and (c) an achene with fine hairs on the beak (both × 15).

the strong winds of the Columbia River canyon. Precipitation averages less than 15 cm annually.

The new species occurs exclusively on the exposed basaltic flow top of the Lolo Flow (mid-Miocene, 14 mybp) of the Priest Rapids Member of the Wanapum Formation (Goff, 1981), with the gaps in the population correlating with the absence of exposed flow top. The flow top material typically has high porosity and high permeability. Weathering has transformed the top into a surface comprised of pebble to gravel sized pieces of vesicular volcanic material. The average chemical composition of the Lolo basalt flow differs from the other Columbia Basin basalt formations in having high concentrations of calcium oxide, iron oxide, magnesium oxide, phosphorous pentoxide, titanium oxide, and the mineral olivine (Reidel & Fecht, 1981). In addition, the Priest Rapids Basalt flows have unusually high water-holding capacity (Reidel, pers. comm., 1995). It is not known if the strong association of *Eriogonum codium* with the Lolo Flow is related to the particular chemical composition of the flow.

The basalt desert buckwheat occurs in the shrub-steppe vegetation zone which is the primary vegetation of the Columbia Basin (Franklin and Dyrness, 1973). Perhaps as a result of the chemistry of the substrate, vegetational cover in the vicinity of *Eriogonum codium* is low when compared with other shrub-steppe sites. Common perennial associates include *Artemisia tridentata, Grayia spinosa, Krascheninnikovia lanata* (Pursh) A. D. J. Meeuse & Smit, *E. sphaerocephalum* Dougl. ex Benth., *Salvia dorrii, Hesperostipa comata, Pseudoroegneria spicata, Poa sandbergii* Vasey, *Sphaeralcea munroana* (Dougl. ex Lindl.) Spach ex A. Gray, *Astragalus caricinus* (M. E. Jones) Barneby, and *Balsamorhiza careyana* A. Gray. Common annual associates include *Bromus tectorum* L., *Phacelia linearis* (Pursh) Holz., *Gilia leptomeria* A. Gray, *G. inconspicua* (Sm.) Sweet var. *sinuata* (Dougl. ex Benth.) A. Gray, *Camissonia minor* (A. Nels.) Raven, *Mentzelia albicaulis* (Dougl. ex Hook.) Dougl. ex Torr. & A. Gray, and *Cryptantha pterocarya* (Torr.) E. Greene. Adjacent areas on Umtanum Ridge support populations of two local, rare endemics, *Lomatium tuberosum* Hoov. and *Astragalus columbianus* Barneby.

The cover of *Eriogonum codium* is higher than that of most other species within its habitat. There is a wide range of size and age classes within the population. In 1995 (a wet year), plants were in flower from early May through late August. Seed set, however, was low with less than five percent of the flowers producing mature, viable seed in 1995. Seed germination has not been evaluated.

Umtanum Ridge is currently managed by the U.S. Department of Energy. The Hanford Site has large areas of relatively undisturbed, high-quality shrub-steppe vegetation due to the cessation of virtually all agricultural and grazing activities when the Site was established in 1943. Therefore, the population of *Eriogonum codium* does not appear to be threatened by human activity at this time. Change in ownership or changes in the Department of Energy's management policies could allow public access, the use of off-road vehicles, and/or livestock grazing. If public access is allowed in this area, the population could also be affected by petrified wood collectors. Major deposits of petrified wood occur in the substrate throughout the area. Petrified wood is often collected with the aid of bulldozers and other heavy machinery. Any change of ownership or management of the Umtanum Ridge area could potentially threaten the viability of this highly restricted species.

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VEGETATION, BROWSING, AND SITE FACTORS AS DETERMINANTS OF CANADA YEW (*TAXUS CANADENSIS*) DISTRIBUTION IN CENTRAL NEW HAMPSHIRE

JOHN J. STACHOWICZ AND TABER D. ALLISON

ABSTRACT

Taxus canadensis (Canada yew) in Hanover, New Hampshire, was studied to determine the relative importance of site factors, deer browsing, and past land-use in determining its distribution. Data indicate that the species' distribution is strongly linked to habitats with high soil moisture and low solar radiation (e.g., concave and/or north-facing slopes). *Taxus canadensis* is less abundant on slopes and in habitats with southern exposure. Deer browsing is greater on south-facing than on north-facing slopes and higher under deciduous than under coniferous canopies. Species associations do not indicate a restriction of *Taxus canadensis* to sites of particular (canopy) successional status, but land-use data suggest that it may be absent from areas which have been recently logged. *Taxus canadensis* is more abundant in Hanover than in sites in north-central Massachusetts, suggesting that suitable habitat for this species may increase with latitude.

Key Words: *Taxus canadensis*, land-use history, plant-site relationships, deer browsing, New Hampshire, Canada yew

INTRODUCTION

The genus *Taxus* L. comprises eight species worldwide. It is well known for its horticultural importance and has a long economic and mythical association with humans (e.g., Hartzell, 1991). Public awareness of this genus has recently been increased by the discovery that taxol, a chemical constituent of all parts of the yew plant, is an effective anti-tumor agent (National Cancer Institute, 1992). As a result, there was a major increase in the exploitation of yew species, particularly for their bark. Recent development of synthetic sources of taxol (e.g., Wheeler and Hehnen, 1993; Nicolau et al., 1994) has reduced the pressure on wild *Taxus* species, but the threat of harvesting wild populations has highlighted the lack of detailed information on the ecological status of all species in the genus.

Taxus canadensis Marsh. (Canada yew) is a spreading, evergreen shrub of cool, moist forests of the northeastern United States and southeastern Canada. The southern limit of its range in New England extends roughly in a line from Newburyport, Massachusetts, through Providence, Rhode Island, to New Haven, Connecticut. We conducted a survey of the distribution and abundance of this species in Hanover, New Hampshire, in order to determine its ecological status and, specifically, to assess which environmental factors are important in influencing its current distribution.

It has been suggested that logging can have a negative effect on *T. canadensis* distribution (Nichols, 1913; Hosley and Ziebarth, 1935). New England's forests were heavily logged during the 18th and 19th centuries when much of the land was cleared for agriculture, and subsequent reforestation beginning in the mid-19th century has resulted in a mosaic of primary (areas cut but never cleared for agriculture) and secondary woodlands (Foster, 1993). Vegetation surveys performed in the 1930's indicated that *T. canadensis* was associated with primary woodlands in Petersham, Massachusetts, but the species was too rare for this conclusion to have been stated with statistical confidence (Whitney and Foster, 1988; Whitney, 1991). Anecdotal reports also have suggested that winter browsing by white-tailed deer (*Odocoileus virginianus* Zimmermann) and moose (*Alces alces americana* Clinton) can locally extirpate *T. canadensis* populations (Allison, 1990, and references cited therein).

A review of the literature on forest community composition of New England and New York (a list of papers is available from the authors) and preliminary surveys of areas supporting *T. canadensis* populations indicated that most sites supporting this species were located at or near the base of slopes with a northerly or westerly aspect. While such surveys of forest composition can yield information on where *T. canadensis* is present, they are not useful in determining where the species is absent. This is significant, as these surveys are often biased to old-growth stands where *T. canadensis* may be more likely to occur.

We sampled *T. canadensis* in the town of Hanover, New Hampshire, in order to characterize its distribution in relation to specific environmental variables and associated vegetation. Based on the results of our preliminary survey and literature search, we evaluated our data with reference to the hypotheses that *T. canadensis*: (1) is restricted to sites which have experienced low browsing pressure in the past and/or present; (2) is limited by the availability of microhabitats with suitable moisture regimes, growing particularly on north-facing slopes which typically receive low insolation and have high humidity (Geiger, 1965); and (3) has been eliminated by extensive forest clearing and is currently confined to primary woodlands.

