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The biosystematics of Carex section Scirpinae (Cyperaceae)

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THE BIOSYSTEMATICS OF CAREX
SECTION SCIRPINAE (CYPERACEAE)

BY

DEBRA A. DUNLOP
B.A. New England College, 1976
M.S. University of New Hampshire, 1983

DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy

in

Plant Biology

May, 1990

This dissertation has been examined and approved.

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TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

ABSTRACT

THE BIOSYSTEMATICS OF *CAREX* SECTION *SCIRPINAE* (CYPERACEAE)

by

Debra A. Dunlop
University of New Hampshire, May, 1990

Carex section *Scirpinae* is a small group of North American sedges that possess a dioecious breeding system, unispicate inflorescences and pubescent perigynia. Historically, ten different taxa had been recognized at the specific or infraspecific levels based primarily on morphological characters. Taxonomic problems in the group were related to the lack of a comprehensive monographic treatment. Floristic treatments were limited and focused only on a few regional taxa. Descriptions were often incomplete, lacking descriptions of staminate material or complicated by the inconsistent use of the terms phyllopodic and aphyllopodic. Patterns of variation in morphological characters across a wide geographic range were not understood. Little, information was available concerning chromosome numbers, anatomy, interbreeding relationships, micromorphological features and ecology.

A systematic investigation of taxa assigned to this section was carried out to: 1) circumscribe taxa, 2) examine phenetic relationships, 3) resolve the question taxonomic rank, and 4) determine whether the group was monophyletic. Based on evidence drawn from morphology, chromosome numbers, leaf anatomy and surface structure, achene and perigynium micromorphology, interbreeding relationships, ecology and distributions, six taxa are recognized in two species, one with four subspecies. The section, as treated here, consists of *Carex scirpoidea* Michx., with four subspecies (ssp. *scirpoidea*, ssp. *convoluta*, ssp. *pseudoscirpoidea*, and ssp. *stenochlaena*). and *Carex curatorum* Stacey. The subspecies of *C. scirpoidea* are geographically based ecotypes that differ morphologically in only a few characters. *Carex curatorum* is distinguished by characters of perigynium morphology, domed silica bodies of the achene, sparsely pilose leaf surfaces, a restricted distribution in riparian habitats in southern Utah and northern Arizona. The section *Scirpinae* forms a cohesive group of dioecious, unispicate sedges with pubescent perigynia, chromosme numbers of *n*=31, similar leaf anatomy and high degree of interfertility between subspecies based on hand-pollinations.

Two taxa, *Carex gigas* (Holm) Mack. and *C. scabriuscula* Mack., previously assigned to the section, have been excluded. Plants are often not dioecious, rarely unispicate and have perigynia with few short hairs, have chromosome numbers of *n*=29 and exhibit amphistomatous leaves.

INTRODUCTION

Taxonomic History

In the genus Carex, Tuckerman (1843) was first to apply the epithet Scirpinae to one of nine groups of sedges of unspecified rank under the section Psyllophorae. He distinguished the Scirpinae as a group of plants that were almost always dioecious with red-brown, pubescent perigynia. His concept of the Scirpinae included Carex scirpoidea Michx. (=Carex scirpina Tuckerman) and Carex drummondiana Dew.

Other sectional treatments and concepts followed. Bailey (1887) assigned Carex scirpoidea to the section Sphaeridiophorae Drejer in his treatment of North American carices. Bailey took a broad view of the section, including in the section Sphaeridiophorae subsections Filifolia Tuckerman and Montanae Fries. In that same year, Pax (1887) included C. scirpoidea in the section Dioicae Fries and subsection Scirpoideae. Despite these sectional treatments, Kükenthal (1909) took Tuckerman's concept of the Scirpinae, excluding C. drummondiana, and transferred it to sectional rank under the subgenus Primocarex. The sectional name appears to be validly published by Kükenthal and according to Greuter et al. (1988), falls under the conditions outlined in Article 35.2, example 2 of the International Code of Botanical Nomenclature.

The subgeneric placement of the section has varied depending on an author's sectional concept (Koyama, 1962; Krechetowich, 1936; Kükenthal, 1909; Nelmes, 1951; Savile and Calder, 1953) and has been based primarily on the morphology, arrangement and number of inflorescences. Viewpoints differ as to whether unispicate plants represent a primitive or a derived condition within the genus.

Kükenthal's (1909) treatment of Carex recognized four subgenera (Primocarex, Vignea, Indocarex, Eucarex) placing the section Scirpinae in the subgenus Primocarex, since he considered the unispicate condition primitive.

Krechetowich (1935) recognized 3 subgenera, (Megalocranion, Vignea and Eucarex) in which the latter subgenus included the section Scirpinae (= section Trysanolepsis V. Krecz.). He viewed the Primocarex as an artificial group, stating that the unispicate condition represented a derived state brought about through reduction from multispicate ancestors to which the unispicate types must be aligned (Krechetowich, 1935, 1936). Krechetowich (1936) believed the section Scirpinae represented a digressive reduction through a simple decrease in spike number that arose during periods of glaciation.

Likewise, Nelmes viewed the subgenus Primocarex as artificial, as he believed it included taxa that had closer affinities with other unispicate or rachilla-bearing genera, such as Uncinia, Schoenoxiphium and Kobresia, than with Carex. He viewed C. scirpoidea and other dioecious, unispicate taxa as "true, reduced Carices" (Nelmes, 1951, p. 429).

Taking another viewpoint, Koyama (1962) recognized only two subgenera (*Carex* and *Vignea*) in his treatment of Japanese carices. He included taxa of the section *Montanae* Fries and the smaller sections *Filifoliae* Tuckerman and *Grallatoriae* Kükenthal within his concept of the section *Digitate* Fries. Applying Koyama's concept, the section *Scirpinae* would probably be included with the section *Digitatae*.

Since 1803, when Michaux described *C. scirpoidea*, the taxon on which the section is based, nine additional taxa have been recognized by various authors (Table 1 and 2). Rydberg (1900) recognized *Carex pseudoscirpoidea* Rydb. as a distinct species differing from eastern *C. scirpoidea* on the basis that the former were more robust plants with scales shorter than the perigynia. Then, Holm (1904) described two new varieties of *C. scirpoidea*, var. *stenochlaena* Holm and var. *gigas* Holm. Two other taxa, *C. scabriuscula* Mack. and *C. scirpiformis* Mack., were recognized and described by Mackenzie (1908) in a treatment of *C. scirpoidea* and allies. Kükenthal (1909) recognized two additional varieties of *C. scirpoidea*, var. *convoluta* Kük. and var. *europaea* Kük. *Carex curatorum* Stacey and *C. athabascensis* Hermann were described in 1937 by Stacey and in 1957 by Hermann respectively.

All but two of the above mentioned taxa (*C. athabascensis* and *C. scabriuscula*), have been treated by different authors at the specific level or as varieties of

C. scirpoidea (Table 2). Taxonomic studies of the taxa in this section are few and primarily limited to regional floristic treatments which do not treat all taxa of the section. Kükenthal (1909), in his worldwide monograph, took a narrow view of the section and recognized only one species with 5 infraspecific taxa. In contrast, Mackenzie (1935), in a treatment of North America carices, recognized six species.

In addition to differing taxonomic viewpoints, various interpretations in terminology, primarily in the use of the words aphyllopodic and phyllopodic (see discussion under Macromorphology section), have further complicated our understanding of the systematics of this group. Furthermore, staminate material has often not been described, nor even observed, for some taxa. Apparently, some taxa have been assigned to the section based on superficial resemblance to taxa of the section or on descriptions based on very few specimens. Patterns of variation in morphological characters have not been assessed across the full geographic range of the widely distributed taxa and information on endemic taxa was sparse.

The taxonomic treatment presented here recognizes two species in section *Scirpinae*, *Carex scirpoidea*, with four subspecies, and *C. curatorum*. The treatment is based on a detailed analysis of variation in characters of morphology, anatomy and micromorphology, chromosome numbers, ecology, interbreeding relationships and distributional patterns. Two taxa, *C. gigas* and *C. scabriuscula*, have been excluded from the section based on inconsistencies in characters that distinguish the section.

Taxonomic Criteria

This study follows the criteria and definitions of species and infraspecific taxa outlined by Standley (1985b) and Crins and Ball (1989b) for *Carex*. Species are defined as groups of populations that are distinguished by discontinuities in a suite of morphological and anatomical characters. Additionally, species have a unique geographic distribution or ecolog and are reproductively isolated which is maintained through either genetic incompatibilities, geographic or ecological isolation, or differences in flowering phenology.

Some widely distributed species have geographically or ecologically distinct subunits. Subunits have been recognized either as subspecies or varieties and differ from the nominate taxa by a few characters. Subspecies are defined as groups of populations that are distinguished by discontinuities in a few characters having a unique distribution and ecological traits. These infraspecific taxa generally have a limited geographic range, or are restricted to a unique habitat. Intergradation may occur in some characters in geographic areas where taxa overlap.

The infraspecific rank of subspecies has been used in this study since subunits of the wide ranging *C. scirpoidea* are well defined. Four subspecies are recognized, each distinguished by a few vegetative or reproductive characters, a distinct distribution, and a unique habitat.

Table 1. Taxonomic history of the section Scirpinae.[1]

Kükenthal 1909	Mackenzie 1935	Abrams 1940	Cronquist 1969 & 1977	Hermann 1970	Dunlop 1990
Carex scirpoidea	Carex scirpoidea	Carex scirpoidea	Carex scirpoidea	Carex scirpoidea	Carex scirpoidea ssp. scirpoidea
var. scirpoidea					
f. basigyna	-	-	-	-	-
var. europaea	*	*	*	*	-
var. convoluta	-	*	*	*	Carex scirpoidea ssp. convoluta
var. stenochlaena	Carex stenochlaena	Carex stenochlaena	var. stenochlaena	Carex stenochlaena	Carex scirpoidea ssp. stenochlaena
var. gigas	Carex gigas	Carex gigas	*	*	excluded
-	Carex scirpiformis	*	*	Carex scirpiformis	-
-	Carex pseudoscirpoidea	Carex pseudoscirpoidea	var. pseudoscirpoidea	Carex pseudoscirpoidea	Carex scirpoidea ssp. pseudoscirpoidea
-	-	*	var. curatorum[2]	-	Carex curatorum
-	Carex scabriuscula	Carex scabriuscula	*	*	excluded

Note:

[1] Carex athabascensis was described in 1957 by Hermann but not within the geographic range of the 1970 reference.

[2] Carex curatorum was described in 1937.

* = taxon not within range of floristic treatment

- = taxon not recognized in treatment.

Table 2. Taxa described for the section Scirpinae.

Carex scirpoidea Michaux	1803 Fl. Bor. Amer. 2:171
var. *scirpoidea*	
ssp. *scirpoidea* Löve & Löve	1964 Taxon 13:202
var. *convoluta* Kükenthal	1909 Pflanzenreich 38:81
var. *europaea* Kükenthal	1909 Pflanzenreich 38:81
Carex pseudoscirpoidea Rydberg	1900 Mem. N.Y. Bot. Gar. 1:78
C. scirpoidea var. *pseudoscirpoidea* (Rydb.) Cronquist	1969 Univ. Wash. Publ. Biol
Carex stenochlaena (Holm) Mack.	1908 Bull. Torrey Bot. Club 35:269
C. scirpoidea var. *stenochlaena* Holm	1904 Amer. J. Sci. 18:20
C. scirpoidea ssp. *stenochlaena* (Holm) Löve & Löve	1964 Taxon 13:202
Carex scirpiformis Mackenzie	1908 Bull. Torrey Bot. Club 35:269
C. scirpoidea var. scirpiformis (Mack.) O'Neill & Dumas	1941 Rhodora 43:417
Carex curatorum Stacey	1937 Leafl. W. Bot. 2:13
C. scirpoidea var. *curatorum* (Stacey) Cronquist	1977 Intermountain Flora 6:113
Carex athabascensis Hermann	1957 Leafl. W. Bot. 8:109
Carex scabriuscula Mack.	1908 Bull. Torrey Bot. Club 35:269
Carex gigas (Holm) Mackenzie	1908 Bull. Torrey Bot. Club 35:268
C. scirpoidea var. *gigas* Holm	1904 Amer. J. Sci. 18:20

I. MACROMORPHOLOGY

Introduction

Most systematic studies in *Carex* rely on morphological characters to circumscribe and delineate species. Relative to other taxa, morphological characters in *Carex* are often limited due to the considerable reduction in the reproductive structures. A pistillate spikelet in *Carex* consists of an ovary and style enclosed within a perigynium, subtended by a scale and the staminate structure consist of three stamens, subtended by a scale. Characters of the perigynia, subtending scales, achenes and inflorescences are often the most useful morphological characters in separating taxa in *Carex*. Additionally, vegetative characters of the leaves, basal sheaths, ligules and scale leaves are useful.

In the *Scirpinae*, few studies have focused on the patterns of variation in morphology across a wide geographic range as most treatments are regional and floristic in nature. This morphological analysis focused on variation in all taxa throughout North America to reveal discontinuities in qualitative and quantitative characters. It is important to note that *Carex gigas* and *C. scabriuscula*, previously thought to belong in this section, but now excluded, were included in this analysis in order to fully evaluate their affinity with the other taxa in section *Scirpinae*.

Methods

The morphological study was based on examination of over 5,000 herbarium specimens borrowed from the following herbaria: AA, ARIZ, ALA, ALTA, ASC, BH, BYU, CAN, CAS, COLO, CS, DAO, DAV, DS, F, HSC, MAINE, MASS, MBG, MICH, MIN, MONTU, MSC, MT, NA, NHA, NY, OS, ORE, OSC, PAC, POM, RSA, RM, SASK, TRTE, UBC, UC, US, UT, USAS, USFS, VT, WAT, WILLU, WIS, WS, WTU (acronyms follow Holmgren et al., 1981). In addition, population samples were collected in the field from New England (1983-1986), Michigan (1984), western United States (1985) and Newfoundland (1986). From each of thirty field sites, live plants were collected, potted in a standard potting medium, grown in the greenhouse and evaluated for morphological characters.

A detailed morphological analysis was conducted on a sample of 139 OTUs. In this study an OTU was an individual plant. The sample consisted of three to ten individuals selected from 36 populations representing a wide geographic range and encompassing the full range of morphological variation observed. Sixty-nine characters, both quantitative and qualitative, were evaluated (Table 3) using herbarium specimens and live material collected in the field. This data set was initially analyzed for morphological trends using descriptive statistics and histograms in an effort to discern discontinuities in values for character states. Means and ranges for each character were analyzed and evaluated for inter- and intrapopulation variation. Populations that were not significantly in character means were then grouped and compared. Taxa were determined based on discontinuities between groups of populations.

Although the section *Scirpinae* is dioecious, the macromorphological analysis focused mainly on characters of the pistillate plants since staminate flowers are so greatly reduced (3 stamens and a subtending scale) in the genus *Carex* and rarely exhibit characters with taxonomic value. There is little sexual dimorphism in the section *Scirpinae*, although staminate plants tend to be smaller in size and inflorescences have longer, narrower scales than those of pistillate plants. Based on this macromorphological analysis, the salient morphological characters of pistillate plants are outlined below. General patterns and trends in variation, and taxonomic implications within the section are discussed.

Results and Discussion

Breeding System

The section *Scirpinae* is characterized by a dioecious breeding system, in contrast to the more typical monoecious condition in *Carex*. As in other dioecious plant species, some variation occurs in the stability of this breeding system. For instance, Kükenthal (1909) recognized *Carex scirpoidea* forma *basigyna* Lange, a form described from Greenland where a number of individuals possessed staminate flowers at the base of pistillate spikes.

Observations on the breeding system were best made on live plants, either in the field or the greenhouse, but the presence of staminate flowers on pistillate spikes was noted on herbarium specimens by the remnants of stamen filaments adaxial to scales lacking perigynia. The presence of one to five staminate flowers intermingled with pistillate flowers or the presence of an occasional pistillate flower (or mature achene) in the axil of the subtending involucral bract, or very rarely at the base of the spike was observed. This variation occurred throughout the geographic range of *C. scirpoidea* but was limited to less than 5% of the plants. When variation in dioecy was observed in a population, a number of individuals would often exhibit mixed-flowered spikes. Only *Carex curatorum* was found to be strictly dioecious.

The breeding system in *Carex gigas* and *C. scabriuscula* was much less stable. In these two species some of the staminate spikes often possessed basal pistillate flowers. The frequency of mixed spikes was estimated to be much higher than in *C. scirpoidea* and great enough to suggest that *C. gigas* and *C. scabriuscula* might actually represent aberrant specimens of some otherwise monoecious species.

Habit

Plants varied in habit. In *Carex scirpoidea*, ssp. *scirpoidea*, ssp. *convoluta* and ssp. *stenochlaena* were cespitose while ssp. *pseudoscirpoidea* was rhizomatous. In the cespitose plants, new shoots diverged at various directions from the short rhizome, while in rhizomatous plants, new shoots arose in a strictly linear fashion (Fig.

1A-C).

Carex gigas and *C. scabriuscula* were strongly cespitose. They formed especially dense clumps because of the retention of persistent, withered leaf bases from early spring growth and/or from the previous year.

Culms

Much of the previous taxonomic confusion in this section has been related to characters of the culm and the cauline leaves. Historically the terms phyllopodic and aphyllopodic had been used to characterize the type, placement and nature of the leaves of the flowering shoots.

Mackenzie (1908) was the first to apply the terms phyllopodic and aphyllopodic to the section *Scirpinae*. He distinguished the phyllopodic taxa, *Carex pseudoscirpoidea*, *C. gigas* and *C. scabriuscula*, from the aphyllopodic taxa, *C. stenochlaena*, *C. scirpoidea* and *C. scirpiformis*. Stacey (1937) modified Mackenzie's key to the section, placing *C. gigas* with the aphyllopodic plants and when he described *C. curatorum*, grouped it with the aphyllopodic taxa. On the other hand, when Hermann (1957) described *Carex athabascensis* (= *C. scirpoidea* ssp. *scirpoidea*) from Alberta, he treated it as phyllopodic.

Cronquist distinguished *C. scirpoidea* var. *scirpoidea* as "distinctly aphyllopodic", var. *pseudoscirpoidea* as "chiefly or wholly phyllopodic," var. *stenochlaena* as "phyllopodic or aphyllopodic" (1969, p. 326) and *C.*

curatorum as "phyllopodic to strongly aphyllopodic" (Cronquist, 1977, p. 114). Interestingly, Rydberg (1900, p. 78), when describing C. pseudoscirpoidea, mentioned that the leaves are "mostly basal; the earliest reduced to brown scales". He did not make reference to differences in the foliage at the base of the culms, nor did he use the terms aphyllopodic or phyllopodic. This confusion has been compounded as various authors have emphasized these characters in separating the group.

The primary problem stems from the many different interpretations of the terms aphyllopodic and phyllopodic. Holm (1919) proposed the use of the terms by caricologists after Fries described them in 1843. Holm (1902, p. 418) interprets Fries' descriptions of phyllopodic and aphyllopodic as flower bearing stems with "basal leaves being provided with large, assimilating blades or being merely scale-like with rudimentary or non-developed blades, at the time of the flowering". In descriptions of C. scopulorum, Holm describes the culm as having a "base surrounded by green leaves (phyllopodic)".

Mackenzie's (1908, p. 267) interpretation was that aphyllopodic plants have culms with "lower culm leaves are reduced to bladeless sheaths", thus having a "few (usually 3-5) well-developed leaves to a culm" whereas phyllopodic plants have culms bearing six to ten leaves with well-developed blades.

In 1935, Mackenzie continued to use the terms in the same sense but incorporated some descriptive phrases referring to the presence or absence of the dried-up leaves of the previous year at the base of the culm. This is the first reference that incorporates vegetative parts from a previous growing season into the definition.

Cronquist (1969, p. 326) clarified the phyllopodic-aphyllopodic problem by adding some additional descriptive information concerning the maturation sequence in flowering culms. He makes the distinction that phyllopodic plants have flowering culms that arise from "vegetative shoots of the previous year, on which the characteristic basal scale leaves have degenerated and cannot be readily distinguished individually" in contrast to aphyllopodic plants that have culms that arise "from vegetative shoots of the current year, on which the characteristic (often anthocyanic) basal scale leaves are well-developed and conspicuous".

Murray (1970) recognized the inconsistency of the use of these two terms and suggested returning to the original definitions by Fries. Murray pointed out that the terms refer only to the "basal leaves of fertile culms at the time of flowering, not to those of the previous years nor to the leaves of the sterile shoots" (Murray, 1970, p. 313). I interpret Murray's definition to refer only to those leaves of the present year on the culm of the present year. It is still not clear what consideration should be given to the presence of persistent and withered leaf bases from the previous year that might remain or surround the culm of the current year.

In order to clarify this problem Fries' Latin description, as quoted by Holm (1919, p. 19), has been translated as follows: "A remarkable difference was placed in the foot of the stem: this (base) is bound either by leafless sheaths (Aphyllopodae) or by the lowest leaf-bearing sheaths (or by all the basal portions of the leaf bearing sheaths), although withered "(Phyllopodae) (R. Clairmont, translation).