These hypotheses may be confounded. For example, deer browse *T. canadensis* only in the winter when north-facing slopes may be less accessible to deer due to rugged topography and a more persistent snowpack. North-facing slopes are also less likely to have been cleared for farming and are thus frequently associated with primary woodlands. While complete evaluation of these and additional hypotheses requires experimental approaches beyond the scope of our study, we report here the results of our survey and an initial evaluation of these hypotheses based on the survey data.

METHODS

Study Site

The climate of Hanover, New Hampshire, is characterized by long, cold winters with heavy snowfalls and relatively short, cool summers. Precipitation is distributed evenly throughout the year and the average number of frost free days is 134. Elevation ranges from slightly less than 120 m to 712 m. The land in and around the town was extensively cleared during the agricultural period, with a maximum of 65% of the total land area in farms in 1880; over 40% of this land was actually tilled (United States Census Bureau, 1883). The majority of undeveloped land in the town is now forested although recent agricultural census data suggest that about five percent of the town's area remains in cultivation (United States Census Bureau, 1989), most of which is in the floodplain of the Connecticut River or the level plains of the highlands.

In early successional sites, forested lands are dominated by white pine (*Pinus strobus* L.), gray birch (*Betula populifolia* Marsh.), quaking aspen (*Populus tremuloides* Michx.) and pin cherry (*Prunus pensylvanica* L. f.). Northern red oak (*Quercus rubra* L.), red maple (*Acer rubrum* L.), and white pine dominate mid-successional forests. Late successional lower elevation and stream valley forests are dominated by northern hardwoods species such as yellow birch (*B. lutea* Michx. f.), sugar maple (*A. saccharum* Marsh.), and beech (*Fagus grandifolia* Ehrh.). Hemlock (*Tsuga canadensis* (L.) Carr.) is also important at lower elevations and is replaced by red spruce (*Picea rubens* Sarg.) and balsam fir (*Abies* *balsamea* (L.) Mill.) at higher elevations. Nomenclature follows Gray's Manual of Botany (Fernald, 1950).

Vegetation Survey

Twenty study points were selected randomly using Universal Trans-Mercator (UTM) coordinates from areas zoned for forestry and recreation by the town of Hanover. Wetlands were excluded from the sample. The study was limited to these zones in order to assure forest cover in all randomly selected survey sites and to avoid sampling near residences. According to 1989 Town of Hanover zoning maps, approximately 44% of the town's area, and the majority of its undeveloped land, is included in this designation. At each point a transect was established in a compass direction chosen randomly. We located 10 plots of 10 m radius at randomly selected intervals between 20 and 100 m apart along the transect. Twenty transects (200 plots) were sampled. Vegetation data were limited to recording presence of all species in three strata (canopy, understory, and forest floor).

These measures of community composition may not be the most precise method of determining association; however, simple presence-absence data may be the best indicator of a forest's age (Rackham, 1986; Whitney and Foster, 1988). We sampled in this way in order to survey a large number of sample plots that could be easily compared with other available data, since much of the information on *T. canadensis* occurrence and associated forest composition gathered from the literature was available only in presence/absence form. Environmental parameters were also recorded for each plot including elevation, percent slope, aspect, slope shape (concave, planar, or convex), and slope position (base, lower, middle, upper third, or ridge). Land-use history data were collected from historical documents where available, but for most sites detailed historical records were unavailable, and land-use history was inferred using field observations and local (anecdotal) sources.

Sampling of *Taxus canadensis* Populations

Density, biomass, growth, and browse damage of *T. canadensis* were determined in a separate survey of sites known to support

T. canadensis populations, including sites other than those in our vegetation survey. These sites were selected according to the following criteria: (1) each contained a population of *T. canadensis* which extended over an area of at least 1000 m^2; (2) preliminary data indicated that at least a portion of the site contained plots with a density of 0.25 shoots per m^2; and (3) sites were selected to ensure representation of habitats with different canopy vegetation and slope aspect. At each of these sites, we marked 30 sampling points along a 100 m transect. The starting point of the transect, its direction, and the spacing of the sampling points were all determined using a random number table. At each point, the distance to the nearest *T. canadensis* shoot and the distance from that shoot to its nearest neighbor were measured. These distances were used to estimate density according to the formula derived by Batcheler (1971): $\log(\text{density}) = \log(n/\pi(\Sigma r_a^2)) - (0.1416 - 0.1613(\Sigma r_a/\Sigma r_b))$; where r_a is the distance from the point to the nearest shoot, r_b is the distance from that shoot to its nearest neighbor, and n is the number of shoots sampled. This method avoids the biases inherent in using random quadrat methods to sample a clumped distribution like that of a vegetatively spreading species such as *T. canadensis* (Batcheler, 1971).

Because *T. canadensis* spreads vegetatively, the delineation of an individual (genet) is impossible without tracing the root system. Therefore, we used the shoot (ramet) as our unit of measurement. A ramet was defined as a single emergent stem of the plant, disconnected from neighboring stems at a soil depth of 2 cm. For each shoot, we measured the basal diameter and the diameter of all branches greater than or equal to 3.0 mm on these shoots. These values were converted to grams dry weight by comparison with a standard curve of biomass versus branch diameter determined previously for *Taxus canadensis* [mass = 0.685 − 1.02 (diameter) + 0.539 (diameter)^2; $r^2 = 0.99$ (J. J. Stachowicz, unpubl. data)]. Biomass per shoot was multiplied by the density of each population (shoots per m^2) to obtain an estimate of biomass for each population.

Annual growth increments on *T. canadensis* are indicated by terminal bud scars on the stem and are often apparent as far back as five years. To estimate aboveground growth for each population, we measured the stem diameter just above the third terminal bud scar (Figure 1) from the apex of ten randomly selected branches on each shoot used for biomass estimates. Growth measurements were made in late fall, at the end of the growing season, so the measurement should represent three full years of growth. By measuring growth for the most recent three-year period, and then dividing by three to convert to an annual rate, we attempted to minimize the effects of year-to-year variability on our growth estimates. The annual diameter increment was converted to biomass using the standard curve of diameter versus mass, and an average annual biomass increment per branch was calculated. Total annual growth was estimated by multiplying the average annual biomass increment per branch by the total number of branches per shoot.

We estimated removal rates by deer (in grams of tissue per year) by measuring the diameter of all branches browsed within the past year at the point of removal, estimating biomass of removed tissue from the diameter-biomass relationship described above, and summing over all browsed branches for the entire shoot. Both annual growth and removal rates per shoot were multiplied by density to obtain areal estimates per m^2.

The nearest canopy and understory individuals to each shoot were recorded and environmental data taken as previously described. The canopy at each site was classified based on whether the majority of the nearest canopy individuals recorded were coniferous or deciduous. At all of the locations we sampled, either conifers or deciduous trees greatly outnumbered the other, so determination of canopy type was unambiguous and no mixed canopy areas were sampled.

DATA ANALYSIS

Relationships between environmental variables and *T. canadensis* presence were examined using Chi-Square tests (Sokal and Rohlf, 1981), testing the null hypothesis that the frequency of occurrence was the same in all categories. Biomass, annual growth, and deer removal rates for different habitats were evaluated by ANOVA with site characteristics as fixed effects. Data on species presence-absence in the 200 sample plots were analyzed by divisive classification using TWINSPAN (Hill, 1979a) to determine associations among different species and *T. canadensis.* Species presence-absence data were also analyzed by correspondence analysis (CA), an ordination technique, using DECORANA (Hill,

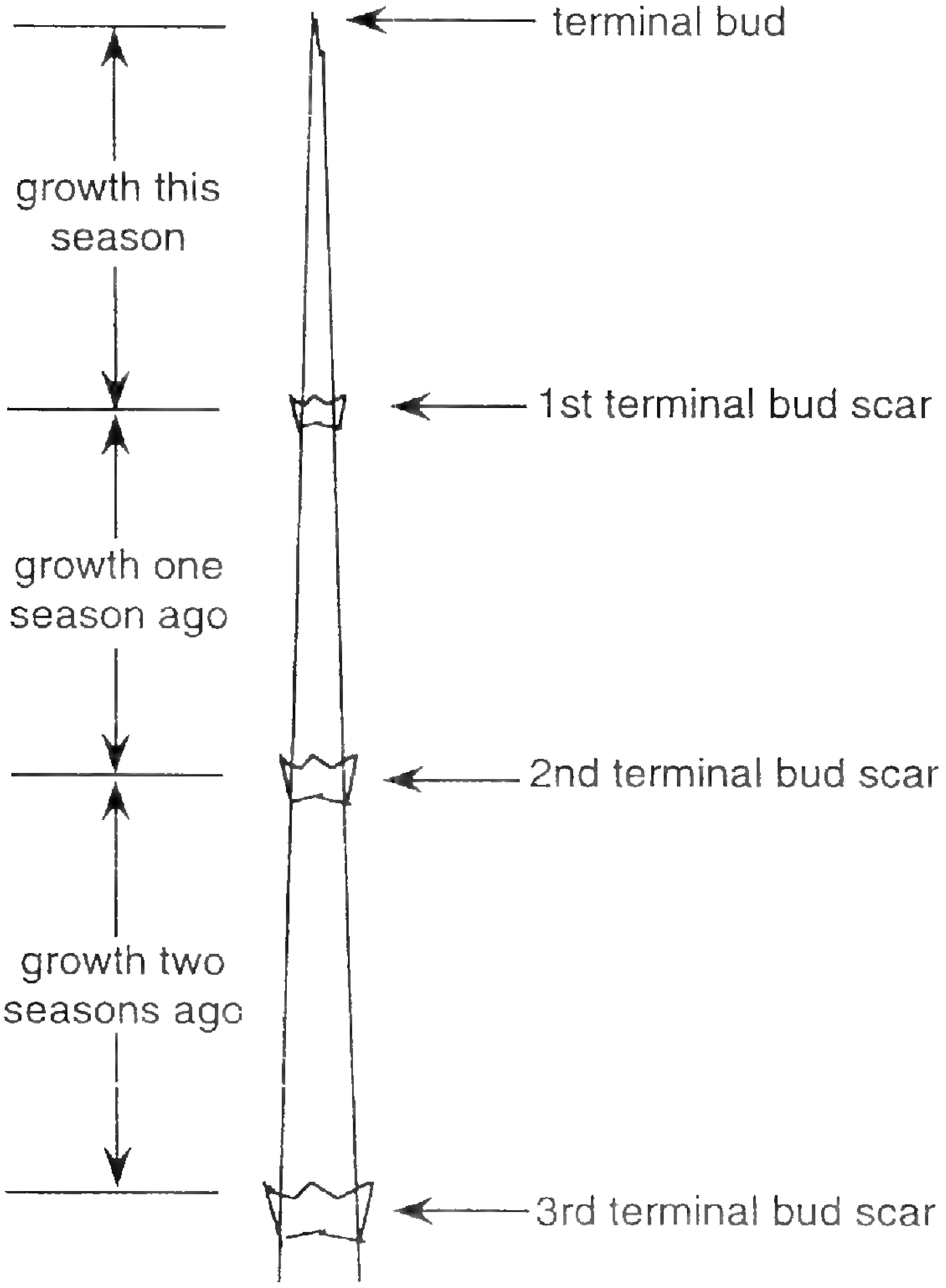

Figure 1. Branch tip of *Taxus canadensis* showing bud scars marking annual growth increments. Measurements of growth were made over the most recent three-year period by measuring the branch diameter just above the third terminal bud scar (see text).

1979b). This analysis represents plots or species graphically, on a two (or greater) dimensional set of axes, placing those with the most similar patterns of occurrence closest together, and thereby allowing relationships between many samples or species to be easily recognized. To test if the axis values generated by DECORANA were predictive of *T. canadensis* presence, we correlated them, along with environmental parameters (slope, aspect, elevation, etc.), with *T. canadensis* presence by multiple logistic regression (Kleinbaum et al., 1988). This analysis is similar to standard multiple linear regression, with the exception that the dependent variable (in this case *T. canadensis* occurrence) is dichotomous (yew is either present or absent).

RESULTS AND DISCUSSION

Taxus canadensis occurred in 37 out of 200 plots sampled (18.5%). The only understory or forest floor species that occurred more frequently was striped maple (*Acer pensylvanicum* L., 43.5%). Several other forest floor species were similar in frequency to *T. canadensis.* These include *Rubus* sp., 17%; *Lycopodium obscurum* L., 16.5%; *Lycopodium clavatum* L., 14.5%; *Lycopodium annotinum* L., 14.5%; *Aster divaricatus* L., 13.5%; and *Mitchella repens* L., 13%. The frequency of occurrence of *T. canadensis* in Hanover is higher than that in north-central Massachusetts. *Taxus canadensis* occurred in seven of 74 (9.5%) plots in the Harvard Forest and surrounding area of Petersham, Massachusetts (Gerhardt, 1993), and a survey of a 40 township region in north-central Massachusetts found *T. canadensis* in 17 out of 360 plots, less than five percent (C. Mabry and D. R. Foster, unpubl. data). These studies used 20 m × 20 m plots in which presence/absence of all vascular plant species was recorded, so general methods are comparable to this study. The land-use history and topography of these central-Massachusetts sites are similar to those of Hanover, New Hampshire, and both receive ample precipitation throughout the year. However, Hanover has a shorter growing season and more of the precipitation comes as snowfall than at the Harvard Forest, suggesting that the primary difference between these sites is related to temperature and latitude.

Presence-absence data (Table 1), collected during our vegetation survey, show that *T. canadensis* occurs more frequently on sites with concave slopes, at slope bases, at low elevations, on north- and east-facing slopes, or on level ground (slope $<10\%$) than in locations with other physiographic characteristics. The sampling of *T. canadensis* populations showed that, where this species grew, density was greatest in level areas (0.83 shoots/m^2) and lowest on south-facing slopes (0.23 shoots/m^2). Shoots growing on north-facing slopes have the greatest standing crop or biomass ($F = 4.52$; $P < 0.001$) and growth rates or production equal to shoots on level ground but greater than those on south slopes ($F = 6.09$; $P < 0.001$; Figure 2A). Production of *T. canadensis* did not differ under deciduous versus coniferous canopies, although biomass was slightly greater under deciduous canopies (Figure 2B).

The distribution of *T. canadensis* in upland forests of Hanover

Table 1. Occurrence of *Taxus canadensis* by habitat characteristics for 200 plots in Hanover, New Hampshire.

	***Taxus* present**	***Taxus* absent**	**Frequency**
Slope Shape			
Concave	21	28	42.9
Planar	15	65	18.8
Convex	1	70	1.4
	$\chi^2 = 33.04$	df = 2; $P < 0.0001$	
Slope Position			
Slope Base	16	16	50.0
Lower Third	20	32	38.5
Middle Third	0	57	0
Upper Third	1	50	2.0
Ridge Top	0	8	0
	$\chi^2 = 49.09$	df = 4; $P < 0.0001$	
Elevation (meters)			
100–200	10	0	100
200–300	6	17	26.1
300–400	19	45	29.7
400–500	2	94	2.1
>500	0	7	0
	$\chi^2 = 68.99$	df = 4; $P < 0.0001$	
Aspect			
North	23	59	28.0
East	12	33	26.7
South	0	31	0
West	2	40	4.8
	$\chi^2 = 19.24$	df = 3; $P = 0.0002$	
Percent Slope			
0–9°	15	26	36.6
10–19°	8	53	13.1
20–29°	7	44	13.7
>30°	7	40	14.9
	$\chi^2 = 11.244$	df = 3; $P = 0.0105$	
Time since abandonment[1]			
less than 30 years	0	42	0
30–120 years	6	15	28.6
>120 years or never cleared	31	106	22.6
	$\chi^2 = 12.50$	df = 2; $P = 0.0019$	

[1] Time since the land was last cultivated or intensively cut.