This definition clearly does not refer to culms of the current year nor to maturation time of the leaf-bearing sheaths, although it does refer to withered leaf sheaths. In order to avoid continued confusion I have not utilized these terms, although I prefer Cronquist's (1969) interpretation of the leaves of the flowering shoot. In C. scirpoidea ssp. pseudoscirpoidea culms of the current year distinctly and consistently arise from within leaves of the vegetative shoots of the previous year, and therefore the culms are clothed at the base by the withered, persistent leaf bases of the previous year. On the other hand, in C. scirpoidea ssp. scirpoidea, ssp. convoluta and ssp. stenochlaena, all the vegetative shoots die back to the rhizome so that there are only buds of the current year, some of which produce culms while others remain vegetative. Thus these culm bases possess only current year bud scales and cauline leaves of the current year.

Initially it was thought that this difference in culm development might be a response to some environmental factor, such as soil type or climatic influence. Based on label data from herbarium sheets, specimens bearing culms arising from previous year shoots seemed to be closely associated with sites with gravelly soils on ridges at the highest elevations. Only one population of *C. scirpoidea* ssp. *pseudoscirpoidea* was grown in the greenhouse (Dana Plateau, CA), and it continued to exhibit culms that developed from the previous year shoots. On close examination of western populations that were represented by large numbers of herbarium specimens, a suite of characters was discernible which correlated with culms arising from the shoots of the previous year. This suite of vegetative characters of the culms, leaves and rhizome further segregates *C. scirpoidea* ssp. *pseudoscirpoidea* from ssp. *scirpoidea* (Table 4). Since the culms arise from the shoots of the previous year, the characteristic anthocyanic scale leaves are lacking at the base of the fertile shoots. Additionally, these plants are more rhizomatous, with internodes generally over one cm long, and possessing thicker and less fibrous roots than the other three subspecies. Leaves of the vegetative and flowering shoots in *C. scirpoidea* ssp. *pseudoscirpoidea* tend to diverge from one place, anywhere up to 20 mm above the soil surface, in contrast to the ssp. *scirpoidea* where the leaves begin to diverge from the shoot axis very near the ground and continue to diverge at spaced intervals along the shoot axis.

Aside from the confusion over the interpretation of the culm terminology, the problem is further exacerbated since many herbarium specimens bear culms lacking the basal portion of the plants, as plants are often very difficult to dig from the hard stony soils. Since differences in basal characteristics are diagnostic, especially for *C. scirpoidea* ssp. *pseudoscirpoidea*, many specimens lacking leaves of the flowering shoots were difficult to identify to subspecific rank unless duplicates with all plant parts were available.

Culm Height

Within the section *Scirpinae* there is a general east-west trend in increasing culm height. *Carex curatorum* was the most variable species. Plants of this taxon grew in hanging garden communities on vertical canyon walls, and exhibited the tallest culms, some reaching a maximum of 91 cm. In *C. scirpoidea* the shortest plants were from the single Norwegian site. Kükenthal (1909) recognized plants from this mountain site as *C. scirpoidea* var. *europaea*. Although this locality is greatly disjunct from the rest of the range and plants tend to be shorter, all characters fall within the normal range of variation for *C. scirpoidea* from North America, hence this variety is submerged into synonymy here.

Involucral Bracts

The presence or absence of an involucral bract, subtending the pistillate and staminate inflorescences, was variable in the taxa studied. When absent, the culm was naked. When present, the bract was either foliaceous or reduced to a short scale-like structure. The foliaceous bract was green, laminate, attenuate, and inserted below the spike and located within the top half of the culm. These bracts varied in length from a few millimeters to many centimeters. Due to the variability in features of the bract, only the relationship between the bract length and height of the top of the spike was taxonomically important. In some taxa the involucral bract was reduced and scale-like. In appearance this scale was similar in shape, size and color to the scales of the pistillate and staminate inflorescences but inserted just below the spike.

The involucral bract was generally present in *Carex scirpoidea* (all its subspecies) and *C. curatorum*. In all these taxa (excluding ssp. *pseudoscirpoidea*) the bracts were generally foliaceous and varied in length from a few millimeters to a few centimeters, rarely exceeding in length, the top of the spike. In contrast, ssp. *pseudoscirpoidea* exhibited naked culms, or occasionally possessed culms with a short scale-like bract. Involucral bracts in *C. gigas* and *C. scabriuscula* the bracts were usually present, foliaceous and in length, exceeded the top of the spike. Bracts in these two taxa were consistently wider and longer than those in the section *Scirpinae*. These features of the involucral bracts distinguished *C. gigas* and *C. scabriuscula* from the taxa in the section *Scirpinae*.

Leaves

Features of the leaves of the vegetative and flowering shoots are often diagnostic in *Carex* at the species and infraspecific level. Generally, in the section *Scirpinae*, both the culm and vegetative leaves are morphologically similar, although the number of vegetative leaves per shoot is greater than the number of culm leaves per shoot. Both culm and vegetative leaves are linear, with sheathing tubular bases with the abaxial side prolonged into a well-developed blade that tapers apically. The leaf base of one leaf sheaths the base of the next youngest leaf. In the section *Scirpinae*, outer surfaces of the leaf sheath is reddish-brown, in contrast to the green blade. The inner sheath surface is light green to tan. At the junction of the sheathing base and blade, a leaf sheath orifice, or mouth, is present which, in the section *Scirpinae*, is semicircular, convex and often ciliate along its edge.

Opposite the sheath mouth, a ligule is present on the adaxial leaf surface. Ligule height was measured from the base of the arch to the highest point in the arch, while ligule width coincided with leaf width and therefore was not measured separately. Ligule height of culm leaves in *C. curatorum* was the most variable, ranging from 1 to 5 mm whereas *C. scirpoidea* ranged between 0.2 to 3 mm. Although there was some overlap, ligule height generally distinguished *C. curatorum* as ligules were mostly more than 3 mm high.

The base of the culm and vegetative shoots are surrounded by short, apically acute scale leaves which function as winter bud scales. These scale leaves are anthocyanic, red-purplish in color, and persistent, remaining at the culm base, except where culms arose from vegetative shoots of the previous year, as in *C. scirpoidea* ssp. *pseudoscirpoidea*, or where persistent leaf bases surround the culm bases, as in the excluded taxa *C. gigas* and *C. scabriuscula*.

Width of the leaves of the flowering shoots varied and had taxonomic significance. *Carex scirpoidea* ssp. *convoluta* had previously been recognized by Kükenthal as a narrow-leaved variety of *C. scirpoidea* restricted to the Lake Huron and Niagara Escarpment region. On examination of maximum culm leaf width, for the Lake Huron populations, values fell below the normal range of ssp. *scirpoidea* (Fig. 2). ANOVA across four populations of ssp. *convoluta* and a sample from the range of ssp. *scirpoidea* gave $F_{4,\ 195} = 49.11$; $p < .001$. Using a Bonferroni t test on width of fowering shoot leaves, populations of ssp. *convoluta* were not significantly different from one another but differed from those of ssp. *scirpoidea*. Plants of ssp. *convoluta* from the type locality, (Alpena Co., Thunder Bay Island, Michigan), had the narrowest leaves and consistently maintained this character when grown under uniform greenhouse conditions with other taxa, thus suggesting a probable genetic basis for this trait.

Initially vegetative leaf width was examined for ssp.

convoluta, but so many of the Lake Huron/Niagara Escarpment plants lacked vegetative shoots that measurement of vegetative leaves was abandoned. Field and greenhouse studies on plants from Drummond Island and Thunder Bay Island showed that vegetative shoots were sparse due to a high percentage of flowering culms per plant relative to plants in other populations of *C*. *scirpoidea*. This high reproductive output was also evident in plants from herbarium specimens from other Lake Huron/Niagara Escarpment populations.

Other features of the leaf surface provided diagnostic characters. The type, distribution and taxonomic significance of hairs, prickles and stomata are discussed under the foliar anatomy and leaf surface structure section.

Inflorescences

The section *Scirpinae* is distinguished by having unispicate culms. Typically, each culm bears a solitary, terminal, unisexual spike. However some variation occurs. In *C*. *scirpoidea* rarely to occasionally a small, sessile, lateral spike subtends the terminal spike by less than 1 cm. These small lateral spikes occur more frequently in *C*. *curatorum* than in *C*. *scirpoidea*.

In contrast, *Carex gigas* and *C*. *scabriuscula* exhibit the most variation with 1-3 small, peduncled spikes subtending the terminal spike. Approximately 50% of plants of these taxa are multispicate. This feature clearly distinguishes them from taxa in the section *Scirpinae*.

Inflorescence size and shape are often taxonomically useful characters. In *Carex scirpoidea* pistillate spike width varied between 0.1 mm and 0.6 mm, but was not a consistently reliable character since width depended on spike maturity. Spike length was found to be correlated with plant size. Diminutive alpine plants of *C. scirpoidea* ssp. *scirpoidea* possessed the narrowest and shortest spikes. Both the staminate and pistillate spikes of ssp. *stenochlaena* are distinct, having a clavate shape, instead of the more common linear shape typical of the other three subspecies. In the clavate spike the scales are longer and more numerous at the spike apex.

Carex gigas and *C. scabriuscula* had the longest and widest spikes, possessing the greatest number of flowers per spike.

Pistillate Scales

Characteristics of the pistillate scales are often taxonomically important. In the section *Scirpinae*, scales exhibited considerable variation. However, of the taxa in this section, only *C. scirpoidea* ssp. *stenochlaena* was distinguished by scale characters. Within *C. scirpoidea*, scales of ssp. *stenochlaena* were lanceolate and distinctly longer and narrower than the obovate or ovate scales of the other subspecies and of *C. curatorum*.

Scale color is so variable that it had minimal taxonomic value. Scales in mature plants range from a pale green to a purplish-black. *Carex scirpoidea* ssp.

pseudoscirpoidea and ssp. *stenochlaena* possess the darkest scales.

Scale margins are often hyaline in *Carex*. Mackenzie (1908) described *C. scirpiformis* which he distinguished from *C. scirpoidea* by broad hyaline margins and somewhat greater length of scales than those of *C. scirpoidea*. I found that the hyaline portion of the scale varies greatly in width and therefore it is not a reliable taxonomic character. This was also confirmed in the greenhouse-grown plants. O'Neill and Duman (1941) also recognized that the scale margins and characters of the perigynia used by Mackenzie to distinguish *C. scirpiformis* were variable. They recognized this taxon as a variety of *C. scirpoidea*. However, based on examination of many specimens, there is no justification to recognize these plants with a broader hyaline margin at any taxonomic rank.

Perigynia

Some of the most important characteristics that separate species of carices are those of the perigynium (Table 5). Perigynium size, shape and pubescence are critical in separating the taxa in the section *Scirpinae*. Perigynia in *C. scirpoidea* ssp. *scirpoidea*, ssp. *convoluta* and ssp. *pseudoscirpoidea* are ovate, range from 1.5-3 mm long and have a length to width ratio less than 2.5. On the other hand, ssp. *stenochlaena* has lanceolate perigynia, ranging from (2.8)3-4(5) mm long and have a length to width ratio greater than 2.5. Perigynia in *C. curatorum* are obovate to ovate and range in length from 2-3(4) mm.

Perigynium color was extremely variable and ranged from a pale green to a purplish-black in C. scirpoidea. There was a tendency for perigynia of ssp. pseudoscirpoidea and ssp. stenochlaena to be predominantly dark purplish-black, but some were reddish-brown. Specimens from the highest elevations often had the darkest scales and the exposed portion of the perigynium above the scale was always darker than the area covered by the scale. Perigynia in C. curatorum were tawny to light brown.

Perigynium pubescence on C. scirpoidea ssp. scirpoidea, ssp. convoluta and ssp. pseudoscirpoidea was white to light tan, whereas hairs on ssp. stenochlaena were often, but not always, a golden-brown color.

The amount and type of pubescence on the perigynium was taxonomically important in segregating C. gigas and C. scabriuscula from taxa retained in the section Scirpinae. In these two taxa the perigynia had shorter, stiffer and fewer hairs in contrast to the densely hirsute perigynia of C. scirpoidea and C. curatorum. This difference is discussed in more detail in the micromorphology section.

A number of additional qualitative characters of the perigynium differed among taxa in the section. First, the nature of perigynium/achene abscission differed. In Carex, the perigynium and achene generally abscise as a unit from the spike axis and are dispersed by various vectors such as wind, water, ants and waterfowl. The perigynia of C. curatorum seem to abscise when mature and "shatter" when disturbed. In contrast, the perigynia and achenes of C. scirpoidea persist when mature and remain attached to the spike axis along with persistent scales well into autumn. This trait has ecological implications for dispersal and is further discussed under the taxonomic notes.

Secondly, in Carex perigynium terminate in a tubular beak of variable length and shape. In C. scirpoidea the perigynium either tapered gradually to a beak (ssp. stenochlaena) or was abruptly contracted to a beak (ssp. convoluta, ssp. pseudoscirpoidea and ssp. scirpoidea). The beak was generally less than 0.3 mm long, except those of ssp. stenochlaena which ranged from 0.3 mm to 0.5 mm in length. In C. curatorum the perigynium contracted abruptly to a beak.

Previously, descriptions by other authors referred to plants in this section as having bidentate beaks. However, upon close examination with the scanning electron microscope, the orifice of the beak was found to be entire. Some taxa such as C. scirpoidea ssp. stenochlaena, had an oblique orifice, elongated on the abaxial side.

The two excluded taxa, C. gigas and C. scabriuscula, possessed variable shaped beaks. Beaks of some plants exhibited an entire orifice while in others the apex was slightly bidentate.

Most species of Carex possess two lateral marginal nerves that are consistent with the origin of the perigynium as a prophyll. Additional, some species exhibit prominent nerves on the abaxial or adaxial surfaces or both. These nerves are often most conspicuous on the adaxial surface over the face of the achene. However, in the section *Scirpinae* the abundance of perigynium hairs obscures both surfaces such that veins or nerves are not evident, although two lateral veins are prominent in *Carex curatorum*. In the less pubescent *C. gigas* and *C. scabriuscula*, two lateral veins are evident but no nerves across the surface.

Achenes

Achene size varied little in the section *Scirpinae* although the degree to which the achene was enveloped by the perigynium did vary among taxa. In *C. scirpoidea* ssp. *scirpoidea* and ssp. *pseudoscirpoidea* the achene was enveloped tightly by the perigynium whereas, in ssp. *stenochlaena* and in *C. curatorum*, the achene filled only a portion of the length and width of the perigynium. In contrast, the achene in ssp. *stenochlaena* filled the full width of the perigynium, but only 3/4 of the length. The achene in *C. curatorum* filled less than 1/2 the width and from 1/2 to 3/4 the length of the perigynium.

Interestingly, many specimens in this section possessed spikes with few mature achenes, while others exhibited a high percentage of fully developed achenes. Achene maturation could not be correlated with plant maturity or relative period of the growing season. A geographically based trend was observed in which eastern populations of *C. scirpoidea* ssp. *scirpoidea* had a tendency to produce spikes with a high percentage of well-developed, fully-formed achenes, whereas western populations of C. scirpoidea ssp. scirpoidea and some of ssp. pseudoscirpoidea had lower percentages of mature or fully formed achenes. The latter may be due to factors such as low pollination success or environmental stress. A similar trend of lowered fertility in western plants was observed in the greenhouse and is discussed under breeding relationships.

Hermann (1957) described what he considered a new species for the section, Carex athabascensis, from robust specimens which bore small ovoid achenes. However, when the achenes from type material were measured, their dimensions were found to lie within the normal range of C. scirpoidea ssp. scirpoidea, except for a few achenes which measured 0.1 mm wider than the normal range. There is no justification for recognizing C. athabascensis as anything other than a group of unusually robust, aberrant specimens of ssp. scirpoidea.

Rachilla

In Carex the pistillate flower is believed to represent a branch of an inflorescence that has been reduced to a single flower (Cronquist, 1977). Occasionally, the axis of this inflorescence continues to elongate inside the perigynium beside the achene. This structure, called the rachilla, is found in some species in the subgenus Primocarex, and is often correlated with unispicate inflorescences (Nelmes, 1951). The rachilla is a flat structure with an entire or serrated margin (Svenson, 1972).

The presence or absence of a rachilla was found to be diagnostic in the section *Scirpinae* (Fig. 3). A high percentage of pistillate spikelets of *C. curatorum* possessed a rachilla whereas it was observed in fewer than 10 flowers of *C. scirpoidea*.

Infection by Smut

Infection by fungal smuts in *Carex* may be species-specific and interrelationships of *Carex* species with specific smuts have been used to interpret phylogenetic relationships within the genus (Savile and Calder, 1953; Standley, 1985). Smut infected plants were common throughout the range of *C. scirpoidea* (all subspecies), while populations of *C. curatorum* were characteristically free from any smuts. Additionally, specimens of *C. gigas* and *C. scabriuscula* were not infected by smuts perhaps due to their lower elevation and drier habitats.

Conclusions

Few quantitative characters separate *Carex scirpoidea* and *C. curatorum*. There is a general tendency for plants of *C. curatorum* to exhibit taller culms than those of *C. scirpoidea*. However, qualitative characters of the perigynium shape and color, and the relationship of the achene to the perigynium, are highly diagnostic. In addition to the morphological characters presented here, other lines of evidence from achene micromorphology, leaf surface structure, and ecological data support the recognition of *C.*

curatorum as a distinct species.

Within *C. scirpoidea*, three subspecies are recognized on the basis of vegetative or reproductive characters. Subspecies *convoluta* is distinguished by its narrow leaves, while ssp. *pseudoscirpoidea* is recognized by a suite of characters related to growth form and culms that arise from shoots of the previous year. A taxon of the Pacific Northwest, ssp. *stenochlaena* is distinguished by having lanceolate perigynia, which exceed 3 mm in length, and have a length to width ratio over 2.5. Other reproductive characters of the scales and spikes further delineate this subspecies.

Few characters relate *C. gigas* and *C. scabriuscula* to the section *Scirpinae*. Most significantly they differ in the three important characters that distinguish the section: they are not consistently dioecious, they are not unispicate, and they do not possess the characteristic pubescent perigynium of the section. Additional evidence from chromosome numbers, leaf surface structure and ecology strongly support the exclusion of these two taxa from the section. With the exclusion of *C. gigas* and *C. scabriuscula*, the section *Scirpinae* forms a coherent group of dioecious, unispicate sedges with distinctly pubescent perigynia.

Table 3. Reproductive and vegetative characters used in the morphological study.

- Culm features
  - culm height cm
  - culm width at base mm
  - culm width at top mm
  - culm angles +/-

- Culm leaf characters
  - number culm leaves
  - maximum culm leaf width mm
  - maximum culm leaf length cm
  - culm leaf sheath inner band
  - culm leaf sheath inner band surface
  - culm leaf sheath mouth color
  - culm leaf sheath mouth shape
  - culm leaf ligule shape
  - culm leaf ligule width mm
  - culm leaf ligule height mm
  - culm leaf ligule color
  - culm leaf ligule apex shape
  - number scale leaves per culm
  - color culm scales
  - culm scale surface

- Vegetative leaf features
  - number vegetative leaves per shoot
  - maximum vegetative leaf width mm
  - maximum vegetative leaf length cm
  - vegetative leaf sheath inner band color
  - vegetative leaf sheath inner band surface
  - vegetative leaf sheath mouth color
  - vegetative leaf sheath mouth shape
  - vegetative leaf ligule shape
  - vegetative leaf ligule width mm
  - vegetative leaf ligule height mm
  - vegetative leaf ligule color
  - vegetative leaf ligule apex shape

- Reproductive features
  - multispicate culm +/-
  - flowers from previous year shoots +/-
  - inflorescence length mm
  - inflorescence width mm
  - involucral bract +/-
  - length to bract from inflorescence mm
  - bract base characteristics - auriculate or scale-like
  - involucral bract length mm
  - involucral bract base width mm

Table 3 continued. Morphological characters analyzed.

- Scale characteristics
  - scale shape
  - scale apex shape
  - scale length mm
  - scale width mm
  - scale color
  - scale pubescence +/-
  - color scale pubescence
  - scale nerves +/-
  - extent hyaline margin
  - scale midrib length mm

- Perigynium characters
  - perigynium length to scale length ratio
  - perigynium shape
  - perigynium base shape
  - perigynium shape apex
  - perigynium width mm
  - perigynium length mm
  - perigynium cross sectional shape
  - perigynium pubescence
  - perigynium nerves
  - beak length mm
  - beak tip color

- Achene characteristics
  - achene shape
  - achene width mm
  - achene length mm
  - achene color
  - achene surface
  - stipe length mm

- Other features
  - rachilla +/-
  - infection by smut +/-

+/- denotes presence or absence

Figure 1. Morphological features. A. Carex scirpoidea ssp. scirpoidea, habit from herbarium specimen, (Bennington Co., VT, Dunlop, 2003). B. Carex scirpoidea ssp. convoluta, habit showing narrow leaves, (Chippewa Co., MI, Dunlop 1730). C. Carex scirpoidea ssp. pseudoscirpoidea showing rhizomatous habit, (San Juan, UT, Dunlop 2285). D. Carex scirpoidea ssp. stenochlaena, showing cespitose habit, (Deerlodge Co., MT, Dunlop 2285).