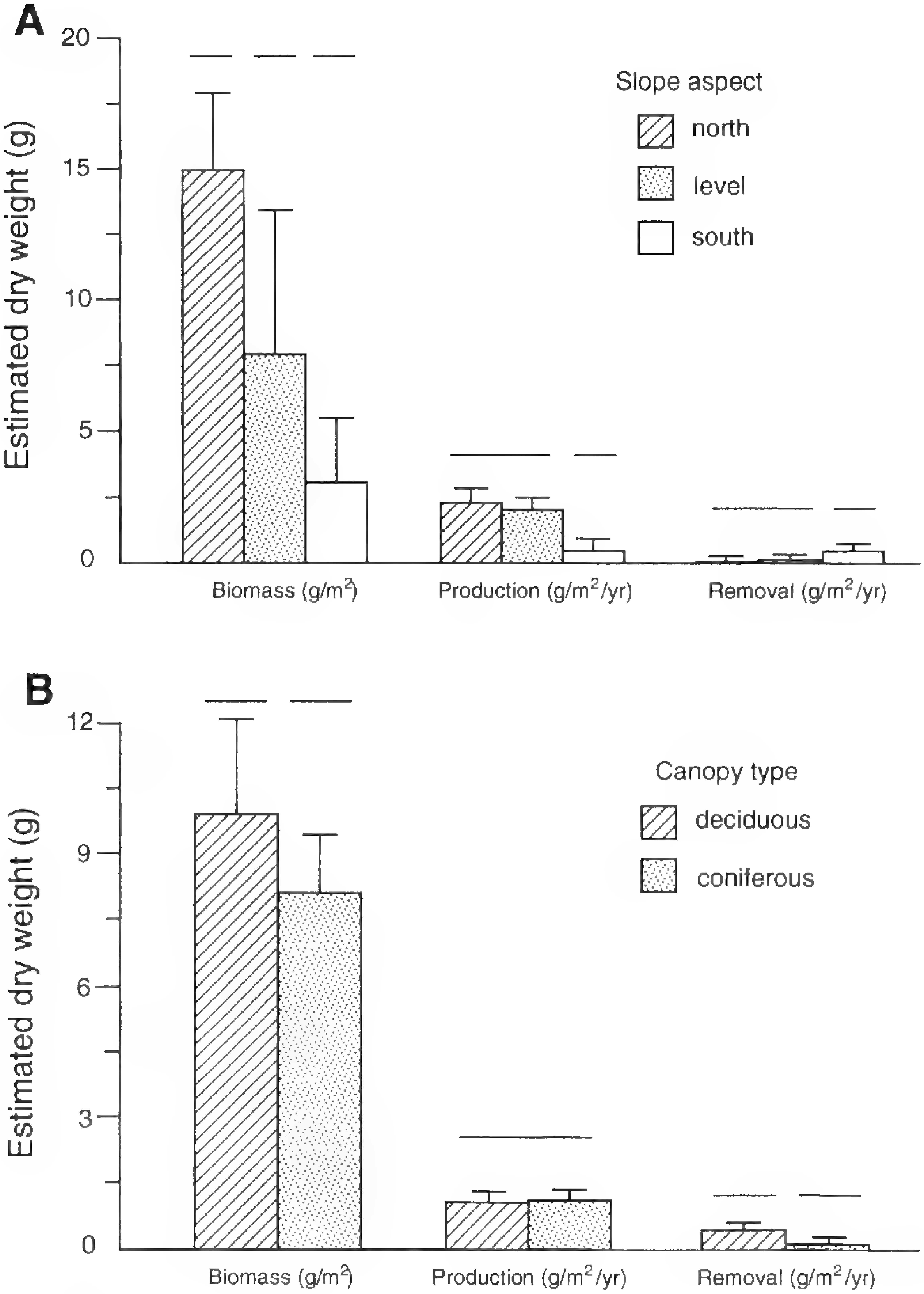

Figure 2. *Taxus canadensis* biomass, production (annual growth), and removal by deer per m^2 (mean + 1 SE) at sites with various aspects (A) and canopy types (B). Lines above bars indicate means that do not differ significantly at $P > 0.05$ by ANOVA.

is linked strongly to environmental variables, such as slope shape, slope position, elevation, aspect, and percent slope, that affect soil moisture and relative humidity. This is consistent with the hypothesis of habitat preference as a determinant of the distribution of this species. In north-temperate locations, north-facing slopes are generally cooler and have higher relative humidity and soil moisture than comparable south-facing slopes (Geiger, 1965; Oke, 1978). Cold air drainage can also account for a similar pattern of increased moisture and decreased temperature on the lower portions of a slope compared to upper regions (Oke, 1978). These facts are in accord with what has been observed anecdotally for *T. canadensis* in the southern portion of its range. Nichols (1913), for example, noted that in Connecticut, *T. canadensis* was much more common in "lower ground." In north-central Massachusetts, it is not uncommon to find *T. canadensis* at the boundary between upland and wetland or on steep rock ledges where "moisture conditions are favorable" (Hosley and Ziebarth, 1935; T. D. Allison and J. J. Stachowicz, unpubl. data). Populations in southern Minnesota and northern Iowa are typically found at the talus base of north-facing limestone cliffs (T. D. Allison, pers. obs.).

Our survey data also indicated a potential impact of deer browsing on *T. canadensis* distribution and an interaction of browsing with habitat. Browsing rate (removal) was higher under deciduous than coniferous canopies (Figure 2B). However, because a large proportion of the areas where *T. canadensis* grew under a deciduous canopy were on south-facing slopes, it is unclear whether this difference is attributable directly to canopy or if it is an indirect effect because deer are more likely to winter on south-facing slopes than on north-facing ones. Where *T. canadensis* occurred on south-facing slopes, browse damage was greatest ($F = 4.081$; $P < 0.001$), with removal nearly equaling annual growth or production (Figure 2A). North-facing slopes and level areas did not differ in removal rates. High deer populations have been implicated in limiting *T. canadensis* distribution in Michigan, Wisconsin, and New York (e.g., Spiker, 1935; Beals et al., 1960), but similar reports have not been made for New England. Despite the fact that removal equals annual growth on south-facing slopes, *Taxus canadensis* may persist in these areas if there is high annual variability in browse pressure that could allow the population to recover following an episode of intense browsing. Thus deer browsing may not result in extirpation of local *T. canadensis*

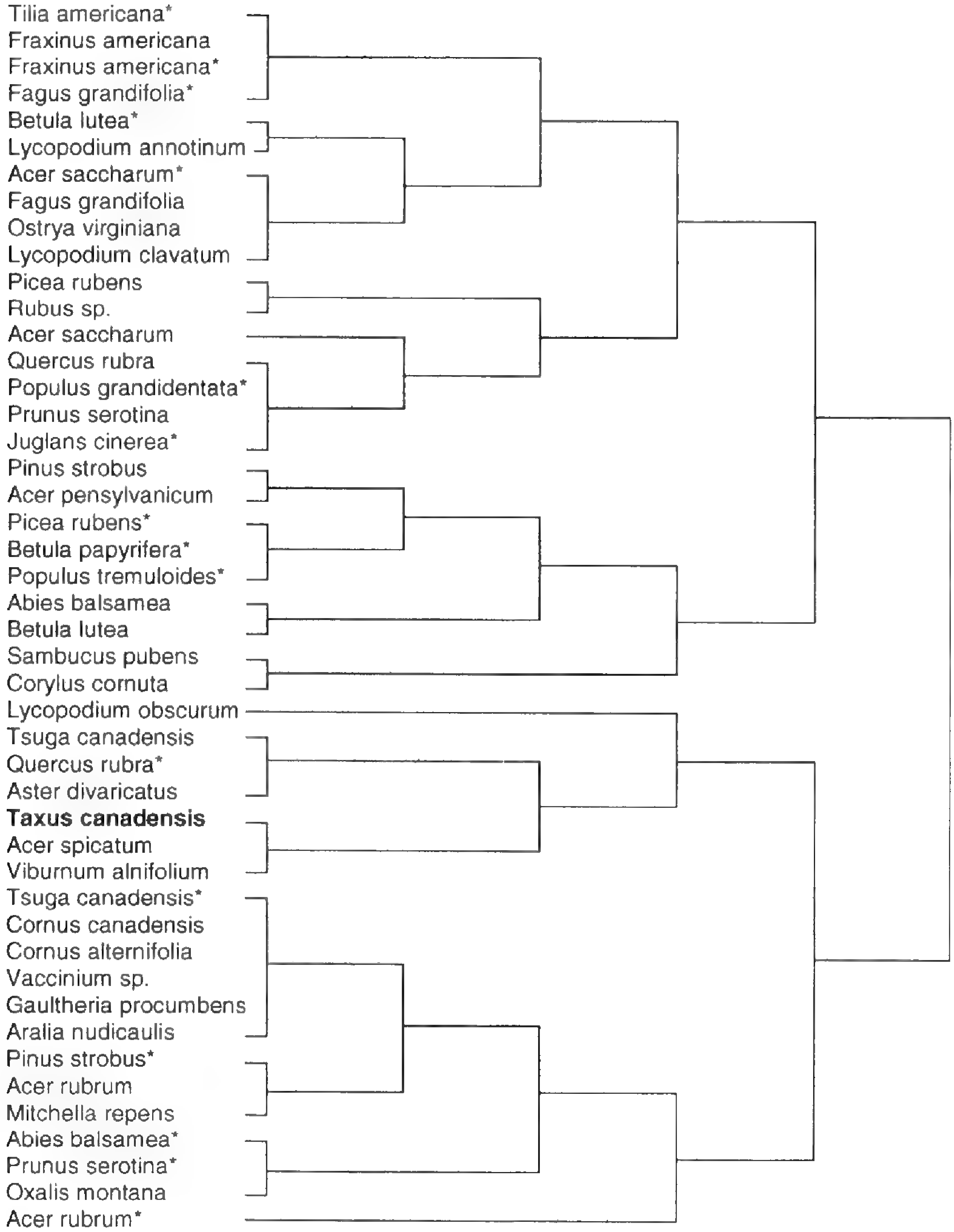

Figure 3. Results of TWINSPAN divisive classification of presence-absence data from survey of 200 plots (see text). Species with asterisks are canopy representatives; the same species without asterisks are understory representatives.

populations, although our data indicate that in certain habitats browsing may retard expansion of existing populations by reducing clonal expansion and seed production (Allison, 1990).

Divisive classification (Figure 3) indicated that *T. canadensis* was most closely associated with mountain maple (*Acer spicatum* Lam.) and hobblebush (*Viburnum alnifolium* Marsh.). *Quercus* *rubra* was the most closely associated canopy species (Figure 3). Red oak is generally common in mesic woodlands which were logged but not cleared for agriculture, a land-use category in which *T. canadensis* occurred frequently (Table 1). The divisive classification (Figure 3) also indicated that *T. canadensis* is not closely linked with *Acer saccharum, Tilia americana* L., *Betula lutea,* or *Fagus grandifolia* although these species are characteristic of the northern hardwoods forest found in the lower elevations of Hanover. The apparent absence of any association of *T. canadensis* with late-successional northern hardwoods and its association with red oak, a species that occurs in mid-successional forests around Hanover (see Study Site description), suggest that *T. canadensis* may not be restricted to late-successional forests.

In Hanover, *T. canadensis* was absent from areas which were logged within the past 30 years, but was not limited to primary woodlands (Table 1). One of the densest populations we observed was located on a floodplain at the base of a northwest-facing slope that was cultivated as recently as the 1880's. We have also observed *T. canadensis* populations growing in old-field white pine stands in north-central Massachusetts. An effect of past land use on *T. canadensis* distribution was indicated in a 1930's survey of vegetation in Petersham, Massachusetts, where this species was restricted to primary woodlands (Whitney and Foster, 1988). Any such effect should diminish with time as *T. canadensis* recolonizes suitable habitat, as has been suggested in more recent forest surveys of north-central Massachusetts (Gerhardt, 1993; C. Mabry and D. R. Foster, unpubl. data). Because our data on land-use history lacked detail on the time of abandonment or reforestation, we cannot determine the length of time required by *T. canadensis* for recolonization, except that it is a minimum of 30 years.

The divisive classification (Figure 3) suggests that *T. canadensis* is associated with red oak, and thus not necessarily linked to old-growth forests, but the ordination of the vegetation survey data with DECORANA indicates an affinity for a more coniferous canopy. The ordination produced four vegetation axes, only two of which were significantly correlated with *T. canadensis* occurrence (Table 2). The first vegetation axis corresponds to an increasing importance of *Abies balsamea* and a decreasing importance of *Betula papyrifera* Marsh. The second axis was positively correlated with low elevation coniferous forests near the base of north and northwest slopes, and negatively correlated with high

Table 2. Results of multiple logistic regression analysis. Measured independent variables predict the outcome of the dichotomous dependent variable *Taxus canadensis* presence (only variables with significant contribution to the final model are listed). Positive values of estimates indicate a positive association of *T. canadensis* presence with that variable (e.g., *T. canadensis* occurs more frequently on slopes that are concave rather than convex or planar). Negative values of estimates indicate a negative association of *T. canadensis* with that variable (e.g., *T. canadensis* occurs less frequently with distance upslope). The magnitude of the estimate suggests the relative importance of that factor in predicting the presence of *T. canadensis.* Tolerance statistics for all independent variables fall within the allowable limits, so no significant collinearities ($P > 0.05$) between predictors are apparent. CA = correspondence analysis.

		95% confidence interval of estimate			
Factor (indep. variable)	**Estimate**	**Lower**	**Upper**	**G**	***P***
Slope position	−1.282	−1.919	−0.646	49.31	0.0005
Slope shape (concavity)	2.601	1.203	4.000	21.55	0.0005
Slope aspect	−0.011	−0.022	0.000	4.40	0.05
CA Axis #1	0.647	0.234	1.061	8.77	0.005
CA Axis #2	1.101	0.423	1.780	12.05	0.001

elevation deciduous forests on south-facing slopes. Neither of these axes give any evidence for an association of *T. canadensis* with climax northern hardwood forests. In addition to these two vegetation axes, the final logistic regression model of *T. canadensis* presence-absence was influenced strongly by slope shape, aspect, and position (Table 2), environmental variables that influence moisture levels (Geiger, 1965; Oke, 1978). The model indicates that *Taxus canadensis* occurs most frequently near the base and on the lower portions of north- and east-facing concave slopes and that its frequency is lower in plots higher upslope, on a convex-shaped slope, and with a more southerly aspect (Tables 1, 2).