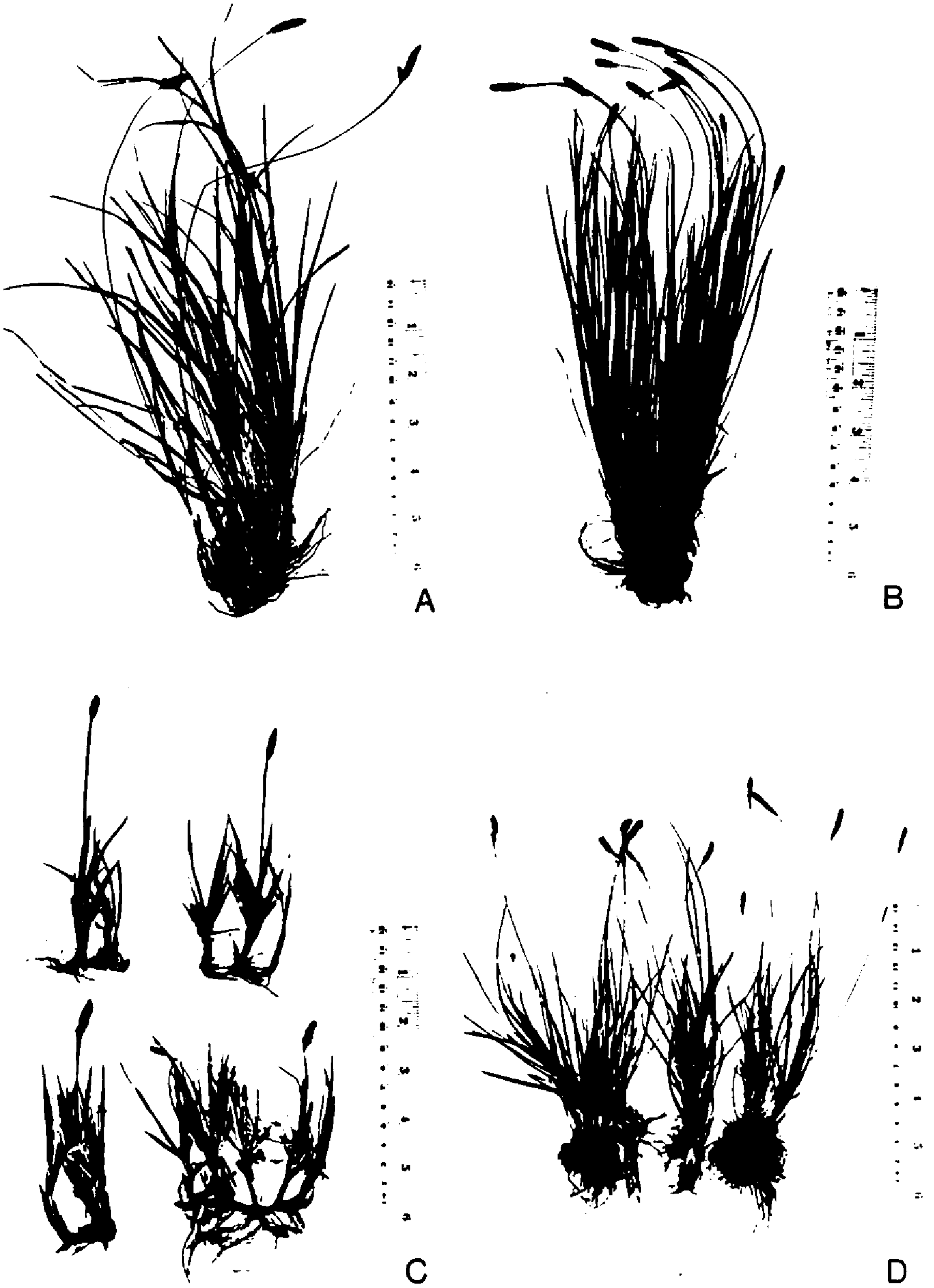
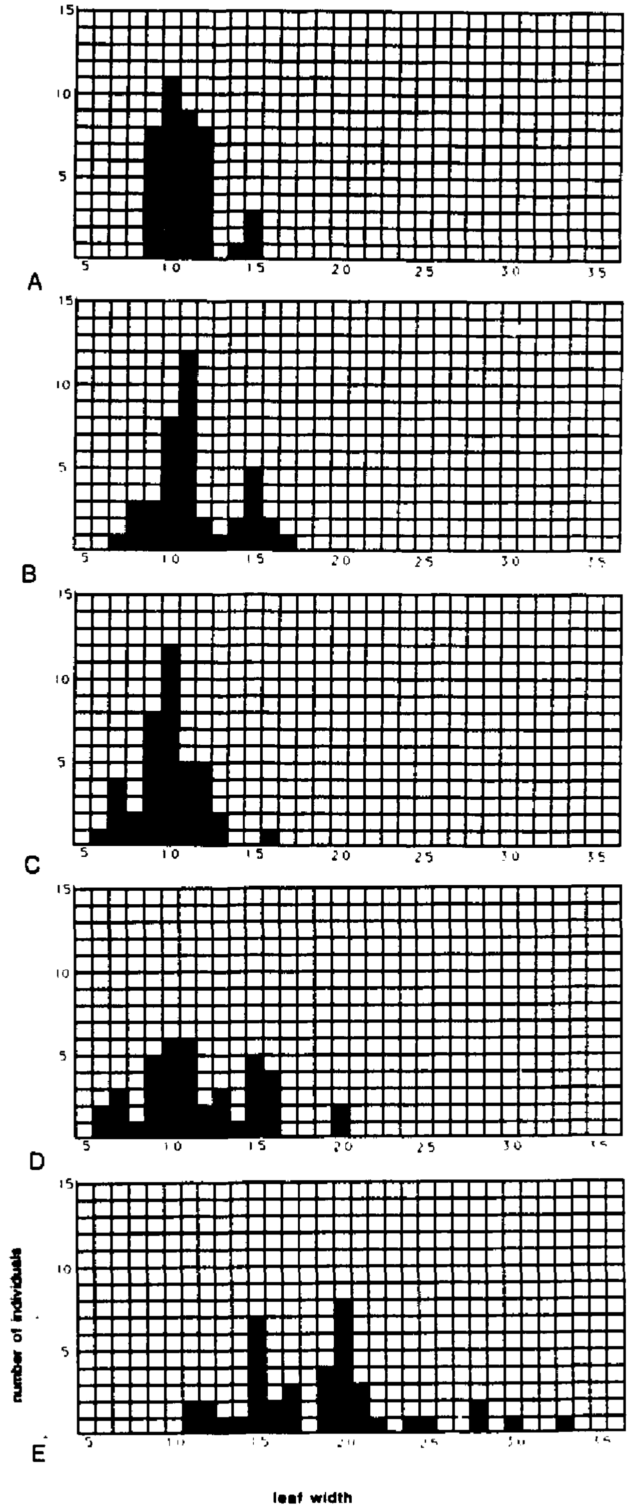

A
B
C
D

Figure 2. Histogram comparison of width of fertile shoot leaves in Carex scirpoidea ssp. convoluta and Carex scirpoidea ssp. scirpoidea (40 individuals each). A. Carex scirpoidea ssp. convoluta from Michigan, Alpena Co., Thunder Bay Island. B. Carex scirpoidea ssp. convoluta from Michigan, Chippewa Co., Drummond Island. C. Carex scirpoidea ssp. convoluta from Manitoulin Islands, Ontario. D. Carex scirpoidea ssp. convoluta from the Bruce Peninsula, Ontario. E. Carex scirpoidea ssp. scirpoidea from throughout the range.



POPULATION	MEAN[1]	MIN	MAX	SD[2]
ssp. convoluta				
A) Thunder Bay Is.	1.09A	0.90	1.5	0.16
B) Drummond Island	1.14A	0.70	1.7	0.25
C) Manitoulin Is.	0.99A	0.70	1.6	0.19
D) Bruce Peninsula	1.17A	0.60	2.0	0.35
ssp. *scirpoidea*				
E) from range	1.87B	1.10	3.3	0.50

[1] = mean of the same letter not significantly different.
[2] = standard deviation

Figure 3. Carex curatorum achene and rachilla, scale bar = 1 mm. (Kane Co., UT, Dunlop 2087).

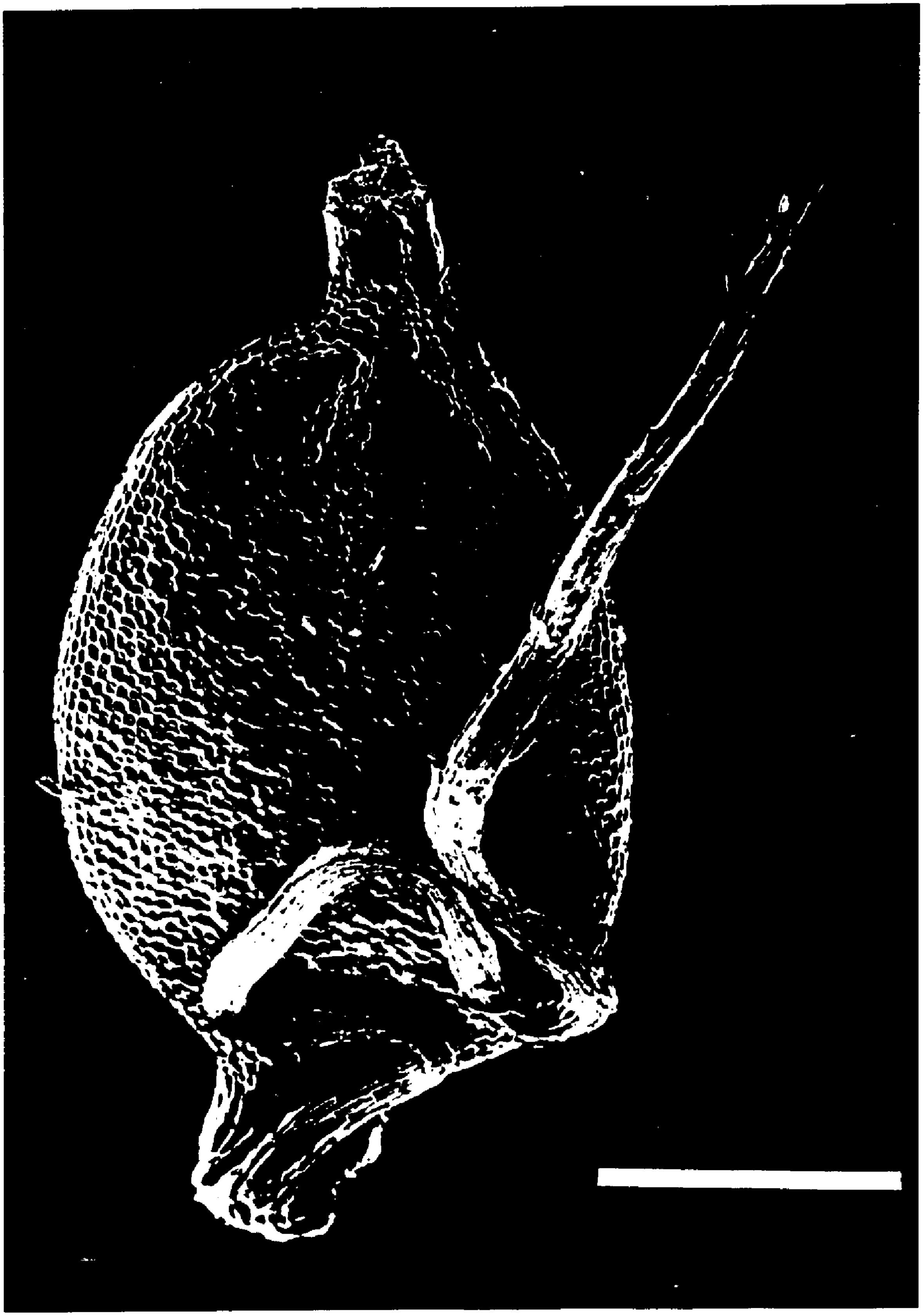


Table 4. Characters distinguishing *Carex scirpoidea* ssp. *scirpoidea* and *Carex scirpoidea* ssp. *pseudoscirpoidea*.

Carex scirpoidea ssp. *scirpoidea*	*Carex scirpoidea* ssp. *pseudoscirpoidea*
plants cespitose	plants rhizomatous
culms with basal anthocyanic scale leaves	culms lacking scale leaves
culms arise from first year shoots	culms from previous year shoots
internodes < 1 cm long	internodes > 1 cm long
new shoots diverge in many directions	new shoots diverge in a linear fashion
leaf blades diverge at widely spaced intervals along the shoot axis	leaf blades diverge in close proximity to each other on shoot axis

Table 5. Summary of morphological features in the section _Scirpinae_ and two excluded taxa.

						EXCLUDED TAXA	
	Carex scirpoidea				Carex curatorum	Carex gigas	Carex scabriuscula
	ssp. scirpoidea	ssp. convoluta	ssp. pseudoscirpoidea	ssp. stenochlaena			
breeding system	dioecious	dioecious	dioecious	dioecious	dioecious	dioecious/ monoecious	dioecious/ monoecious
habit	cespitose/ rhizomatous	cespitose	rhizomatous	cespitose	cespitose/ rhizomatous	cespitose	cespitose
inflorescence	unispicate	unispicate	unispicate	unispicate	+/-unispicate	multispicate	multispicate
spike shape	linear	linear	linear	clavate	linear	linear	linear
culm type[1]	1	1	2	1	1	2	2
involucral[2] bract length	< spike	< spike	< spike	< spike	< spike	> spike	> spike
culm leaf width	1.5-3	0.7-2	1.2-3.5	1.4-2.1	1.5-2.3	1.9-3.5	2-4.4
leaf surface	glabrous	glabrous	glabrous	glabrous	sparsely pilose	+/- glabrous	glabrous

Table 5. Summary of morphological features continued.

						EXCLUDED TAXA	
	Carex scirpoidea				Carex curatorum	Carex gigas	Carex scabriuscula
	ssp. scirpoidea	ssp. convoluta	ssp. pseudoscirpoidea	ssp. stenochlaena			
leaf scales	+	+	-	+	+	-	-
pistillae scale shape	ovate	ovate	ovate	lanceolate	oblanceolate	lanceolate	lanceolate
pistillate scale length	1.5-2.9	1.5-2.4	2-3	2.4-3.5	2-3.5	2.5-4.1	2.5-4.0
pistillate scale width	1-1.5	0.9-1.2	1.1-1.5	1-1.5	0.7-1.9	0.8-1.5	1.0-1.5
perigynium length	1.8-3	1.5-2.6	1.5-3	2.8-4.8	2-4	2-3.4	3-3.8
perigynium width	0.9-1.5	0.7-1.2	1.0-1.6	0.9-1.6	1.5-1.8	1.5-2.2	1.1-1.8
perigynium l x w ratio[3]	< 2.5	< 2.5	< 2.5	> 2.5	< 2.5	> 3.0	> 3.0

Table 5. Summary of morphological features continued.

	Carex scirpoidea					EXCLUDED TAXA	
	ssp. scirpoidea	ssp. convoluta	ssp. pseudoscirpoidea	ssp. stenochlaena	Carex curatorum	Carex gigas	Carex scabriuscula
perigynium color	green - red-brown	green - red-brown	purple black	purple black	tawny	tawny - purple black	tawny purple black
achene/ perigynium[4]	tight	tight	tight	loose	loose	loose	loose
perigynium pubescence	hirsute	hirsute	hirsute	hirsute	hirsute	hirtellulose	hirtellulose
abscission [5]	persist	persist	persist	persist	abscise	abscise	abscise
rachilla	-	-	-	-	+	-	-
smut	+	+	+	+	-	-	-

Note: All measurements in mm.
+/- = plus or abscence

[1] culms from current year shoots (1) or previous year shoot (2)
[2] Length of involucral bract less than spike (< spike) or greater than spike (> spike)
[3] length to width ratio of perigynia
[4] relationship of achene to perigynium (tight=perigynium envelops achene tightly, loose=perigynium envelops achene loosely)
[5] abscission of perigynium/achene (persists or abscises)

II. NUMERICAL ANALYSIS

Introduciton

Numerical analyses, especially principal components analysis (PCA), have proven useful in analyzing large data sets of morphological and systematic information. In Carex, PCA has been used to test hypotheses of phenetic relationships, to discriminate between closely related taxa and to examine patterns of variation within and between populations (Crins and Ball, 1983, 1989a; Standley, 1987b, 1989). In addition to elucidating phenetic relationships among taxa, PCA is useful in examining correlations among characters and character variability.

In this study on the section Scirpinae, PCA was used to analyze the morphological data set in order to examine trends in patterns of variation in character distributions and potential phenetic relationships among taxa.

Methods

A subset of the 139 OTUs was analyzed using PCA from the SAS statistical package on the VAX computer at the University of New Hampshire. Each OTU represented variables chosen from the original data set (Table 3). Some variables were excluded if characters were invariant across the group or so variable that they were problematic to code. The data set analyzed numerically included OTUs representing the following taxa: C. scirpoidea ssp. scirpoidea (23), ssp.

convoluta (14), ssp. *stenochlaena* (22), ssp. *pseudoscirpoidea* (6), *C*. *curatorum* (25), *C*. *scabriuscula* (11), *C*. *gigas* (19), the latter two taxa formerly included in the section. The data set contained population samples or groups of geographically related specimens in order to compare within and between population variation. Each OTU represented 32 variables chosen from the original data set (Table 6). Variables were excluded if characters were invariant across the group or so variable that they were problematic to code. Data were standardized to a mean of 0 and variance of 1. OTUs were plotted against axes I and II (Fig. 4) and I and III (Fig. 5).

Results and Discussion

The analysis resulted in the recognition of several trends which supported the phenetic relationships recognized in the initial morphological analysis using descriptive statistics.

First, OTUs from the same population grouped in close proximity to each other. For example, the five OTUs from the type locality for *Carex scirpoidea* ssp. *convoluta*, Thunder Bay Island, clustered on the negative end of axis I (m in Fig. 4).

Secondly, populations from the same geographic region formed loose clusters. Populations from eastern North America (Michigan, Vermont, Newfoundland and Ontario) and the one population from Norway formed a dispersed "cloud" at the negative end of axis 1 (Fig. 4).

The major phenetic groups sorted out on axis I (Fig. 6). OTUs of *C. scirpoidea* clustered to the negative end of axis I and separated from *C. scabriuscula* and *C. gigas*, the farthest outliers grouped at the positive end although the latter two were interspersed with OTU of *C. curatorum*.

Separation between *Carex scirpoidea*, *C. scabriuscula* and *C. gigas* is not distinct on axis II. However, OTUs of *C. curatorum* are dispersed towards the middle of axis II (Fig. 6).

Two subspecies of *Carex scirpoidea* form "clouds" of points interspersed with OTUs of ssp. *scirpoidea* (Fig. 4). OTUs for *C. scirpoidea* ssp. *stenochlaena* (A, L, H, O, in Fig. 4) formed a distinct cluster in the center of axis I. Populations of *C. scirpoidea* ssp. *convoluta* (m, B, D) clustered in a cloud with OTUs of *C. scirpoidea* ssp. *scirpoidea* from Vermont (v), Europe (E), USSR (I), Newfoundland (F) and Ontario (K). The six OTUs of ssp. *pseudoscirpoidea* (P) are widely scattered with OTUs of ssp. *scirpoidea*.

Although there is substantial overlap in the center of the plots, patterns of clustering support the recognized phenetic relationships. This overlap can be explained, in part, by the equal weighting of characters by the program. The majority of variables used in the analysis are quantitative and weighted equally with qualitative characters. In the morphological analysis discrimination of taxa is based predominantly on qualitative data. Also it is not surprising that overlap exists among the subspecies as they are distinguished on discontinuities in only a few characters. Some of the characters that distinguish ssp. pseudoscirpoidea were not included in the analysis as they were difficult to code (ie. characters in Table 4). In addition, the PCA are viewed in two dimensional space and perhaps separation is more distinct in three dimensional space as the program is based on multi-dimensions.

Overall patterns of clustering were similar in ordinations of axes I to II (Fig. 4) and I to III (Fig. 5).

The first three axes account for 28.00%, 10.12% and 8.05% of the total variation. These results are similar to those of the C. lenticularis complex where 27.1%, 13.8%, and 10.9% of the variation was accounted for on the first three components (Standley, 1987b). Similarly, Crins and Ball (1989a) found 27.42%, 10.88% and 10.04% for the C. flava complex and 32.34%, 14.32% and 10.64% for the C. pensylvanica complex (Crins and Ball, 1983).

The highest loadings for characters on the first axis represent size differences. Leaf length (both on reproductive and vegetative shoots), inflorescence width and vegetative ligule height are the most important characters followed by perigynia length and width. Culm width (at top), shape of pistillate scale apex and number of culm leaves were the highest for the second axis and presence or absence of involucral bract and culms from previous year shoots, for the third. Interestingly, the high loading characters from the first three axes in this study are similar to those found in other PCA studies in Carex which used similar characters. Length (of leaf, culm, perigynia and inflorescences) and width (of inflorescence and perigynia) are similar high loading characters (Crins and Ball, 1983, 1989a; Standley, 1987b).

Conclusions

The results of PCA support the phenetic relationships recognized in the initial morphological analysis. OTUs of C. gigas and C. scabriuscula tend to separate from the central cloud of C. scirpoidea as the former two are the farthest outliers on axis I suggesting dissimilarity to all other OTUs. OTUs of C. curatorum separate somewhat from those of C. scirpoidea. The OTUs of all but one of the subspecies of C. scirpoidea form clouds of points respective of each subspecies.

Table 6. Morphological characters used in the numerical analysis.