No consistent association between *T. canadensis* and tree species was observed; the ordination, divisive classification, and literature search each suggested different canopy associates. For example, the divisive classification (Figure 3) indicated that the most closely associated canopy species was *Quercus rubra,* while the ordination (axes scores from DECORANA) suggested association with *Abies balsamea* and other conifers. Further, the literature search suggested that in the northeastern United States, *T. canadensis* is associated with a northern hardwoods canopy of

Acer saccharum and *Betula lutea* (e.g., Heimburger, 1934; Egler, 1940; Cline and Spurr, 1942; Stearns, 1951; Leak, 1973; Siccama, 1974). In contrast, the association of *T. canadensis* with other understory shrubs was much more consistent. Understory species were generally too rare to influence the ordination greatly, but both the divisive classification (TWINSPAN results, Figure 3) and limited understory literature (Heimburger, 1934; Egler, 1940) suggest that *Viburnum alnifolium* and *Acer spicatum* are closely associated with *Taxus canadensis.* Additionally, the divisive classification (Figure 3) suggests that none of these three species is particularly closely associated with any canopy species.

The differences in the strength and consistency of *T. canadensis* associations with understory shrubs vs. canopy trees may be the result of differences in the duration of the influence of past land-use in the different layers of vegetation. Long-lived canopy species in secondary woodlands, such as *Quercus rubra,* could be first generation individuals which have not been replaced by later successional northern hardwoods. *Taxus canadensis* may have been eliminated by forest clearing and plowing, but once reforestation began, this species was eventually able to recolonize environmentally suitable sites. Later-successional tree species, however, have to wait for removal of the overstory containing earlier-successional species before succeeding to the canopy. This process is suggested by the closer association of *Taxus canadensis* with understory individuals of *Tsuga canadensis* than with canopy individuals (Figure 3).

CONCLUSIONS

As we predicted, *T. canadensis* is most abundant and productive on north-facing slopes. Although we did not find *T. canadensis* in any south-facing plots in our vegetation survey, it is not completely excluded from south-facing sites (we were able to find some populations for biomass, production, and removal estimates), but it is considerably less abundant and productive when present. Our survey was limited to upland forests, and we specifically excluded open and wet habitats, such as old fields and swamps. Our own observations indicate that *T. canadensis* does not grow in recently abandoned old fields, but may be found in swamps and on slopes surrounding bogs. Therefore, our conclusions about the ecological status of *T. canadensis* are limited to upland habitats.

There are clear differences in the frequency, abundance, and productivity of this species in the upland forests of Hanover: *Taxus canadensis* does best in sites with physiographic characteristics that promote high humidity and soil moisture. Our data indicate that it is most common at or near the base of concave slopes with northerly aspects and is often associated with *Acer spicatum* and *Viburnum alnifolium. Taxus canadensis* is not restricted to primary woodlands, although it is apparently excluded from recently logged sites. It is unclear whether deer browsing restricts *T. canadensis* distribution, and the impact of browsing may be confounded with habitat because deer may be more likely to winter on south-facing slopes. However, browsing is greatest on south-facing slopes and may limit the spread of *T. canadensis* in these habitats. Our data also suggest that *T. canadensis* is more abundant in Hanover than in north-central Massachusetts. This may be related to the cooler climate of Hanover, which results in a wider range of habitats available for use by *T. canadensis.*

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GENTIANA NIVALIS L. (GENTIANACEAE) NEW TO QUÉBEC

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and M. Julien

Key Words: *Gentiana nivalis,* distribution, James Bay, Québec, Labrador

During the course of ecological field work conducted on the northeast coast of James Bay in 1994, we collected a few specimens of a very small gentian, which proved to be *Gentiana nivalis* L. This arctic-alpine taxon is here reported as new to the flora of Québec.

Gentiana nivalis is an amphi-atlantic species (Hultén, 1958), the range of which is mainly Eurasian (Iceland, Northern and Central Europe, and Asia Minor). Previous to this report, the North American distribution of the taxon was thought to be restricted to coastal areas of Greenland and Labrador (Rousseau, 1974; Scoggan, 1979). The species has never been reported from Baffin Island, and Gillett (1963) states that this distribution pattern is due to a different postglacial history for Baffin Island from that of northern Labrador, rather than due to a collection gap. Most of the Labrador localities are north of 57°30′N, especially in the Kaumajet and the Torngat mountains. *Gentiana nivalis* is listed as rare in Canada and in Labrador (Argus and Pryer, 1990). In 1951, the plant was discovered in the Saglek Pass (*Rousseau 1064* QUE) on the Québec-Labrador border. The specimen does not indicate on which side of the border the collection was made. This note is therefore the first valid report for the species in Québec.

We collected *Gentiana nivalis* 17 km east of Pointe Louis-XIV (*Dignard, Lalumière & Julien 94-29* QUE) on July 23, 1994, in the tundra bordering the northeast coast of James Bay (Figure 1). This region, lying within the discontinuous permafrost zone, is characterized by the predominance of an arctic-alpine flora. The area is one of the southernmost Arctic outposts in North America (Ducruc et al., 1976), extending between 54°30′N and 54°45′N, along a strip five to 20 km wide parallel to the coast. The population was found in a dry, grassy meadow on an alluvial terrace of fine sand along a small brook, four km from the sea at 54°37′18″N–79°28′15″W, elevation ca. 20 m. Only a few individuals were observed. Unfortunately, time did not allow us to