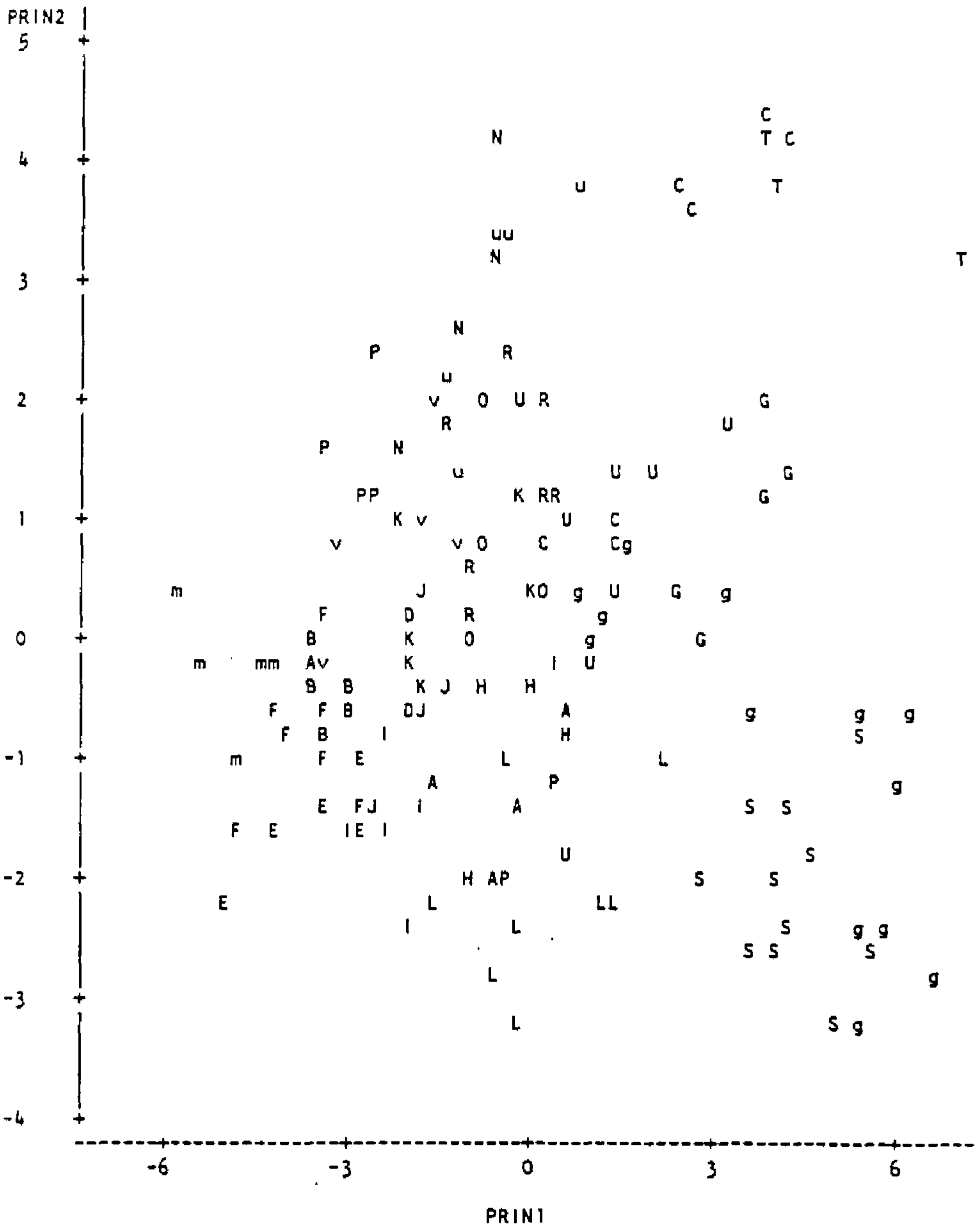
---

multispicate culm +/-
flowers from 2 yr. shoots +/-
spike length mm
spike width mm
subtending bract +/-
length to bract mm
bract length mm
culm height cm
culm width at base mm
culm width at top mm
number culm leaves
maximum culm leaf width mm
maximum culm leaf length cm
culm leaf ligule width mm
culm leaf ligule height mm
number vegetative leaves per shoot
maximum vegetative leaf width mm
maximum vegetative leaf length cm
vegetative leaf ligule width mm
vegetative leaf ligule height mm
scale shape
scale length mm
scale width mm
perigynium shape
perigynium width mm
perigynium length mm
perigynium pubescence
perigynium shape in cross section
perigynium surface nerves
beak length
achene width mm
achene length mm
rachilla +/-

+/- denotes presence or absence

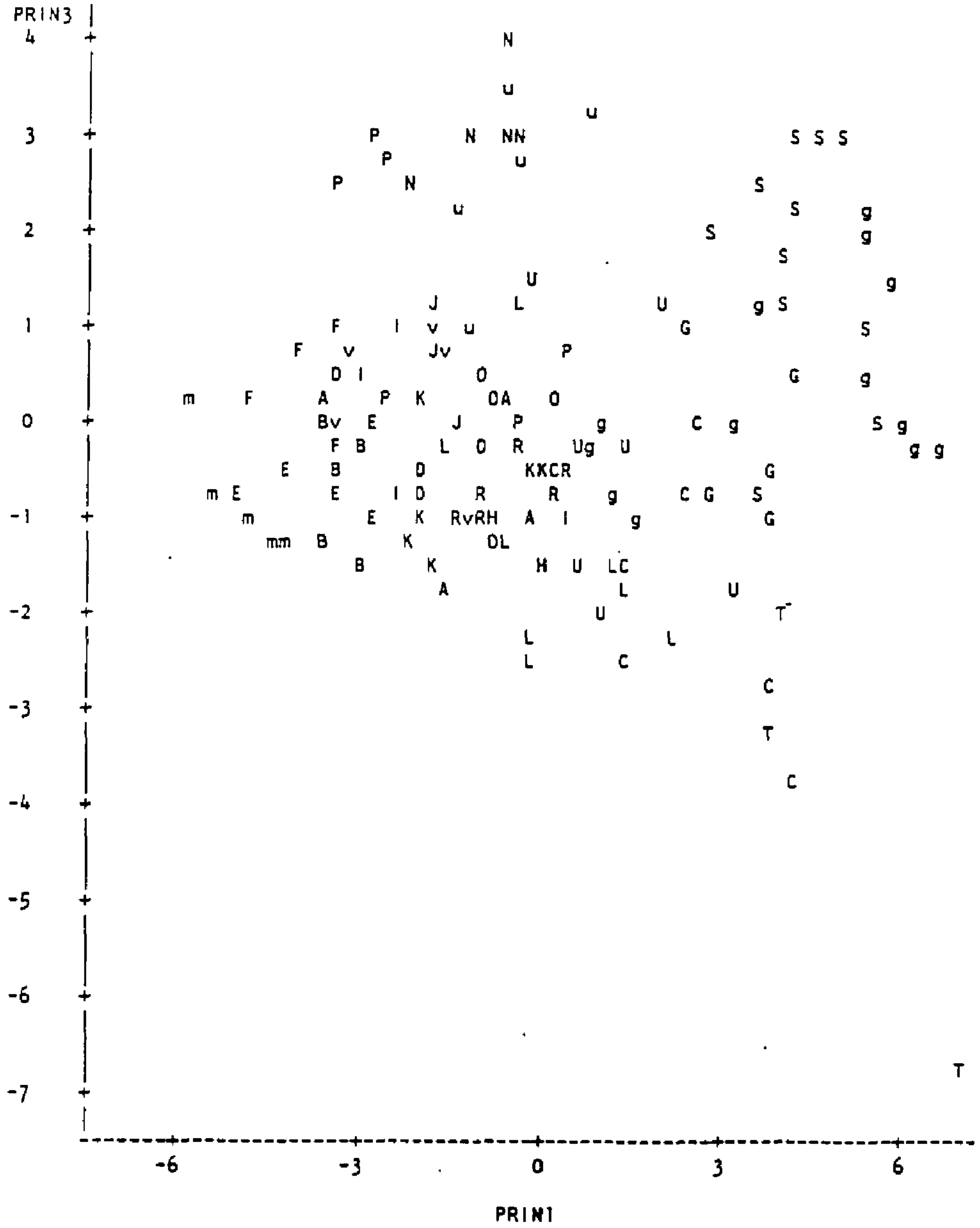
KEY TO SYMBOLS IN FIGURES 4-6

ssp. *scirpoidea*	■	E	Norway
ssp. *scirpoidea*		F	various populations, Newfoundland
ssp. *scirpoidea*		I	Chukotskiy Peninsula, USSR
ssp. *scirpoidea*		J	New Hampshire
ssp. *scirpoidea*		K	Quebec
ssp. *scirpoidea*		N	Monte Neva Hot Springs, Nevada
ssp. *scirpoidea*		u	Pine Lake, Utah
ssp. *scirpoidea*		v	Mt. Equinox, Vermont
ssp. *convoluta*	●	B	Bruce Peninsula, Onatrio
ssp. *convoluta*		D	Drummond Island, Michigan
ssp. *convoluta*		m	Thunder Bay Island, Michigan
ssp. *pseudoscirpoidea*	Ⓟ	P	Manassas Creek, Colorado
ssp. *stenochlaena*	▲	A	Bailey Lake, Montana
ssp. *stenochlaena*		H	various populations, Washington
ssp. *stenochlaena*		L	Ravalli Co., Montana
ssp. *stenochlaena*		O	Beverly Creek, Washington
C. curatorum	●	R	Roaring Springs, Arizona
C. curatorum		C	Coyote Canyon, Utah
C. curatorum		U	Lake Powell, Utah
C. gigas	△	G	Scott Mt, CA
C. gigas	△	g	Carmen Lake, CA
C. scabriuscula	Ⓢ	S	Mt. Eddy region, Oregon



NOTE: 4 OBS HIDDEN

Figure 4. Ordination of 139 OTUs of principal components I and II by population.



NOTE: 12 OBS HIDDEN

Figure 5. Ordination of 139 OTUs of principal components I and III by population.

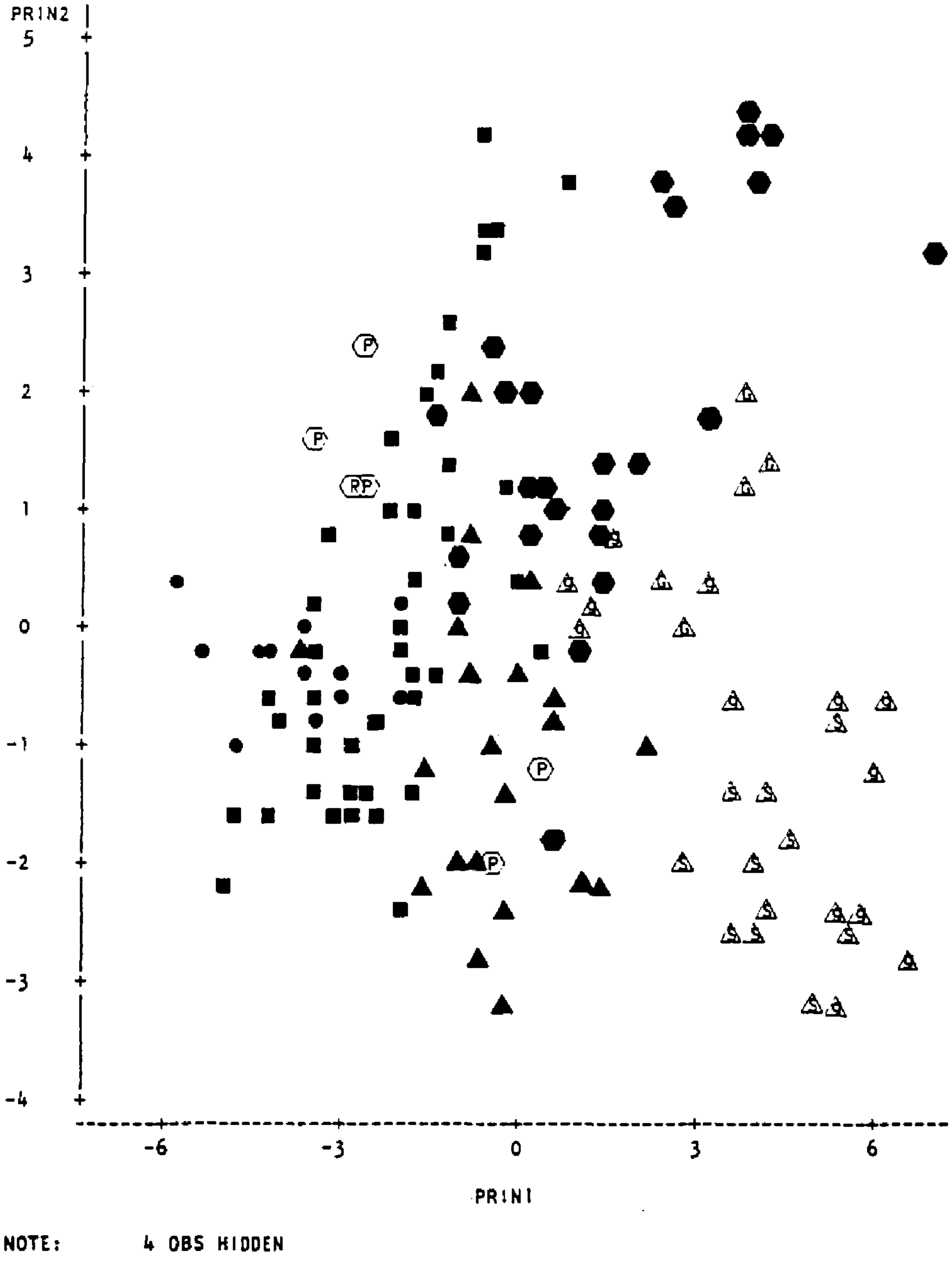


Figure 6. Ordination of 139 OTUs of principal components I and II by taxon.

III. ACHENE AND PERIGYNIUM MICROMORPHOLOGY

Introduction

In the Cyperaceae, micromorphological features of achene and perigynium have proven taxonomically useful by providing additional phenetic characters helpful in the delineation of taxa at the specific and sectional levels (Menapace and Wujek, 1985, 1987; Menapace *et al*., 1986; Standley, 1985b, 1987a, 1987b; Tallent and Wujek, 1983; Toivonen and Timonen, 1976; Walter, 1975). Achenes

Epidermal cells of the leaves and achenes contain silica (SiO_2), deposited in the form of pyramidal-shaped silica bodies. Silica bodies are present in the costal cells that overlay the vascular tissue in the leaves and in most epidermal cells of the achene. The role of silica deposits in plants is uncertain. They may function in control of water loss, keep leaves erect, protect plants from fungal hyphae, play a role in growth metabolism (Soni, Kaufman and Bigelow, 1972) or deter herbivory.

Schuyler (1971) was first to examine and recognize the taxonomic value of achene epidermal features in *Scirpus* and *Eriophorum*. He observed specimens under scanning electron microscopy after having first observed their variation in cell morphology with the light microscope. Le Cohu (1973) was first to examine the silica body in the achene epidermis of Carex. She characterized the silica body as having a single cone arising from a basal platform. In a more detailed study Walter (1975) examined the achene epidermal features for a number of Carex species in an attempt to resolve the sectional placement of two problematic species. Tallent and Wujek (1983) refined the methods for specimen preparation and examined achenes of taxa representing nine sections of the genus. Variation in size and shape in achene epidermal silica bodies has been examined in detail for part of the section Acutae (Standley, 1985b) and sections Folliculata and Collinsiae (Wujek and Menapace, 1986). Evidence from achene micromorphology was used to support recognition of two subsections of section Lupulinae that had previously been recognized on gross morphology (Menapace et al., 1986) and in the placement of a problematic species within the section Vesicariae (Menapace and Wujek, 1987).

Based on the studies cited above, achene silica body morphology was found to differ in the following characteristics: the shape of the sides (sloping and parallel), shape of basal platforms (concave, convex and flat), presence or absence of satellites, degree of satellite development, nature of lateral cell walls (sinuous or straight) and degree to which basal platforms are appressed or not appressed to other cells (Crins and Ball, 1988, 1989a; Menapace et al., 1986; Menapace and Wujek, 1987; Standley, 1985b; Tallent and Wujek, 1983; Wujek and Menapace, 1986; and Rettig, pers. comm.).

The first utilization of achene micromorphology in a phylogenetic context was a study by Crins and Ball (1988) who subjected some morphological character states to a character compatibility analysis and superimposed achene micromorphological characters on the results. Achene micromorphology was used in conjunction with morphological and chemical evidence to support recognition of sections _Ceratocystis_ and _Spirostachyae_ as two separate but closely related sections. Taxa in both sections possess silica bodies with a central body and partially developed satellite bodies, while some taxa in the section _Spirostachyae_ lack satellite bodies. Crins and Ball suggested that silica body ornamentation has evolved independently in each group, with an increased development of ornamentation in the section _Ceratocystis_ and through a loss of satellite bodies in the section _Spirostachyae_.

Perigynia

Scanning electron microscopy was also used as an aid in examining the surface structure of the perigynium. SEM facilitated the examination of perigynium shape, the type and distribution of pubescence and the characteristics of the beak. Additional features of the perigynium epidermis found useful in other studies (Standley, 1987a) were obscured in the taxa studied here by pubescence, and were therefore not examined in this study.

Methods

The methods used here were modified from Menapace _et_ al. (1986) for achenes. Achenes from 62 plants were removed from field collections and herbarium specimens. Ten achenes from each plant were soaked from 12-24 hours in 9:1 (v/v) acetic anhydride and sulfuric acid to remove the outer epidermal surfaces and outer cell walls (Fig. 11A,B). Acidification was enhanced by vortexing for two minutes. Specimens were rinsed in distilled water, sonicated five minutes in an ultrasonic cleaner, rinsed again, and then air dried. Four achenes from each plant were mounted on each aluminum stub using double stick tape, and then coated with gold-palladium to a thickness of 200-300 angstroms using a Hummer V Sputter Coater. Specimens were examined and photographed using an AMR 1000 scanning electron microscope at an accelerating voltage of 10 or 20 kv. The analysis was standardized by examining cells, at an angle, on the surface of the shoulder below the stigma. Over 120 photographs were taken of the silica bodies at 1000x magnification using Polaroid 55 P/N film. Patterns of morphological variation were analyzed by scoring photographs for three characters: shape of silica body top, type of basal platform and presence or absence of partially developed satellites. Interpretations of character states followed that of Walter (1975) and Menapace and Wujek (1987).

Micromorphological features of the perigynium were studied from a sample of 42 perigynia, representing all taxa which have been historically included in the section Scirpinae. The abaxial and adaxial surfaces were examined on perigynia that were removed from herbarium specimens and mounted on aluminum stubs. Specimen coating, examination and photographic procedures followed that used for achenes. Micrographs of samples were scored for three characters: shape of perigynium, amount of pubescence and distribution of pubescence.

Results and Discussion

Achenes

All cells examined had silica bodies with a single central cone (Fig. 7C-F). The top of the silica body was either pointed (Fig. 7D,E), domed (Fig. 8C,D) or nodular (Fig. 7F). The base of the silica body rose from a recessed (Fig. 7D-F), flat (Fig. 8B) or plateaued platform (Fig. 8C,D). Some platforms had raised protrusions or partially developed basal satellites (Fig. 8C,D). Platforms were nearly isodiametric in shape (Fig. 8A) or more orbiculate (Fig. 8C) with acute (Fig. 8A) or obtuse angles (Fig. 8C,D).

Although silica body height varied between photographs, height could not be quantified accurately. All photos were taken at the same magnification but the orientation of the specimens and silica body could not be standardized. Additionally, there was much variation in the degree to which the cell walls were eroded away from the silica body. My observations suggest that the puckering and waviness (Fig. 9A,B) of the treated walls is related to the maturity of the achenes and possibly to the alteration of the lateral walls by extremes in the acidification process. Occasionally the silica body appears (Fig. 9A) as if it has been etched or eroded by the acid or sonication process. The full effect of the acidification process on the shape and form of the lateral cell walls is not known. Attempts to standardize the procedure failed to produce specimens with equally etched surfaces.

Two basic patterns of variation were observed in achene micromorphology (Table 8). The first, or general pattern, consisted of silica bodies with pointed conical tops and flat to recessed bases which lacked satellites (Fig. 7C-E). This pattern was characteristic of *Carex scirpoidea* and all of its subspecies.

The second pattern consisted of silica bodies with domed tops, that rose from plateau-like bases with partially developed satellites (Fig. 8C,D). All the specimens examined of *C. curatorum* exhibited this pattern.

It was not possible to distinguish infraspecific taxa based on achene micromorphology. One population of *Carex scirpoidea* ssp. *convoluta* (Drummond Island, Michigan) had nodular silica body tops, a character found occasionally in the silica bodies of leaves in other species of *Carex* (Metcalfe, 1971). Metcalfe recognized that warty or nodular silica bodies in the leaves were rarely the only type found in an individual species, but if found in high proportions, could sometimes serve as a useful diagnostic character. However, nodular silica bodies proved to be of no taxonomic value within the section *Scirpinae* since they occurred in only one population and did not correlate with any other character.

Achene micromorphology in C. gigas and C. scabriuscula was similar to that exhibited by C. scirpoidea. These taxa had silica body tops with pointed tops and recessed bases lacking satellites, features thought to represent the common or pleisomorphic condition within the genus. However, silica bodies in micrographs of achene surfaces in C. gigas and C. scabriuscula appeared larger than in the members of the section Scirpinae. Although these two taxa have been excluded from the section on other grounds, micromorphology alone does not support the exclusion of these taxa from the section Scirpinae, as their silica bodies characterize the pleisomorphic condition in Carex.

Perigynia

In the section Scirpinae, perigynium shape ranged from elliptic to widely obovate to ovate to lanceolate (Fig. 10A-F). Of the four subspecies of Carex scirpoidea, ssp. stenochlaena differed the most, since it possessed lanceolate perigynia (Table 8 and Fig. 11A).

The upper portion of the perigynium tapered gradually to a beak, as in the lanceolate perigynium of ssp. stenochlaena (Fig. 11A), or was contracted abruptly to a beak, as in the ovate perigynium of ssp. scirpoidea (Fig. 10A-C) and ssp. pseudoscirpoidea (Fig. 10E). The beak orifice was entire, not bidentate as had been reported in the literature (Mackenzie, 1935). Those appearing bidentate were actually torn. The orifice was either circular or elliptical and oriented towards the adaxial surface.

Surfaces of the perigynium were examined for the type and distribution of pubescence. All perigynia in the section *Scirpinae* were pubescent. In *Carex scirpoidea*, including all infraspecific taxa, perigynia were hirsute (Fig. 10A-F). The trichomes were ribbon-like, flattened at the base and approximately the same length in all taxa. Hairs were distributed over the entire adaxial and abaxial surfaces or occasionally restricted to the upper one half to two-thirds of the perigynia (Fig. 10A).

Carex gigas and *C. scabriuscula* had the most variability in perigynium shape, ranging from obovate to ovate to lanceolate. The perigynia in these two taxa were hirtellulose, possessing much less pubescence (Fig. 11C,D) in contrast to *C. scirpoidea* and *C. curatorum*. *Carex gigas* and *C. scabriuscula* possessed very short, stubbly hairs that covered only the top one-third of the perigynium. The type and absence of pubescence distinguished these taxa from the section *Scirpinae*.

Since pubescent perigynia are rare in the genus *Carex*, a survey of fifteen representative species of *Carex* with pubescent perigynia (Table 9 and Fig. 12A-F) was conducted. All species studied exhibited simple, unbranched hairs. However the hair length, and the shape of the base and apex differed among taxa. Some taxa had hairs with flattened bases (Fig. 12A-C) while others had terete bases (Fig. 12D). Hair length varied among taxa from long to short (Fig. 12B) and apices of the hairs were either blunt or pointed (Fig.

12B,D). *Carex tomentosa* possessed hairs coated with cuticular waxes (Fig. 12D). Hair morphologies on the perigynia of *C. concinna* and *C. swanii* were the most similar to those in the section *Scirpinae*. Further investigations of hair morphology in taxa with pubescent perigynia may yield valuable taxonomic characters.

Conclusions

Micromorphological features of the achene and perigynium are useful in distinguishing taxa at the specific level in the section *Scirpinae*, but the subspecies of *C. scirpoidea* could not be distinguished on achene micromorphology. The silica bodies of achenes of *C. curatorum* exhibit a distinct pattern within the section *Scirpinae*. The micromorphological data support other lines of evidence that distinguish *C. curatorum* as a separate species.

Carex gigas and *C. scabriuscula* differ from all the taxa in the section *Scirpinae* in that they have sparsely pubescent perigynia, with very short hairs, distributed only on the top third of the perigynium in contrast to the distinct pubescence of the section *Scirpinae*. The section *Scirpinae* forms a cohesive group when *C. gigas* and *C. scabriuscula* are excluded.

Table 7. Achene micromorphology in the section Scirpinae and excluded taxa.

taxon	silica body top	silica body base	satellites
Carex scirpoidea			
ssp. scirpoidea	pointed	recessed-flat	-
ssp. stenochlaena	pointed	flat	-
ssp. convoluta	pointed	recessed	-
ssp. pseudoscirpoidea	pointed	recessed	-
Carex curatorum	domed	plateaued	+
Carex gigas	pointed	recessed-flat	-
Carex scabriuscula	pointed	recessed-flat	-

Table 8. Perigynium characters as seen with SEM.

taxon	perigynium shape	hair distribution	pubescence type
Carex scirpoidea			
ssp. scirpoidea	ovate	2/3	hirsute
ssp. convoluta	ovate obovate	2/3	hirsute
ssp. stenochlaena	lanceolate	2/3	hirsute
ssp. pseudoscirpoidea	ovate	2/3	hirsute
Carex curatorum	obovate to ovate	2/3	hirsute
Carex gigas	obovate to ovate	top 1/3	hirtellulous
Carex scabriuscula	lanceolate to obovate	top 1/3	hirtellulose

Table 9. Species of *Carex* examined in a survey of representative taxa with pubescent perigynia.

Carex hirta
Carex houghtonii
Carex langinosa
Carex tomentosa
Carex vestita
Carex swannii
Cares virescens
Carex trichocarpa
Carex caryphyllea
Carex concinna
Carex richardsoni
Carex hirtifolia
Carex tenax
Carex tonsa
Carex nigromarginata

Figure 7. Achene micromorphology. A. Partially treated achene), Carex curatorum, scale = 0.5 mm, (Kane Co., UT, Dunlop 2087). B. Partially treated achene surface, Carex scirpoidea ssp. scirpoidea, scale = 0.05 mm, (Magadan, USSR, Derviz-Sokolova s.n.). C. Carex scirpoidea ssp. scirpoidea, scale = 20 um, (Elko Co., NV, Dunlop 2140). D. Carex scirpoidea ssp. scirpoidea (from type specimen of Carex athabascensis), scale = 20 um, (Alberta, Can., Hermann 13498). E. Carex scirpoidea ssp. convoluta, scale = 20 um, (Chippewa Co., MI, Dunlop 1730). F. Carex scirpoidea ssp. convoluta, scale = 20 um, (Chippewa Co., MI, Dunlop 1730).

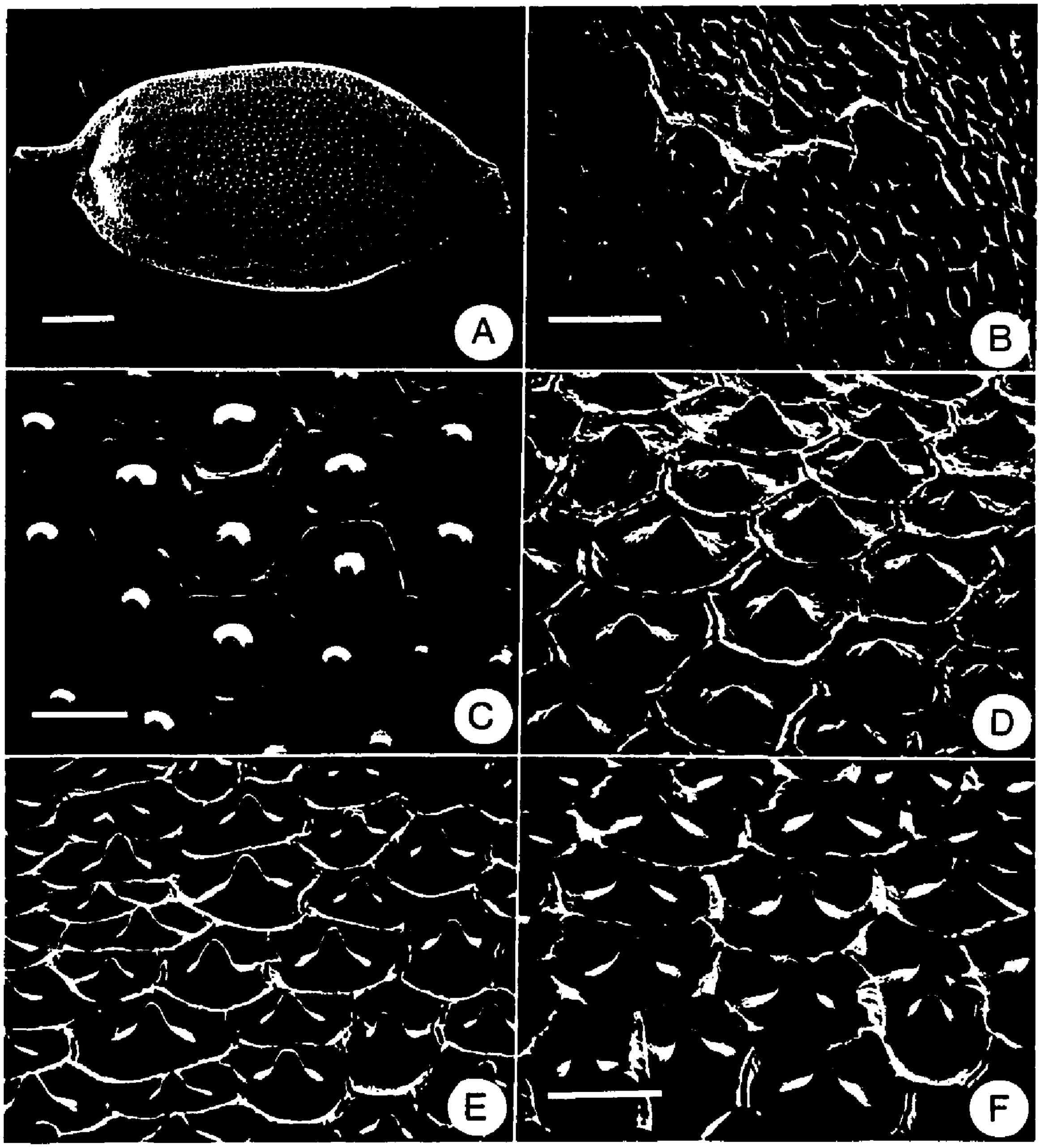

A
B
C
D
E
F

Figure 8. Achene micromorphology (scale = 2 um). A. *Carex scirpoidea* ssp. *stenochlaena* 1000x, (Ravailli Co., MT, *Lackschewitz 1344*). B. *Carex scirpoidea* ssp. *pseudoscirpoidea* 1000x, (Mono Co., CA, *Sharsmith 3516*). C. *Carex curatorum* 1000x, (Kane Co., UT, *Dunlop 2087*). D. *Carex curatorum* 1000x, (Mohave Co., AZ, *McClintock 52-539*). E. *Carex gigas* type 1000x, (Mt. Eddy, CA, *Pringle 126*). F. *Carex scabriuscula* type 1000x, (Cascades, OR, *Cusick s.n.*).

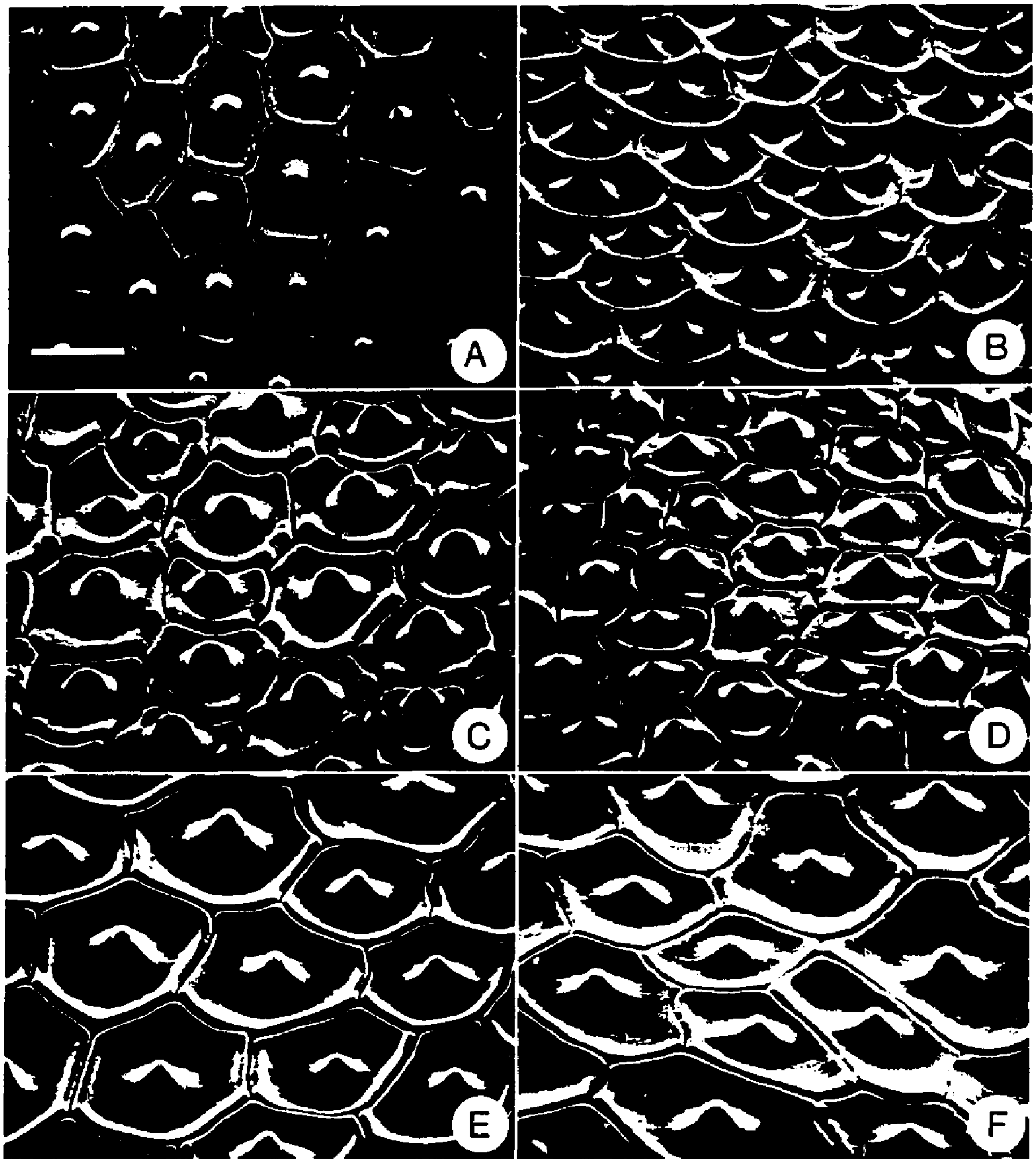

A
B
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Figure 9. Achene micromorphology. A. partially eroded achene, Carex scirpoidea ssp. stenochlaena, scale = 1 um, (Ravailli Co., MT, Lackschewitz 2863). B. Carex scirpoidea ssp. scirpoidea, scale = 2 um, puckered edges, (Bellburn's, Newfoundland, Dunlop 2505).

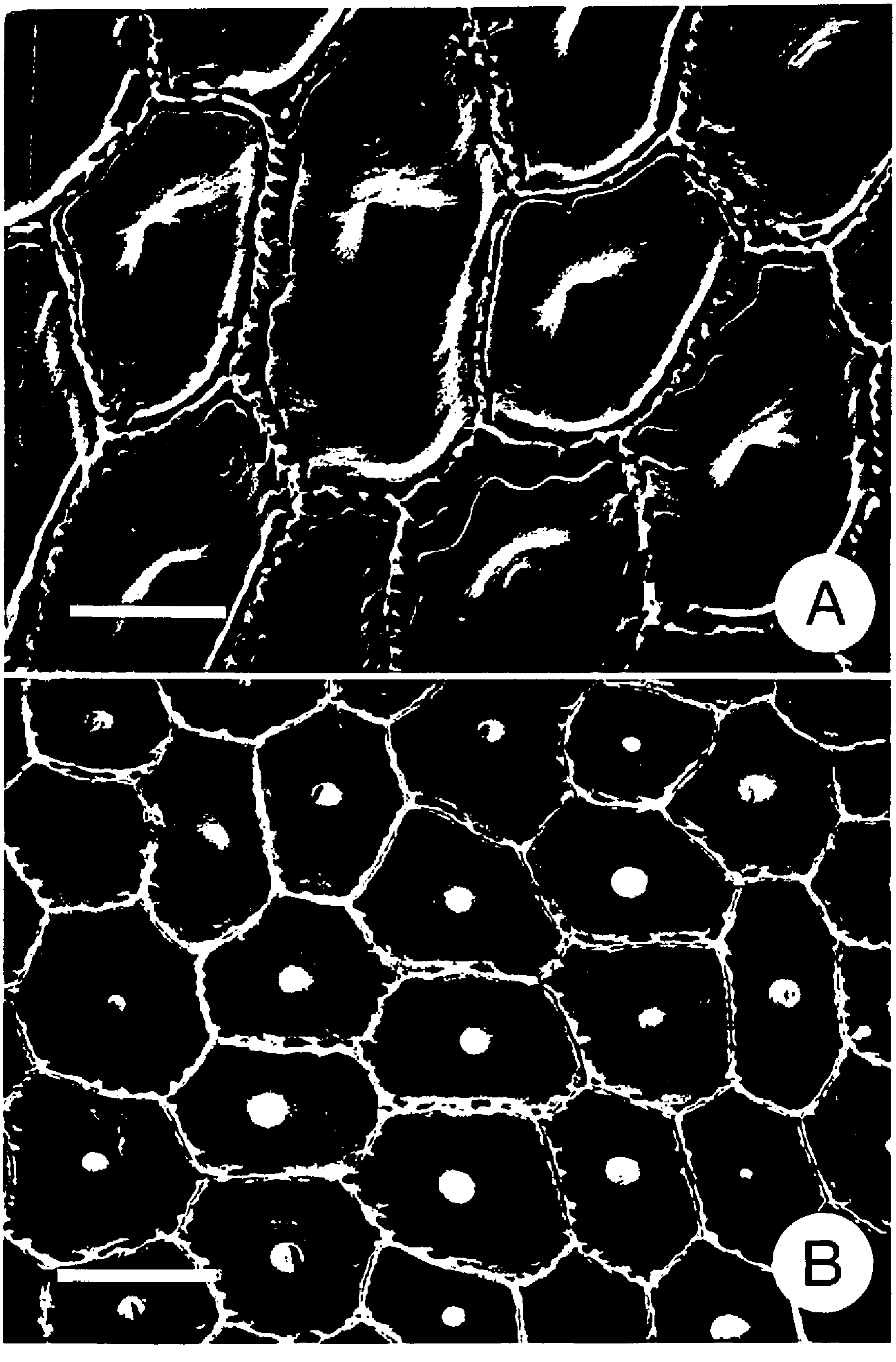

A
B

Figure 10. Perigynium structure (scale approximately 1 mm). A. *Carex scirpoidea* ssp. *scirpoidea* (Elko Co., NV, *Dunlop 2140*). B. *Carex scirpoidea* ssp. *scirpoidea* (=*Carex athabascensis* type) (Alberta, CAN, *Hermann 13498*). C. *Carex scirpoidea* ssp. *scirpoidea* (Magadan, USSR, *Derviz-Sokolova s.n.*). D. *Carex scirpoidea* ssp. *scirpoidea* (Garfield Co., UT, *Dunlop 2100*). E.*Carex scirpoidea* ssp. *pseudoscirpoidea* (Mono Co., CA, *Dunlop 2158*). F. *Carex scirpoidea* ssp. *convoluta* (Alpena Co., MI, *Dunlop 1773*).