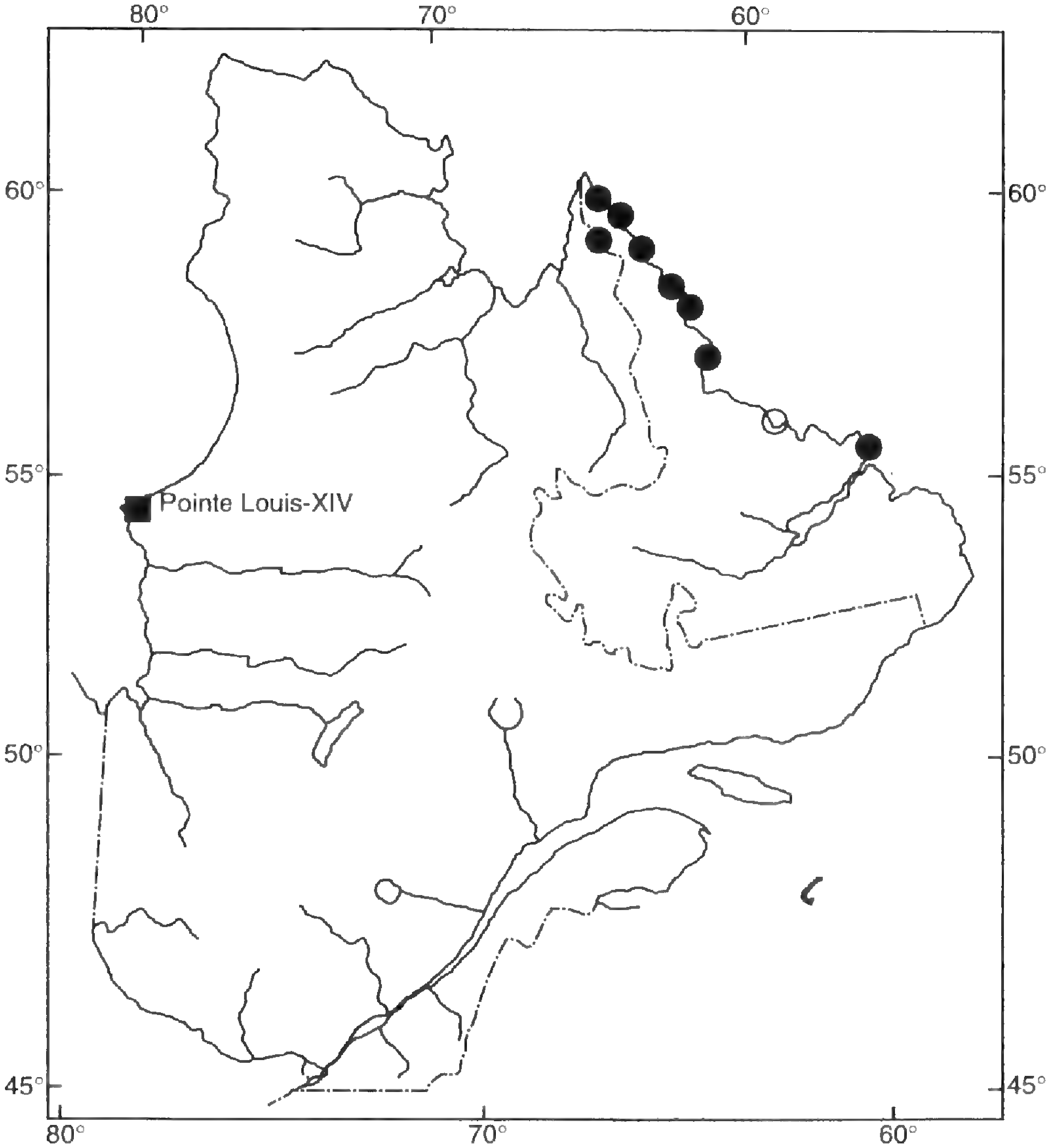

Figure 1. Distribution of *Gentiana nivalis* L. in Québec and Labrador (expanded from Gillett, 1963 and Rousseau, 1974). Square indicates the new locality.

check for its presence in the surrounding area. The terrace vegetation consisted of arctic-alpine and boreal species, the most representative being *Achillea millefolium* L. var. *nigrescens* E. Mey., *Antennaria pulcherrima* (Hook.) Greene, *Astragalus alpinus* L., *Betula nana* L., *Carex capillaris* L., *C. capitata* L., *Cerastium alpinum* L. ssp. *lanatum* (Lam.) Aschers. & Graebn., *Draba glabella* Pursh var. *glabella, Juncus arcticus* Willd. ssp. *arcticus, Kobresia simpliciuscula* (Wahlenb.) Mackenzie, *Luzula multiflora* (Ehrh.) Lej. *s.l., Poa alpina* L., *P. arctica* R. Br., *Polygonum viviparum* L., *Primula stricta* Hornem., *Salix argyrocarpa* Anderss., *S. brachycarpa* Nutt., *S. planifolia* Pursh ssp. *planifolia*, *Senecio pauciflorus* Pursh, *Tanacetum bipinnatum* (L.) Schultz-Bip. ssp. *huronense* (Nutt.) Breitung, and *Trimorpha elata* (Hook.) Nesom. Located in a depression between two low ridges, the terrace is covered by a thick layer of snow during the winter, as indicated by the presence of the willow and dwarf birch community and by late snowbed species such as *Potentilla tabernae-montani* Aschers, and *Taraxacum officinale* G. H. Weber *ex* Wiggers ssp. *ceratophorum* (Ledeb.) Schinz *ex* Thellung. Nomenclature follows Kartesz (1994).

This isolated population of *Gentiana nivalis,* more than 1000 km away from the nearest Labrador locality, is the westernmost occurrence of the species in North America. This wide disjunction could be related to the postglacial history of the taxon and to narrow ecological requirements. The amphi-atlantic boreal *Platanthera albida* (L.) Lindl. var. *straminea* (Fern.) Luer, known from northwest Newfoundland and disjunct in the Richmond Gulf and the Manitounouk Sound on the east coast of Hudson Bay, has a similar distribution (Payette and Lepage, 1977; Deshaye and Cayouette, 1988). Undercollection should also be considered. Due to its small stature, the plant can be easily overlooked, especially when the flowers are immature. It can also be confused in the field with other superficially similar gentians (*Gentianella amarella* (L.) Boerner ssp. *acuta* (Michx.) J. Gillett, *Gentianella tenella* (Rottb.) Boerner and *Lomatogonium rotatum* (L.) Fries *ex* Fern.). The plicate, eciliate corolla tube, the expanding lobes, and the 4–5 parted cylindrical, purple-keeled calyx of *G. nivalis* at once distinguish this species from others.

It is uncertain whether the new disjunct population of *G. nivalis* is the result of long distance dispersal or is relictual. Long distance dispersal, either by winds or birds, seems unlikely. The prevailing winds are westerly and bird migrations occur primarily in a north-south direction. In addition, the small seeds offer little nutritional value to birds although they could be ingested by accident.

Now that *Gentiana nivalis* is known from the James Bay region and its habitat is better defined, other localities of the species might be discovered in the region and perhaps elsewhere in northern Québec. This was recently the case for the amphi-atlantic arctic-alpine *Carex rufina* Drej. Thought to be disjunct between Greenland, the Northwest Territories, and northern Manitoba

(Porsild and Cody, 1980), it is presently known from at least six localities in the Ungava Peninsula, all restricted to volcanic rock formations (Blondeau and Cayouette, 1987).

Because of its extreme rarity in Québec, *Gentiana nivalis* should be added to the list of the vulnerable or threatened vascular plants of this province (Lavoie, 1992).

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BOOK REVIEW

Levine, Carol. 1995. *A Guide to Wildflowers in Winter: Herbaceous Plants of Northeastern North America.* 329 pp. including 19 plates of black and white photographs and 161 pages of line drawings. Yale University Press, P.O. Box 209040, New Haven, CT 06520-9040. ISBN 0-300-06207-9 ($40.00 cloth), 0-300-06560-4 ($20.00 paper).

The scope of this guide extends far beyond any existing similar guides to plants in winter, such as the excellent *Weeds in Winter* by Lauren Brown (1976), both in number of species covered and in the details with which they are described. Since the amount of information presented might be overwhelming to a beginner, the book is best suited to those who already have some familiarity with botanical terms, although all terms are well-defined. The wealth of detail will interest and challenge even the most experienced field botanists. It is an education simply to flip through the illustrations, which immediately command one's attention with their beauty and detail and encourage further investigations in the field.

The book covers most commonly encountered herbaceous plants that have dried remnants in winter, including many grasses, various members of the Cyperaceae (sedge family), not just *Carex,* and Juncaceae (rushes). Four hundred and nine taxa are illustrated and described. Some ferns and fern allies, some of which are evergreen anyway, are included so that everything is together in one volume, which is of a manageable size to take into the field. Even a few galls and leaf spots are noted.

Every effort is made to clarify the meaning of each term or heading. Several headings appear under each taxon's name covering Key Impressions; Fruit; Leaves; Stem; Perennial, Annual, or Biennial; Habitat; and Range. For example, Key Impressions cover a range of characteristics, such as height, odor, shape, and inflorescence. There is an illustrated dichotomous key to help in keying out dried and crumpled specimens and an illustrated glossary in the back.

The illustrations are excellent and capture both the appearance and the accurate details of a plant, which is quite a feat when it is usually lacking leaves and flowers and appears in an uncharacteristically bent, broken, and dried brown condition. Details of the calyces of the Lamiaceae (mint family), achenes of the Asteraceae (daisy family), and fruits of the Apiaceae (carrot family) are beautifully rendered and would be appreciated by any botanist. Details of capsules, seed ornamentation, and shapes of underground stems make one want to take a second look at the infinite variety and curiosities of the plant kingdom. Forty-six black and white photographs show evergreen or commonly persisting basal rosettes.