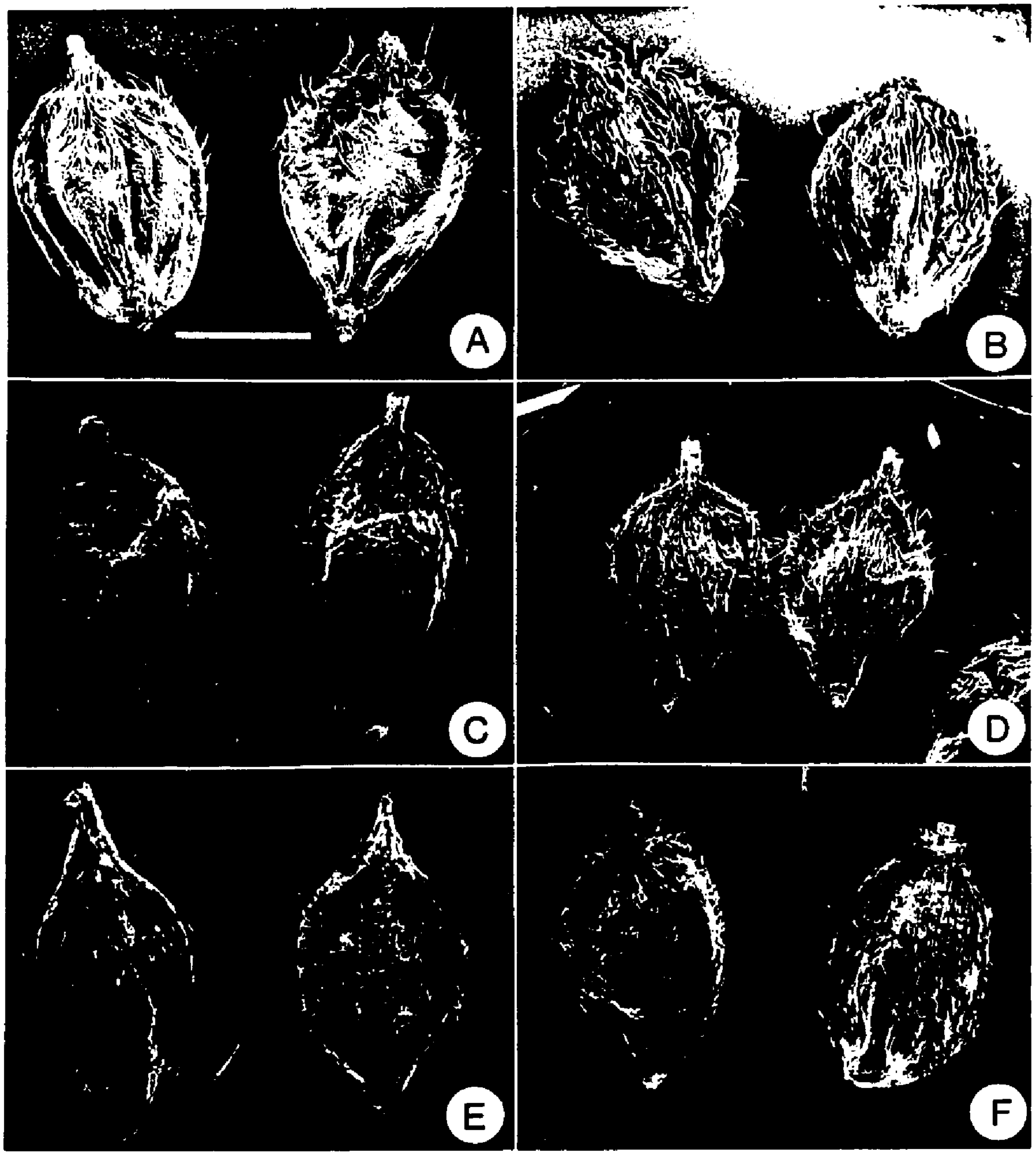
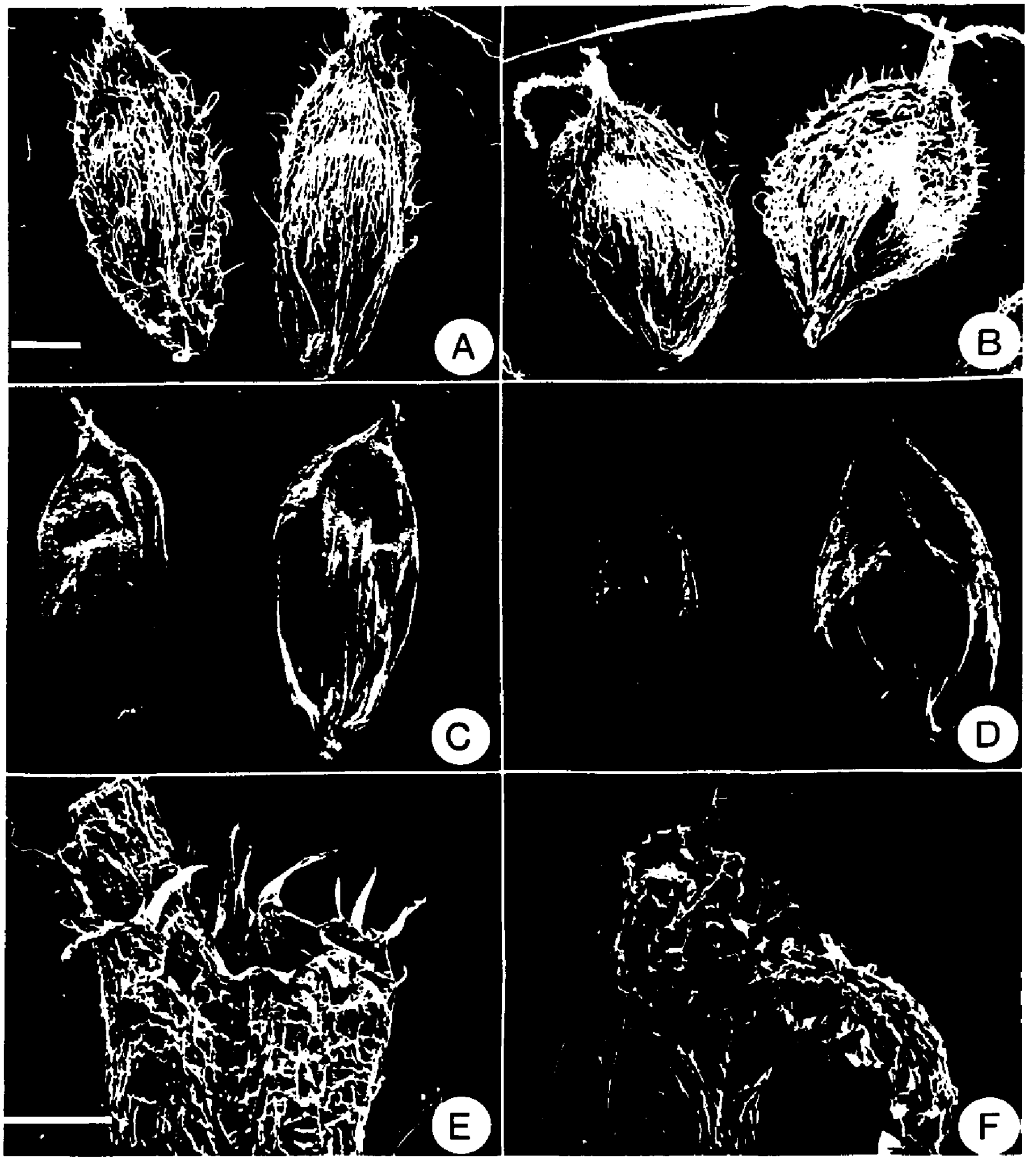

A
B
C
D
E
F

Figure 11. Perigynium structure (scale = 0.5 mm A-D). A. *Carex scirpoidea* ssp. *stenochlaena* (Chelan Co., WA, *Thompson 9580*). B. *Carex curatorum* (Coconino Co., AZ *Eastwood and Howell 1045*). C. *Carex scabriuscula* (Curry Co., OR, *Denton 3106*). D. *Carex gigas* (Trinity Co., CA, *Dunlop 2173*). E. *Carex curatorum*, scale = 0.1 mm, (Coconino Co., AZ, *Eastwood & Howell 1045*). F. *Carex scabriuscula*, scale = 0.1 mm, (Curry Co., OR, *Dunlop 2234*).


A
B
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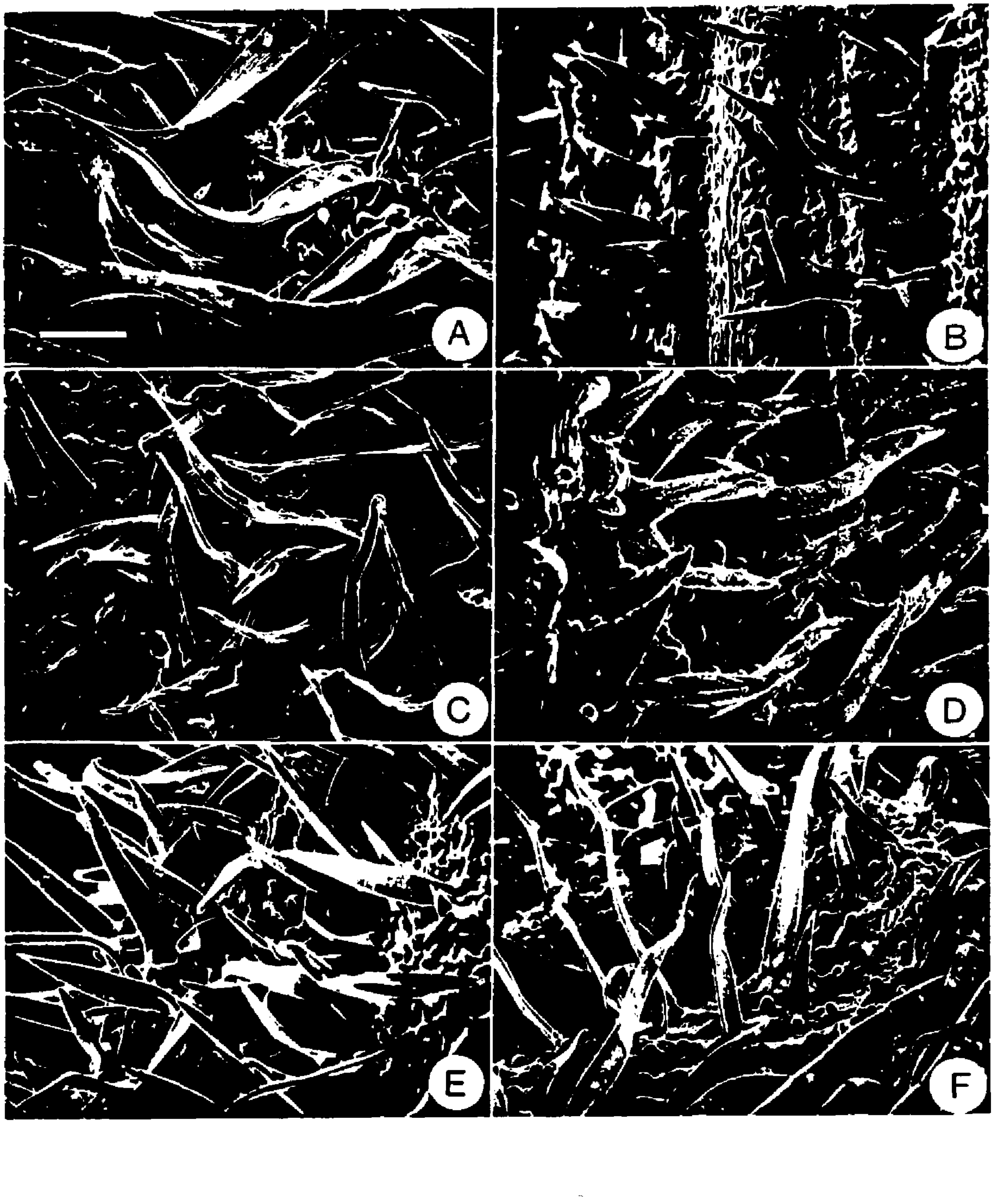
E
F

Figure 12. Perigynium hair morphology (scale = 5 um). A. *Carex langinosa*, (Hampshire Co., MA, *Ahles 82748*, NHA). B. *Carex tenax*, (Clarendon Co., SC, *Radford & Leonard 1570*, NHA). C. *Carex hirtifolia*, (county not known, ME, *Parlin 1460*, NHA). D. *Carex tomentosa*, (Switzerland), *Steiger s.n.*, NHA). E. *Carex virescens*, (Carroll Co., *Hodgdon et al. 19206*, NHA). F. *Carex swanii*, (county unknown, MA, collector unknown, *s.n.*, NHA).


A
B
C
D
E
F

IV. FOLIAR ANATOMY AND SURFACE FEATURES

Introduction

Anatomical characters have long been used in circumscribing species in Carex. In 1891, Mazel surveyed leaf, culm and rhizome anatomy of fifty European species, but according to Holm (1892), Mazel failed at grouping anatomically similar taxa due to his geographically limited sample. However, Lemke, a contemporary of Mazel, was successful in grouping species based on the anatomical structure of the rhizome (Holm, 1895).

Akiyama (1939, 1940, 1941) examined and recorded the leaf and epidermal characteristics of many species of Carex in Japan and based on anatomical relationships, suggested that the subgeneric classification of Carex ought to be completely re-evaluated.

Recent studies in Carex have focused on both internal anatomical structure and on leaf surface features in order to assess relationships between species and infraspecific taxa (Crins and Ball, 1989b; Jalas and Hirvelä, 1964; Standley, 1985b, 1987a, 1987c). At the specific level, foliar characteristics have been found useful in distinguishing species (even morphologically and chromosomally similar species) in some sections (Standley, 1985b, 1987a, 1987c), while not in others (Crins and Ball, 1989b). At the infraspecific level, foliar anatomy may differ among subspecies or varieties of some species, such as in *C. aquatilis*, *C. stricta* (Standley, 1986, 1987a) and *C. elata* (Jalas and Hirvelä, 1964), while not in other polymorphic species such as *C. scopulorum* and *C. lenticularis* (Standley, 1985b, 1987). In addition, hybrids have been recognized by the expression of anatomical characteristics intermediate between the two parent species (Jalas and Hirvelä, 1964). Foliar anatomy and surface features were examined for all taxa in the section *Scirpinae* in order to determine if differences existed among taxa.

Methods

Anatomical features in transverse sections of the leaves and leaf epidermal peels were examined using compound light microscopy, while leaf surface structure was studied in more detail using scanning electron microscopy (SEM). Foliar material of all the taxa in the section *Scirpinae*, representing populations from a wide geographic range, was obtained from herbarium specimens and samples preserved in FAA from the field. Transverse sections were prepared following methods outlined by Standley (1985b, 1987a). Five centimeter long segments were cut from midway between the apex and base of the youngest, most fully expanded leaf on a sterile shoot, then fixed and stored in FAA. Transverse sections were hand-cut using razor blades, cleared in a 10% solution of household bleach for 5-10 minutes and rinsed twice with distilled water. Epidermal peels were made from both the adaxial and abaxial surfaces of the leaf following the scrape methods described by Metcalfe (1971). Transverse sections and leaf peels were mounted on slides in Hoyer's solution for examination with the compound microscope. Measurements were made with an ocular micrometer at 400x.

Foliar materials used in the SEM study were collected and preserved as described above for the transverse sections. Preserved material was cut into 5 mm sections, dehydrated in a 70-100% alcohol series and hexmethyldisilazane (HMDS). HMDS was evaporated off and the dehydrated leaf sections were mounted on aluminum stubs using silver paste and coated with gold-palladium in a Hummer V sputter coater. The specimens were examined using an AMR scanning electron microscope at accelerating voltages of 10-20 kv and photographed with Polaroid 55 P/N film.

Results and Discussion

Leaves in transverse section

The leaves in the section *Scirpinae* generally exhibit the same overall structure. Leaves are dorsiventrally flattened and shallowly folded, ranging from a narrow to a wide V-shape as seen in cross section and may occasionally have median adaxial furrows and short abaxial keels (Fig. 13). In *Carex scirpoidea* ssp. *convoluta* some plants with very narrow leaves are distinctly flanged V-shape (Fig. 13A), bending abaxially along a line approximately midway between the mid-vein and the blade margin. Other leaves have a narrow median adaxial furrow and/or a small keel (Fig. 13A). However, these narrow leaves occur within populations which also have the more typical wider V-shaped leaves. Flanged leaves have a greater abundance of sclerenchymatous cells midway between the central vascular bundle and leaf margin than non-flanged leaves (Fig. 14A,B). Leaves of *C. scabriuscula* and *C. gigas* differ in having broadly V-shaped to almost flat leaves (Fig. 13G,F).

Vascular bundles lie equidistant between the adaxial and abaxial surfaces (Fig. 14). Mean bundle number varies from 14-16 for *C. scirpoidea*, (ssp. *scirpoidea* 16, ssp. *convoluta* 15, ssp. *pseudoscirpoidea* 16) and 14 for *C. curatorum*. The mean number of vascular bundles is 18 for *C. gigas* and 20 for *C. scabriuscula* (Table 10). Bundle number is correlated with leaf width, with wider leaves having more bundles. Each bundle is surrounded by a bundle sheath composed of an inner fibrous layer and outer parenchymatous layer.

In the mesophyll, air cavities are well-developed, range in shape from circular to elliptical, and lie equidistant between the adaxial and abaxial surfaces. The size and shape of the cavities vary with leaf maturation since they are lysogenous - formed by the disintegration of large translucent cells (Metcalfe, 1971).

The mesophyll tissue contains, among the chlorenchyma, darkly colored secretory cells (Metcalfe, 1971). In unstained preparations, these cells are opaque with yellow golden-brown contents.

Foliar sclerenchyma is of the girder type and most developed around the major vascular bundles. At the leaf margins, adaxial sclerenchymatous subepidermal caps form similar to those described for other carices (Mehra and Sharma, 1965).

Leaf epidermal features

Epidermal cells are elongated and arranged in longitudinal files parallel to the leaf axis (Fig. 15). Adaxial cells are generally the same size as abaxial cells (Table 11). Costal cells, i.e., epidermal cells overlying sclerenchyma, are narrower than the intercostal cells overlying the chlorenchyma. Carex curatorum has slightly larger adaxial epidermal cells than those of C. scirpoidea (all subspecies) (Table 11).

Silica bodies are present in costal cells and evident in epidermal peels. However, leaf silica bodies were not examined by SEM, thus their morphology could not be compared with that of silica bodies on the achene.

The epidermal cells overlying the median axial bundle on the adaxial surface are thin walled, inflated bulliform cells which form a single layer and averaging 7-10 in number for C. scirpoidea and 8 for C. curatorum. The average number of bulliform cells is 8 in C. gigas and 10 in C. scabriuscula (Table 10). The number of bulliform cells does not appear to be correlated with leaf width.

Stomata are paracytic and lie in longitudinal files parallel to the leaf axis, interspersed by intercostal cells lacking stomata. Guard cells are dumbbell shaped and subsidiary cells are semicircular. Carex scirpoidea and C.

curatorum have abaxial stomata (hypostomatous), except for one specimen from Newfoundland that had a few files of adaxial stomata. In contrast, *C. scabriuscula* (Fig. 15E) and *C. gigas* have stomata on the abaxial surface as well as on the abaxial surface in most specimens. In general, leaves in the genus *Carex* are hypostomatous, with few exceptions (Crins and Ball, 1989b; Standley, 1985b). Standley (1986) found variation in stomate distribution in *C. aquatilis*, where plants of var. *aquatilis* were amphistomatous and those of var. *divers* were not. Crins and Ball (1989b) observed a few single adaxial rows of stomata in the *C. flava* group.

Leaf epidermal surfaces also possess prickles and hairs. Prickles arise from an enlarged epidermal cell forming a short barb directed towards the leaf apex. Prickles are common in the genus *Carex* (Metcalfe, 1971) and ubiquitous along the leaf margins in the section *Scirpinae* resulting in scabrous margins. Prickles also occur infrequently along the adaxial midrib, veins and intercostal regions of the leaf lamina in the section *Scirpinae* (Fig. 15D).

In contrast, hairs are longer and more flexible than prickles. According to Metcalfe (1971) hairs are rare in *Carex* and, when present, are associated primarily with the abaxial leaf surfaces. In the section *Scirpinae*, foliar hairs were evident in epidermal peels but their abundance and distribution was best assessed using the scanning electron microscope. An occasional hair was observed on a few specimens of *Carex scirpoidea*, whereas the leaves of *C. curatorum* were consistently sparsely pilose. The adaxial leaf surfaces possessed hairs along the median adaxial groove and intercostal areas of the lamina (Fig. 15F). Epidermal leaf hairs clearly distinguish *C. curatorum* from *C. scirpoidea*.

Conclusions

Overall leaf structure is similar in the two species of the section *Scirpinae*. Within *Carex scirpoidea* the subspecies are anatomically indistinguishable, except for slight differences in leaf shape. In *C. scirpoidea* ssp. *convoluta*, plants generally have narrow leaves.

Carex scirpoidea and *C. curatorum* are similar in their characters from internal leaf anatomy. However, *C. curatorum* differs significantly in its epidermal features, being distinguished by the presence of hairs on the adaxial leaf surface.

The distinctly wider, generally amphistomatous leaves of *C. gigas* and *C. scabriuscula* clearly distinguish these taxa from the section *Scirpinae*.

Table 10. Foliar anatomy from transverse sections. All measurements are in millimeters. The three numbers represent minimum, mean and maximum values.

	NUMBER VASCULAR BUNDLES	NUMBER BULLI-FORM CELLS	HEIGHT BULLIFROM CELLS	ADAXIAL CELL HEIGHT	ADAXIAL CELL WIDTH	ABAXIAL CELL HEIGHT	ABAXIAL CELL WIDTH
Carex scirpoidea							
ssp. scirpoidea	13 16 20	7 10 17	.03 .04 .05	.01 .02 .03	.02 .02 .03	.01 .02 .03	.01 .02 .03
ssp. convoluta	8 15 20	5 8 12	.03 .04 .05	.02 .02 .03	.02 .02 .03	.02 .02 .03	.02 .02 .03
ssp. stenochlaena	10 14 17	4 7 9	.03 .04 .06	.02 .03 .04	.02 .02 .03	.01 .01 .01	.01 .01 .02
ssp. pseudoscirpoidea	10 16 23	6 9 12	.03 .04 .07	.01 .02 .04	.01 .02 .03	.01 .02 .03	.01 .02 .03
Carex curatorum	7 14 18	5 8 11	.03 .05 .08	.03 .03 .04	.02 .03 .04	.02 .02 .02	.02 .02 .03
Carex gigas	13 20 27	6 8 10	.03 .06 .08	.01 .02 .03	.01 .02 .03	.01 .01 .02	.01 .01 .03
Carex scabriuscula	17 18 21	5 10 17	.04 .06 .09	.02 .03 .03	.02 .02 .03	.01 .01 .02	.01 .01 .02

Table 11. Foliar anatomy from epidermal peels. Measurements are in millimeters.

	ABAXIAL WIDTH	ABAXIAL LENGTH	ADAXIAL WIDTH	ADAXIAL LENGTH
Carex scirpoidea				
ssp. scirpoidea	.01 .02 .02	.03 .06 .09	.01 .02 .02	.04 .08 .14
spp. convoluta	.01 .02 .03	.04 .06 .08	.01 .01 .02	.04 .06 .09
ssp. pseudoscirpoidea	.02 .02 .03	.04 .07 .11	.01 .02 .02	.04 .07 .14
ssp. stenochlaena	.02 .02 .03	.05 .08 .13	.01 .02 .04	.04 .08 .13
Carex curatorum	.02 .03 .04	.06 .08 .14	.01 .02 .03	.05 .08 .11
Carex gigas	.01 .02 .03	.05 .08 .14	.01 .01 .02	.04 .08 .12
Carex scabriuscula	.02 .03 .03	.05 .06 .08	.01 .01 .02	.05 .08 .11

Table 12. Foliar anatomy from leaf surface features.