Plants are grouped together by obvious similar shapes, such as "climbing vine" or "stems and other parts with spines, barbs, or bristles." The key uses these general descriptions, which can become somewhat unwieldy, and proceeds into more detailed characterizations. Asteraceae, ferns and fern allies, Poaceae (grass family), Cyperaceae, and Juncaceae are treated separately. The drawings explaining the differing structures of these last three groups would be a credit to any botany manual. In an attempt to make it possible to key out asters (*Aster* spp.) to the species, they are first grouped by habitat, then by characteristics. This may not be useful or possible in a guide of this sort, but it will keep one observing.

This book will go a long way toward lightening that grim, brown season between November and March for both the interested amateur and for the professional field botanist who may be called upon to evaluate the vegetation of a parcel of land in the dead of winter. Like any good text, it provides information and stimulates one's observation and desire to see more.

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RHODORA NEWS & NOTES

LISA A. STANDLEY

HIGHLIGHTS OF CLUB MEETINGS

November 1995 (913th Meeting). Seven Club members shared slides and information at the "Annual Exchange of Botanical Explorations and Exploits," AKA Show & Tell. Pam Weatherbee spent much of her summer conducting a floristic survey of a 1000-acre parcel on Mt. Greylock. Pam reported finding an unusually high frequency of *Botryichium matricariaefolium,* and new sites for *Galium boreale* and *Carex baileyi.* Leila Schultz offered a look at rare plant hunting in Utah, where rugged terrain and isolated mountain ranges provide spectacular scenery as well as challenges to the botanist. Her summer's work succeeded in relocating a population of the rare endemic *Thelypodiopsis argillacea,* a delicate pink-flowered mustard, on gypsum outcrops in eastern Oregon. Barre Hellquist spent a month in Australia looking at aquatic plants. Wetlands containing as many as six species of waterlilies were the high point of the trip.

Matt Hickler noted the effects of the 1995 drought on oxbow ponds along the Nashua River at Fort Devens. During the drought, the aquatic vegetation in these ponds was still present and even healthy, but drastically different from normal growth forms. *Potamogeton natans* formed tight appressed rosettes, while *Nymphaea* produced erect leaves on robust petioles. Rare species, like *Panicum philadelphicum,* appeared in abundance on exposed mud flats.

George Newman reviewed the June Club Field Trip to Mt. Washington's Alpine Gardens, attended by 23 people. Ten hardy souls braved the gale winds and continued on to the headwall of the Great Gulf. Highlights included *Loiseleuria, Rhododendron lapponicum, Phyllodoce* and *Cassiope*; people who left early missed seeing *Cardamine bellidifolia* and *Saxifraga rivularis.* In September, George returned to the Presidentials to search for the distinctive bright red leaves of *Arctostaphylos alpina.* On a later trip to Newfoundland, George saw thousands of individuals of *Arethusa* in bloom and located a large population of a form of *Sarracenia* that lacks anthocyanin.

Art Gilman provided a survey of the diversity of club moss species and hybrids in northern Vermont, where it is possible to find *Diphasiastrum tristachyum, D. digitatum,* and their hybrid

(*D.* × *habereri*), as well as *Diphasiastrum* × *zeilleri* and its parents (*D. tristachyum* and *D. complanatum*). Abandoned high pastures are habitats for *Diphasiastrum* × *sabinifolium* (*tristachyum* × *sitchense*), and a newly described hybrid of *D. sabinifolium* and *D. digitatum.*

December 1995 (914th meeting). Dr. Norton Nickerson of Tufts University spoke on "A Look at New Zealand Mangrove Ecosystems Over Time." New Zealand has but a single species of mangrove, *Avicennia resinifera,* the world's southernmost mangrove. The epithet was chosen because early collectors found floating lumps of *Agathis* resin in mangrove swamps. Mangroves have an important ecological role as the tropical equivalent of salt marshes, but are often threatened by grazing, cutting, and filling.

Much of the talk focused on mangrove swamps in embayments near the tip of New Zealand's North Cape. Although a national park, sheep and cattle are grazed on the uplands. Where the hills bordering mangrove swamps are heavily grazed, sediment deposition buries pneumatophores and kills the mangroves. Animals also wander onto the tidal flats at low tide and damage the mangroves by grazing. In the late 1970's, mangroves had been virtually eliminated in this area, and the local fishermen complained about declines in shellfish and fisheries.

Recommendations that a buffer strip of Crown lands along the edge of the estuary be protected were implemented by the local authorities. In the absence of grazing, shrubs and a dense vegetation had become established in this "buffer strip," and trees had been planted in some areas to restore vegetation to overgrazed areas. Consequences were dramatic—mangrove swamps recovered and became re-established in areas where they had practically disappeared. Mangroves have also colonized and replaced stands of the introduced *Spartina anglica,* indicating that the salt marsh grass may be acting as the first successional stage in the establishment of mangroves.

THE GRAY HERBARIUM CARD INDEX OF NEW WORLD PLANTS AND THE HARVARD UNIVERSITY HERBARIA TYPE SPECIMEN COLLECTION DATABASE

The Gray Herbarium Card Index and the Harvard University Herbaria Type Collection databases are now available on the

World Wide Web through the Harvard University Herbaria (HUH) Web page. The Universal Resource Locator (URL) for the HUH Web site is: **http://www.herbaria.harvard.edu.**

With the above URL, users will find a general outline of the Harvard University Herbaria, including "Databases," from which many searchable databases, including the Gray Herbarium Card Index, the Harvard University Herbaria Type Specimen Collections, the Farlow Diatom Collection, Botanical Collectors, and Botanical Authors can be accessed.

The Web page search form, for both the Gray Card Index and Type Collections, has multiple fields (such as Family, Genus, Specific & Infraspecific Epithets, Author, Publication, and Type). This allows users to make complex queries. Detailed instructions on searching are provided.

The Gray Herbarium Card Index provides bibliographic details for new taxa of vascular plants, new combinations, new status, and new names of New World Plants. It also includes information on infrageneric and infrafamilial names, and on types (including epi-, neo-, and lectotypification). From its inception (in 1893), the Gray Index included publication information for all specific and infraspecific names, basionyms, replaced synonyms, and other nomenclatural synonyms, but not taxonomic synonyms.

Although the original scheme of the Gray Index was designed to cover specific and infraspecific names published from 1 January 1886, it was later modified to include all infraspecific names published from 1753. An effort to include infraspecific names from this period is still underway. The information on infrageneric and infrafamilial names and types starts from the early 1970's.

The Gray Index data, which was published in the form of printed cards until the mid 1980's and as microfiche until early 1992, has been made available over the Internet using Gopher since mid-1992. (Users may find additional information on the Web page "About the Gray Herbarium Index.")

The Type Collection database includes information on type specimens in the Harvard University Herbaria (A, AMES, ECON, FH, GH, NEBC), collected from all parts of the world. The data on Type Collections has also been available on Gopher since 1991. (Presently, Internet users may access the Gray Index data and Type Collections data through either Gopher or the World Wide Web; however, at some point in the near future the Gopher services will be discontinued.)

An Appeal to the Users of the Gray Herbarium Card Index and Type Collections. The accuracy and completeness of the Gray Card Index and Type Collections databases depends largely upon the input of the users, who are urged to provide any relevant information (such as additions, omissions, and corrections to the data) via e-mail to either K. N. Gandhi (**gandhi@oeb.harvard.edu**) or David Boufford (**boufford@oeb.harvard.edu**). Contributed by K. N. Gandhi.

THE NEW ENGLAND BOTANICAL CLUB

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THE NEW ENGLAND BOTANICAL CLUB

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The New England Botanical Club is a non-profit organization that promotes the study of plants of North America, especially the flora of New England and adjacent areas. The Club holds regular meetings, has a large herbarium of New England plants, and a library. It publishes a quarterly journal, RHODORA, which is now in its 95th year and contains about 400 pages a volume.

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