	ABAXIAL STOMATA	ADAXIAL STOMATA	MEDIAN ADAXIAL HAIRS	ADAXIAL PRICKLES
Carex scirpoidea				
ssp. scirpoidea	+	-(+1)	-	-
ssp. convoluta	+	-	-	+
ssp. pseudoscirpoidea	+	-	-	-
ssp. stenochlaena	+	-	-	-
Carex curatorum	+	-	+	+
Carex gigas	+	+	-	+
Carex scabriuscula	+	+	-(+)	+

+ = present
- = absent
-(+) = generally absent but few plants possessing hairs

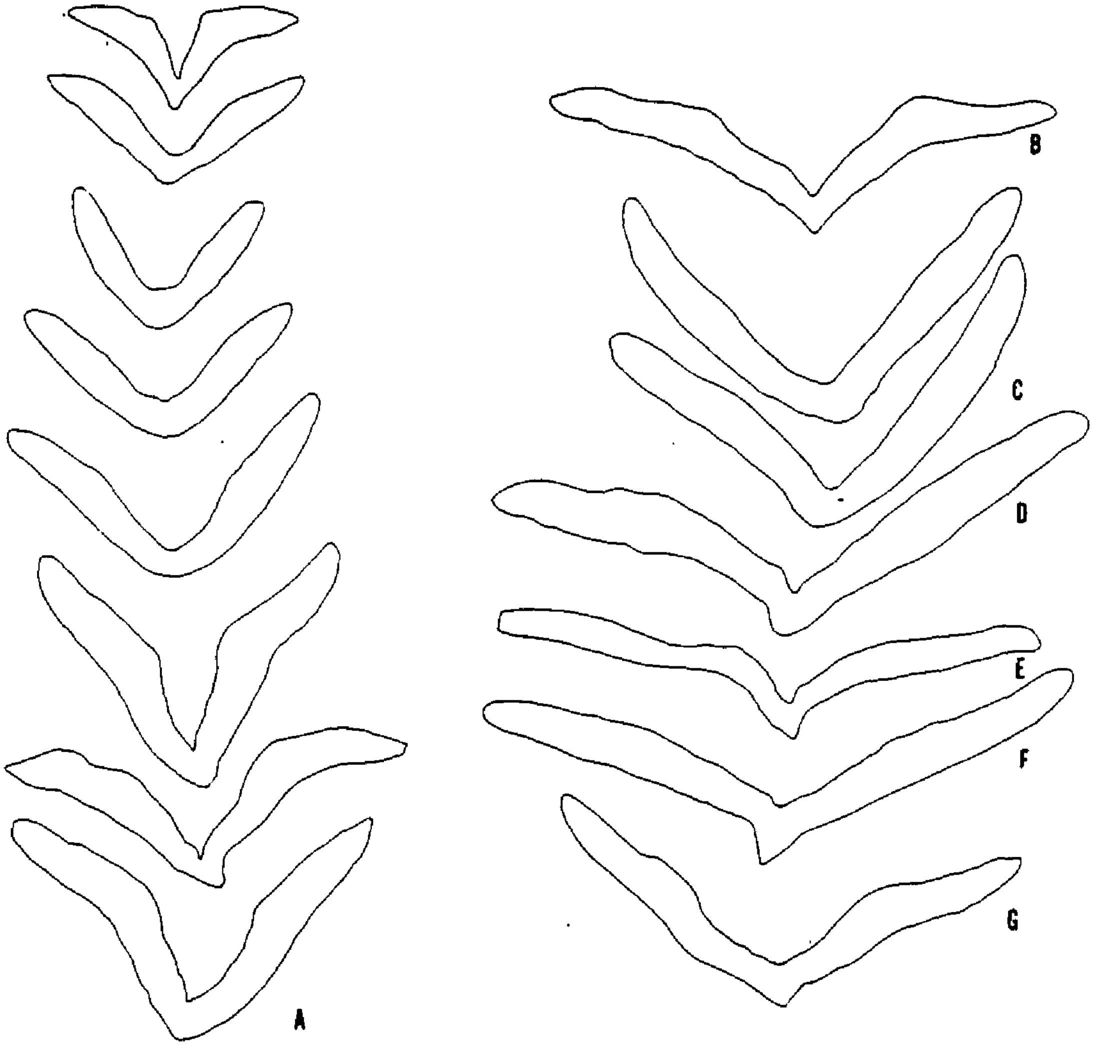


Figure 13. Leaf shape from representative specimens (scale = 0.25 mm). A. Carex scirpoidea ssp. convoluta (5 populations - Michigan and Ontario). B. Carex scirpoidea ssp. scirpoidea (Newfoundland, Dunlop 2480. C. Carex scirpoidea ssp. pseudoscirpoidea (San Juan Co., UT, Dunlop 2075 and Deerlodge Co., MT, Dunlop 2285).). D. Carex scirpoidea ssp. stenochlaena (Ravalli Co., MT, Lachschewitz 1344). E. Carex curatorum (Coconino Co., AZ, Eastwood and Howell 1045 (CAS)). F. Carex scabriuscula (County unknown, OR, Cusick s.n., NY). G. Carex gigas (Siskiyou Co., CA, Pringle s.n., F).

Figure 14. Foliar anatomy in transverse sections (scale = 0.25 mm). A. *Carex scirpoidea* ssp. *scirpoidea*, (Newfoundland, *Dunlop 2480*). B. *Carex scirpoidea* ssp. *convoluta* (Alpena Co., MI, *Dunlop 1840*). C. *Carex scirpoidea* ssp. *stenochlaena* (Ravalli Co., MT, *Dunlop 2272*). D. *Carex scirpoidea* ssp. *pseudoscirpoidea* (San Juan, UT, *Dunlop 2075*). E. *Carex curatorum* (Coconino Co., AZ, *Eastwood and Howell* CAS). F. *Carex gigas* (Trinity Co., CA, *Dunlop 2173*). G. *Carex scarbriuscula* (county unknown, OR, *Cusick s.n.* NY).

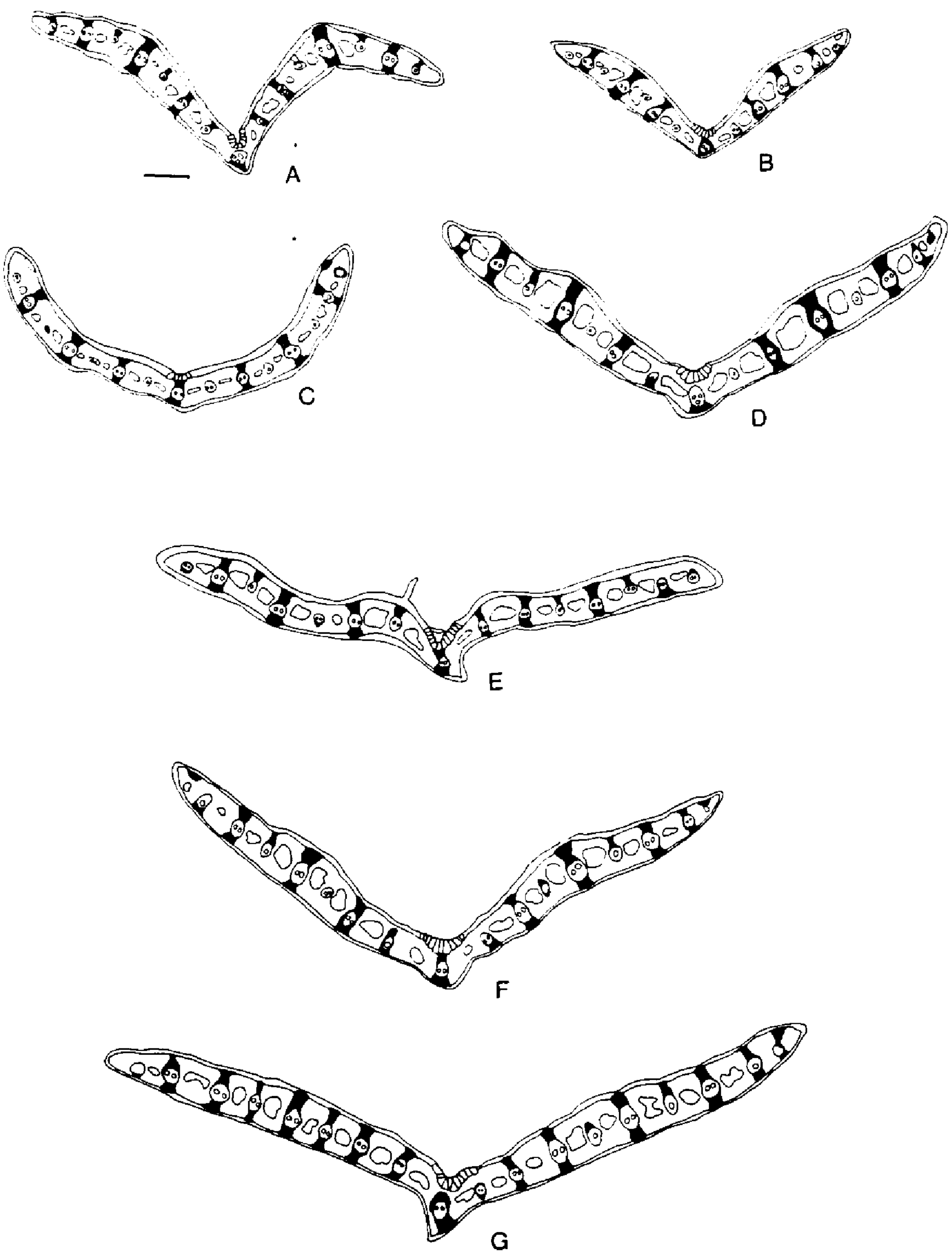
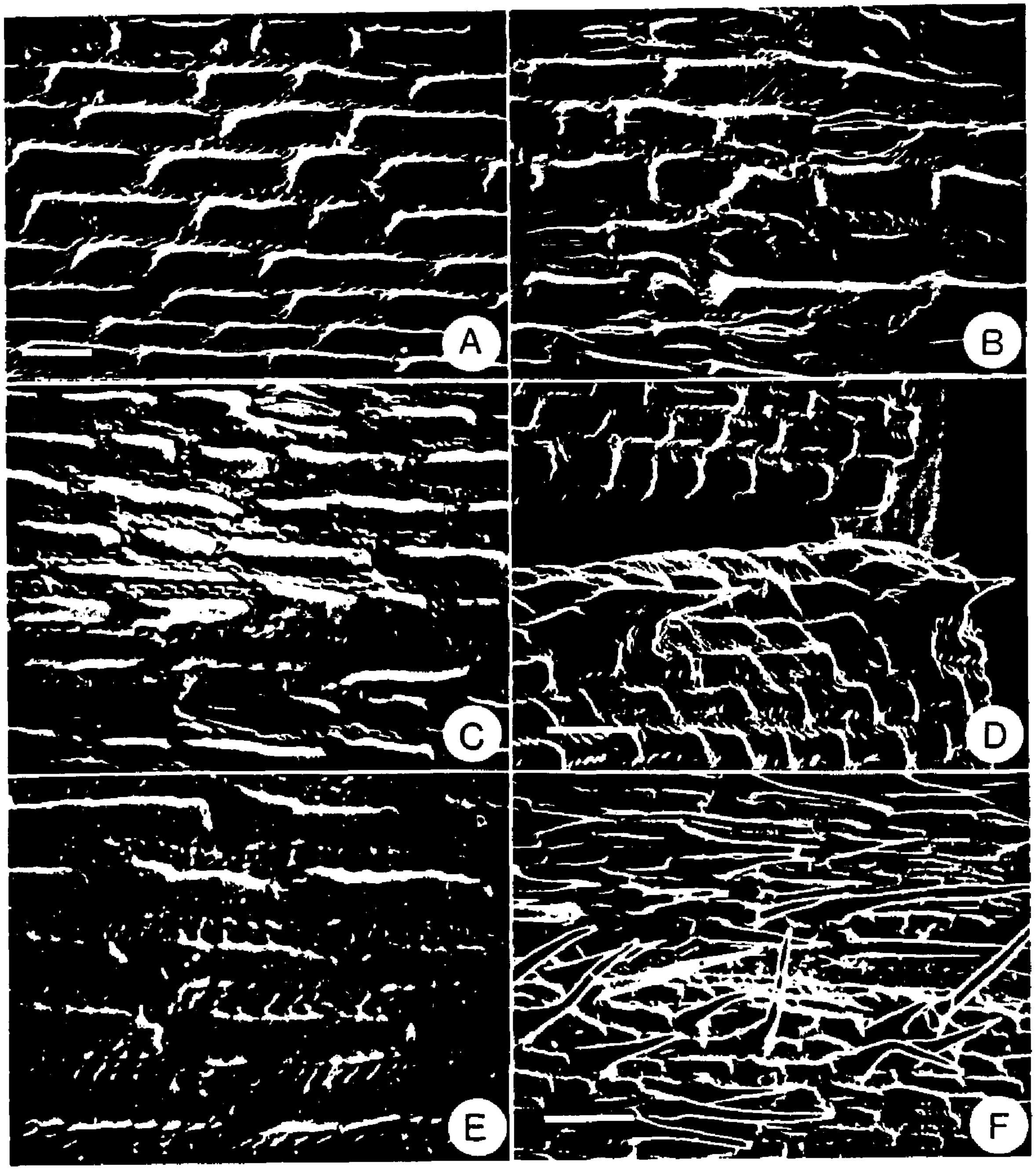

A
B
C
D
E
F
G

Figure 15. Leaf epidermal features (scale = 0.025 mm in A,B,C,E) A. Carex scirpoidea ssp. pseudoscirpoidea, adaxial epidermal surface, (Deerlodge Co,. MT, Dunlop 2280). B. Carex scirpoidea ssp. pseudoscirpoidea, abaxial epidermal surface, (Deerlodge Co., MT Dunlop 2285). C. Carex scabriuscula, adaxial surface with stomata, (CA, Pringle s.n.). D. Carex scirpoidea ssp. convoluta, abaxial surface with prickles, scale = 0.05 mm, (Chippewa Co., MI, Dunlop 1730). E. Carex scabriuscula adaxial leaf surface, Curry Co., CA, Dunlop 2234). F. Carex curatorum, adaxial surface hairs, scale = 0.1 mm, (San Juan, UT, Welsh 2322).


A
B
C
D
E
F

V. CHROMOSOME NUMBERS

Introduction

Chromosome evolution in the genus Carex has been the subject of a number of investigations by Davies (1955, 1956), Heilborn (1924, 1928, 1939) and Wahl (1940). Other studies have focused on the diffuse nature of the kinetochores (centromeres) (Braselton, 1971), a unique sequence of microsporogenesis (Shan, 1960) and aneuploidy (Faulkner, 1972; Heilborn, 1932 and Wahl, 1940). Systematic studies have used chromosome numbers and pairing relationships to examine hybrid relationships (Cayouette and Morrisset, 1985, 1986a, 1986b), and as additional evidence to hypothesize phylogenetic relationships between taxa or to group taxa within sections (Davies, 1956; Manhart, 1986; Standley, 1985b; Whitkus, 1981).

Chromosomes with diffuse kinetochores have been described for the genus Carex based on early researchers' observations that 1) kinetochore constrictions were absent in Carex chromosomes, 2) at anaphase, as daughter chromosomes separate, they lie parallel to each other and 3) at later stages, terminal ends lean poleward and appear concave (Davies, 1956). In light of these observations, surprisingly few modern cytological studies have focused on the nature of the kinetochore in Carex and none have directly shown that kinetochores are actually diffuse. Much of the information is based on comparisons made with detailed studies of other Cyperaceous genera, such as *Eleocharis* (Håkansson, 1958) and *Cyperus* (Braselton, 1971) and with *Luzula* (Juncaceae) (Braselton, 1971; Castro *et al*., 1949). X-ray induced chromosome fragments in these genera behave like individual chromosomes and are not lost during cell division. Braselton (1971) suggests that kinetochore material in *Luzula* and *Cyperus* is not truly diffuse but "packaged" along the chromosome length.

Members of the Cyperaceae are characterized by a unique sequence of microsporogenesis (Davies, 1956; Shan, 1960; Stout, 1912). Microsporogenesis differs from other angiosperm families (except the Epacridaceae, Foster and Gifford, 1974) in that four haploid nuclei are produced from one pollen mother cell (PMC) nucleus and retained within the original PMC wall. Cytokinesis does not occur. Pollen is shed at the three-nucleate stage (Shan, 1960) and referred to as a "pseudomonad". At the four-nucleate stage, three of the nuclei migrate towards one pole and become nonfunctional while the fourth remains functional at the cell center and later divides mitotically to form the sperm and tube nuclei. As a result of this type of microsporogenesis, Heilborn (1932) suggested that allopolyploidy may not be important in chromosome evolution in *Carex* since this type of microsporogensis may not result in unreduced pollen dyads. Types of ploidy and hypotheses on chromosome evolution in *Carex* are further discussed by Faulkner (1972). True polyploidy is not thought to be important in the genus as only a few cases are reported: *C. siderosticta* *n*=12, 24 (Tanaka, 1939) and *C. humilis* *n*=18, 36 (Tanaka, 1942), section *Capillaries* 2*n*=18, 36, 54 (Löve, Löve and Raymond, 1957) and a few triploids (Faulkner, 1972).

Chromosome evolution in *Carex* may reflect a type of aneuploidy called agamatopolyploidy, where short aneuploid series form as chromosome fragments remain viable and function as separate entities.

Short ascending aneuploid series are commonplace within sections in *Carex* (Davies 1956; Faulkner, 1972). Davies (1955) found a short aneuploid series in British populations of the *Carex flava* group (section *Extensae*) of *n*=29, 30, 34, 35, 36. The section *Montanae* forms a coherent group of *n*=14, 15, 17, 18 (Wahl, 1940) and in the section *Acutae*, *n*=28-46 (Standley, 1985b). These series may be a result of structural aneuploidy, chromosome rearrangement with little change in the amount of chromosome material (Faulkner, 1972).

Different chromosome numbers within and between populations have been interpreted as infraspecific variation or mistakes in interpreting chromosome figures. Wahl (1940) reported a series of *n*=25, 26 and 27 for *Carex gracillima*. Manhart (1986) found *n*=17 and 19 for *C. purpurifera* and species in the section *Acutae* may have 3 numbers (Standley, 1985b). Population variation has also been observed in *C. lenticularis* (Standley, 1987b). Some of the observed variation reported in the older literature may actually be a result of the practice of only reporting bivalents. Many studies have shown that univalents and multivalents are common (Faulkner, 1972; Heilborn, 1932; Jørgensen, Sørensen and Westergaard, 1958; Standley, 1987a and Wahl, 1940) and complicate the task of accurate counts, especially in taxa with the high chromosome numbers. Non-bivalents occur in about 40% of the European members of the section Acutae (Faulkner, 1972). Univalents are described as compact, round structures which are difficult to distinguish from chromosome fragments. Chain trivalents and quadrivalents have also been reported (Cayouette and Morrisset, 1985).

Chromosome numbers in Carex range from n=6 to n=66, with low numbers being considered primitive (Heilborn, 1924). Almost every number less than ten has been proposed as a base number for the genus. Wahl (1940) recognized x=5 and x=7 and Tanaka (1949) x=6, 8, 9, 10, 12. The base number concept in Carex has been challenged by Faulkner (1972) who states that many authors may have been influenced by the frequency in distribution of known numbers.

Variation in chromosome size occurs and relative size is correlated with chromosome numbers. Typically, as the number of chromosomes increases, the overall size of individual chromosomes decreases (Heilborn, 1924). Variation in size also occurs within a single nucleus (Cayouette and Morrisset, 1985). There have been reports of one particularly large bivalent in squashes with uniform sized chromosomes (Davies, 1956; Heilborn, 1939). Heilborn (1924) and Löve, Löve and Raymond (1957) recognized three size classes in the genus.

Three different chromosome numbers have been published for the section *Scirpinae* (Table 13). *Carex scirpoidea* ssp. *scirpoidea* has reported counts of $2n = 62$, 64, and 68. *Carex scirpoidea* ssp. *stenochlaena* has a reported diploid number of 62. Numbers for other taxa in the section *Scirpinae* have not been previously reported.

It has been debated whether this reported variation in counts for *C. scirpoidea* represents infraspecific variation or is a result of difficulties in the interpretation of figures of high numbers and small chromosomes. Löve and Löve (1966) suggest that the counts of Heilborn (1939) of $2n=68$ and Moore and Calder (1964) of $2n=64$ are "too high estimates from difficult fixations" (Löve and Löve, 1966, p. 25). Jørgensen, Sørensen and Westergaard (1958) noted that their observations of a plate with $n=30$ and 2_I erroneously lead to a previous count of $2n=64$, and suggest that Heilborn (1939) may have also misinterpreted bivalents.

Differences in chromosome size and presence of non-bivalents have been reported for *C. scirpoidea* from Greenland. Jørgenson, Sørenson and Westergaard (1958) found a heteromorphic pair of chromosomes in their investigation of pollen mother cells in *C. scirpoidea*, which they believed to represent X and Y chromosomes. However. it was not possible to detect this heteromorphic pair in root-tip material due to the very small size and high number of chromosomes. They also observed that some cells had 30 bivalents and two small univalents (which are said not to represent the heteromorphic sex bivalent: see Jørgenson, Sørenson and Westergaard, 1958)

The purpose of the present investigation in the section Scirpinae was: 1) to verify existing published numbers for C. scirpoidea ssp. scirpoidea and ssp. stenochlaena 2) to provide chromosome numbers for the other taxa in the section, 3) determine patterns of variation in haploid chromosome numbers and size, 4) to determine if variation in chromosome number was correlated with morphological or anatomical variation or has taxonomic significance.

Methods

Staminate spikes were collected from greenhouse grown plants as soon as they emerged from the leaf sheaths. Spikes were fixed in Farmers solution (3:1 absolute alcohol:glacial acetic acid) for up to 24 hours, then stored at 0°C in 70% ethanol. Whole spikes were stained at room temperature in Snow's stain (Snow, 1963) from 12 hours to 7 days and dissected in 45% acetic acid. Anthers were removed, macerated and squashed in a 1:1 solution of 40% acetic acid and Hoyer's solution following the method of Beeks (1955) and Radford et al. (1974). Chromosome numbers were based on counts made from at least three meiotic figures per specimen. Meiotic figures were counted and simultaneously drawn using a camera lucida and photographed using a Zeiss microscope with phase contrast at 2000x magnification. Photographic vouchers are presented here.

Results and Discussion

Thirty chromosome counts are reported (Tables 14, 15) for the following taxa: *C. scirpoidea* ssp. *scirpoidea*, ssp. *convoluta*, ssp. *pseudoscirpoidea*, ssp. *stenochlaena*, *C. curatorum*, *C. gigas*, and *C. scabriuscula*. Counts for all taxa except *C. scirpoidea* ssp. *scirpoidea* and ssp. *stenochlaena* are new.

The four subspecies of *Carex scirpoidea* form a group of taxa sharing a common chromosome number of $n=31$ (Figs. 16 and 17). Infraspecific variation exists in two populations of ssp. *scirpoidea* in Nevada where counts were made of $n=34$ and $n=29$ + III (Table 14). The count of $n=34$ appears to correspond to the reported diploid number of $2n=68$ from the literature. However, it should be noted that in my study, this count was made from a spike collected from greenhouse grown material in late summer during a second period of flowering, as opposed to other spikes collected during the "normal" greenhouse spring flowering period in April. It is not known whether chromosomal abnormalities might result from high summertime greenhouse temperatures.

In all but six counts (Tables 14, 15), bivalents could be ascertained with certainty. These six problematic counts are presented as approximations as one structure differed in size perphas because it was partly out of the plane of focus or one chromosome overlapped with another.

Univalents, appearing as small compact structures, and trivalents, chain-like structures, were evident in *C.*

scirpoidea ssp. *scirpoidea* (Table 14). Most bivalents on the metaphase plate had basically the same shape and size, Due to the limited amount of staminate material only two counts of *C*. *curatorum* (Table 14, Fig. 17E) were made. There was some uncertainty as to whether one structure was a bivalent or a univalent, thus the count is reported as *n*= ca. 30-31.

Counts of *n*=29 were made for both *C*. *gigas* (Table 15, Fig. 17F) and *C*. *scabriuscula* (Table 15, Fig. 17E), two taxa which have been ultimately excluded from the section *Scirpinae*. Based on the literature, it would not be unexpected to find *n*=29 as part of an aneuploid series based on *n*=31 in *Carex*. Thus, this lower number alone would not be justification to exclude these two taxa from the group. However, when correlated with morphological, anatomical and ecological data, differences in chromosome numbers strengthens the evidence to remove *C*. *gigas* and *C*. *scabriuscula* from the section *Scirpinae*.

Table 13. Published chromosome numbers in the section *Scirpinae*.

Location	Number (2*n*)	Reference
Carex scirpoidea ssp. *scirpoidea*		
Greenland	68	Heilborn (1939)
Greenland	62	Jørgensen, Sørenson & Westergaard (1958)
Mt. Apex, B.C.	64	Moore & Calder (1964)
Mt. Washington, NH	62	Löve & Löve in Löve & Solbrig (1964)
Churchill, Manitoba	62	Löve & Ritchie (1966)
Mt. Washington, NH	62	Löve & Löve (1966)
Queen Charlotte Is.	62	Taylor & Mulligan (1968)
Chukotskiy Prov., USSR	62	Zhukova & Tikhonova (1971)
Carex scirpoidea ssp. *stenochlaena*		
Yoho Valley, B.C.	62	Löve & Löve in Löve & Solbrig (1964)

Table 14. New chromosome counts in the section *Scirpinae*.

Location	Collection Number[1]	Haploid Chromosome Number[2]
Carex scirpoidea ssp. *scirpoidea*		
Newfoundland, Bay of Islands, Marble Mountain	2480	31
Newfoundland, Bay of Islands, Blomidon	2472	ca. 31-32
New Hampshire, Grafton County, Cannon Mountain	1963	31
New Hampshire, Grafton County, Cannon Mountain	1960	31
Vermont, Bennington County, Mt. Equinox	2003g	31
Vermont, Bennington County, Mt. Equinox	2003i	31
Colorado, Pike County, Horseshoe Cirque	2025e	31
Colorado, Pike County, Horseshoe Cirque	2025f	31
Colorado, Pike County, Horseshoe Cirque	2025m	ca. 30-31
Utah, Garfield County, Pine Lake	2100	31
Utah, Garfield County, Pine Lake	2100	ca. 30-31
Nevada, Elko County, Ruby Mountains	2155c	34
Nevada, Elko County, Ruby Mountain Valley	2140b	29 + III
Nevada, White Pine County	2130a	31
Nevada, White Pine County	2130	29 + III
Carex scirpoidea ssp. *convoluta*		
Michigan, Alpena County, Thunder Bay Island	1805	31
Michigan, Chippewa County, Drummond Island	1738b	31
Michigan, Chippewa County, Drummond Island	1843	31
Carex scirpoidea ssp. *pseudoscirpoidea*		
California, Mono County, Dana Plateau	2158	31
Utah, San Juan County, Mt. Peale	2075d	31
Montana, Deerlodge County, Goat Flat	2285b	31
Carex scirpoidea ssp. *stenochlaena*		
Washington, King County, Beverly Creek	2241	ca. 31
Washington, King County, Eldorado Creek	2255f	31
Washington, King County, Eldorado Creek	2259f	31
Carex curatorum		
Utah, Kane County, Coyote Canyon	2087	31
Utah, Kane County, Coyote Canyon	2087	ca. 30-31

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[1] All collection numbers are those of the author.

[2] All numbers are for bivalents unless otherwise indicated. (III=trivalent).

Table 15. Chromosome numbers for _Carex gigas_ and _Carex scabriuscula_.

Location	Collection Number[1]	Haploid Chromosome Number[2]
Carex gigas		
California, Trinity County, Scott Mountain	2173f	29
California, Trinity County, Scott Mountain	2173i	29
California, Siskiyou County, Big Carmen Lake	2181	ca. 29-30
Carex scabriuscula		
Oregon, Curry County, Snow Camp Mountain	2234	29

[1] All collection numbers are those of the author.

[2] All numbers are for bivalents.

Figure 16. Chromosome counts (scale = 4 um).
A. Chromosome squash of _Carex_ _scirpoidea_ ssp. _scirpoidea_ stamen showing synchronized cell division. B. _Carex_ _scirpoidea_ ssp. _scirpoidea_ (Newfoundland, _Dunlop_ _2480_). C. _Carex_ _scirpoidea_ ssp. _scirpoidea_ (Grafton Co., NH, _Dunlop_ _1963_). D. _Carex_ _scirpoidea_ ssp. _convoluta_ (Chippewa Co., MI, _Dunlop_ _1843_). E. _Carex_ _scirpoidea_ ssp. _pseudoscirpoidea_ (San Juan Co., UT, _Dunlop_ _2075b_). F. _Carex_ _scirpoidea_ ssp. _pseudoscirpoidea_ (San Juan Co., UT, _Dunlop_ _2075b_).

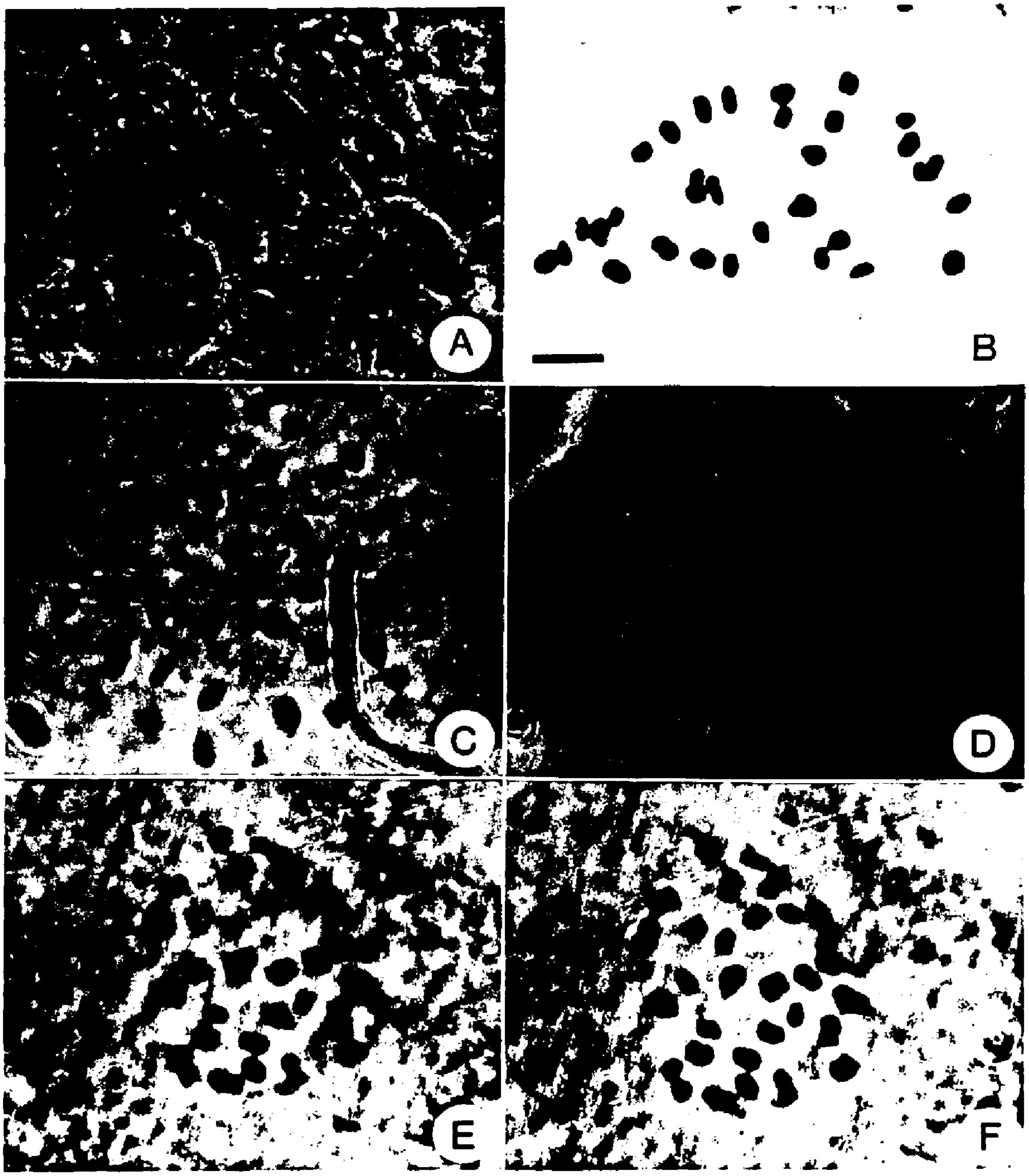
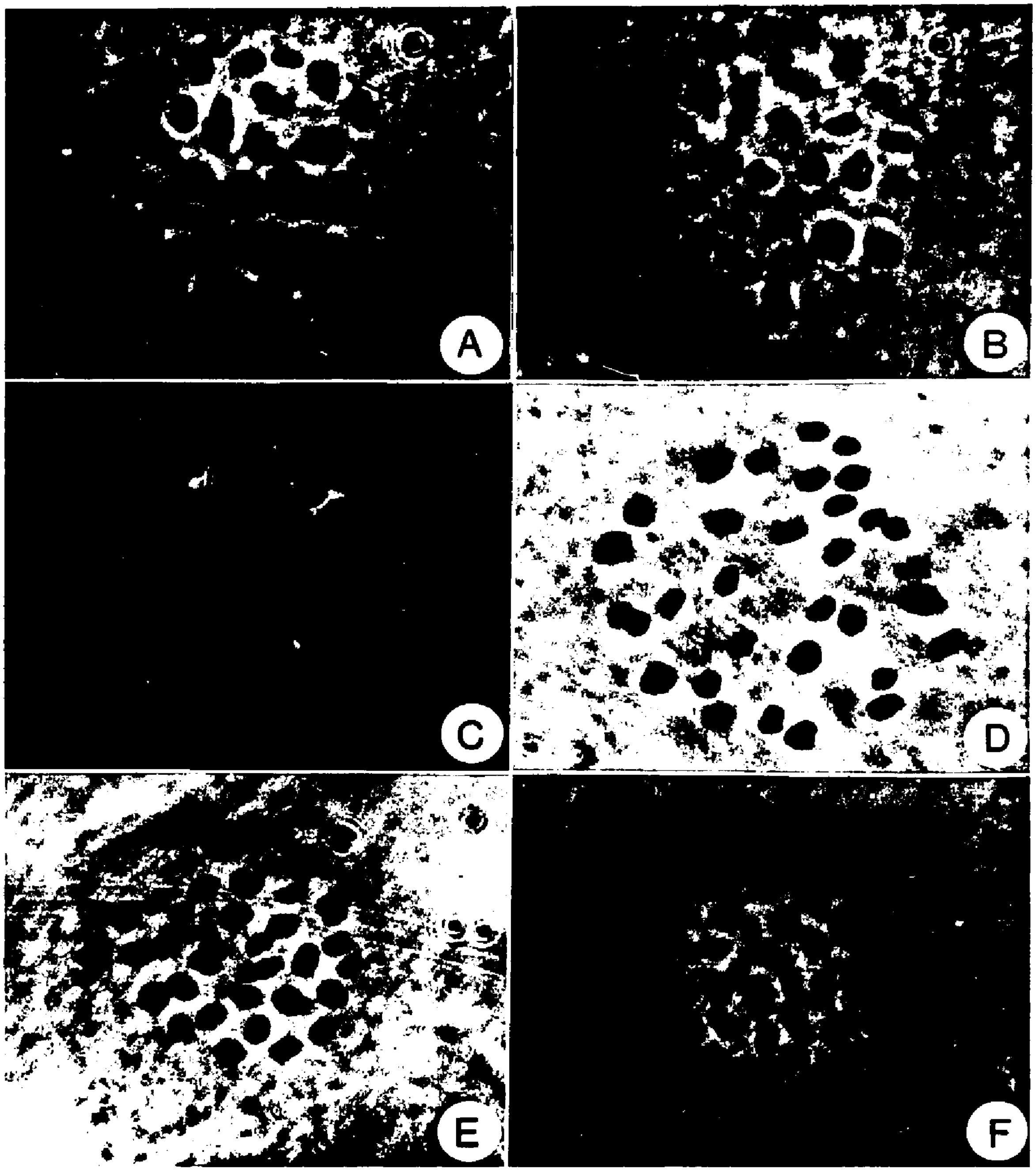

A
B
C
D
E
F

Figure 17. Chromosome counts (scale = 14 um). A. *Carex scirpoidea* ssp. *stenochlaena* (Kittitas Co., WA, *Dunlop 2255e*). B. *Carex scirpoidea* ssp. *stenochlaena* (Kittitas Co., WA, *SDunlop 2255e*). C. *Carex curatorum* (Kane Co., UT, *Dunlop 2087*). D. *Carex curatorum* (Kane Co., UT, *Dunlop 2087*). E. *Carex scabriuscula* (Curry Co., OR, *Dunlop 2234*). F. *Carex gigas* (Trinity Co., CA, *Dunlop 2173*).


A
B
C
D
E
F

VI. BREEDING SYSTEM

Introduction

In this predominantly monoecious genus, few of the thousands of species of Carex possess a dioecious breeding system. Dioecy is established only in the sections Scirpinae, Dioicae and Pictae (Martens, 1939) and occurs occasionally in a few other unrelated infrageneric groups. Based on its occurrence in these unrelated groups and following the premise that, in angiosperms, dioecy has evolved from monoecy, it is inferred that dioecy in Carex has arisen independently in a number of different lines. Ultimately, phylogenetic studies may align these dioecious groups with potential monoecious ancestral groups. However, at this time, little is known about this type of breeding system in the genus. In fact, one recent study has shown that Carex macrocephala, previously described as dioecious, is actually paradioecious (monoecious with unisexual flowering individuals) (Standley, 1985a).

The factors controlling sex expression in plants are complex and some appear to be genetic. The flowers in Carex are unisexual; primordia of stamens or carpels are never associated with flowers of the opposite sex (Smith, 1967). Smith (1966) found that two types of primordia (male flower and spikelet primordia) give rise to three different structures (lateral spikes, pistillate flowers and staminate flowers). The male flower primordium gives rise to a staminate flower but a spikelet primordium develops into either a lateral spike or a one-flowered pistillate spikelet (=perigynium, ovary and style). Experiments show that the application of auxins and kinetins on Carex floral primordia will alter the number and gender of both flowers and whole inflorescences (Smith, 1967).

Experimental breeding relationships have been investigated for only a few sections. Monoecious systems are characterized by both self-compatible and self-incompatible taxa. In compatibility tests, Handel (1978) found 75.7% seed set in self-pollinations of Carex platyphylla and 59.4% in Carex plantaginea, whereas cross-pollinations resulted in a seed set of only 25.5% and 18%, respectively, for the two species. Many taxa in the section Acutae from the Pacific Northwest were highly self-compatible (50-90%), while others, such as Carex aquatilis were weakly self-compatible (Standley, 1985b).

Faulkner (1972) found a high degree of seed set and fertile F_1 hybrids in a study of artificial interspecific crosses in the section Acutae. Furthermore, reciprocal crosses resulted in differential seed set, depending on which taxon was used as the pollen source or pistillate parent. Faulkner utilized this breeding information to align the taxa of the section Acutae into two groups based on the degree of interfertility.

Although few studies have addressed the question of apomixis in Carex, there is no evidence to suggest that it occurs, with the exception of single report of bulbil formation in *Carex ebenea* (Johnson, 1966). Handel (1978) found no evidence for agamospermy; although seed set in bagged inflorescences was 1.1%, it was attributed to exogenous pollen contamination in basally opened pollination bags. The question of agamospermy in a dioecious group has never been investigated.

The objectives of this study were: 1) to make general observations on anthesis, phenology and reproductive synchronization in staminate and pistillate plants, 2) to determine if gender was fixed or labile, 3) to examine gender ratios in populations, 4) to test for possible agamospermy, 5) to make observations that might explain the low seed set observed in some natural populations, and 6) to examine percent seed set in artificial crosses between taxa.

Methods

Observations on the Breeding System

Observations on plants in the natural field populations and in the greenhouse provided information on the nature of the breeding system. Over thirty populations in Newfoundland, New Hampshire, Vermont, Michigan, Colorado, Utah, Arizona, Nevada, California, Oregon, Washington and Montana were visited between 1984 and 1987. For each population an approximate sex ratio was determined by counting the number of staminate and pistillate plants. In addition, 4-10 plants of each gender were collected and grown in the greenhouse for chromosome analysis, breeding system observations and crossing experiments. Plants were potted in a standard potting mix in 8" pots and grown in greenhouses at the University of New Hampshire until July and August of each year, then moved outside. In November, dormant plants were mulched with sawdust and kept at ambient winter temperatures until March. Plants were then returned to the greenhouses and separated by gender.

Interbreeding Relationships

Crosses. In March of 1986, 1987 and 1988, cross-pollinations were made for all possible combinations. Availability of receptive stigmata and mature pollen determined the types of crosses. Pollen was collected from dehisced anthers by inserting staminate spikes into glass vials and gently tapping to release the pollen. Pollinations were made by inserting entire pistillate spikes into the vial containing pollen and dusting until all white, moist stigmatic surfaces were covered with pollen. Pollinated spikes were enclosed in bags of dialysis tubing, folded and stapled closed at the top, and secured at the spike base with tape. Plants with pollinated spikes were left in the greenhouse to set seed, and achenes were harvested within 6-8 weeks. The number of mature achenes (F=fertile) and pollinated flowers (P) were counted and percent seed set (%) calculated (F/P x 100 =%).

Two types of crosses were made in this study. All possible pairwise crosses were made within and between species and within and between subspecies. As each taxon was

represented in the greenhouse by plants from a number of different populations, numerous combinations of crosses with different pollen donors and seed parents were possible.
Controls. Controls were established for each cross to test for pollen contamination and possible agamospermic development of achenes. After pollen was dusted on a pistillate spike, a second pistillate spike on the same plant was selected, bagged and sealed and left in the greenhouse with the other pollinated plants.

Pollen Viability. Pollen viability was checked in every pollen sample using Alexander's stain (Radford *et al.*, 1974). One hundred grains were counted for each pollen sample and only full, rounded, stained pollen was assumed to be viable.

F_1 Hybrids. In July 1986 spikes with mature achenes were collected from the greenhouse plants. Percent seed set was determined and then spikes were stored in a dry, cool place until September when approximately twenty achenes from each of thirty-one crosses were excised from the perigynia and sterilized in a 10% solution of household bleach. Achenes were placed on moist sterile filter paper in sterile petri plates to germinate. Since only a small percentage of achenes germinated, achenes were stratified using a freezing treatment from December 1, 1986 until January 5, 1987. Achenes were then removed and allowed to germinate with natural and artificial light until April 1987. As achenes germinated they were planted in a sterilized peat/soil mixture.

Results and Discussion

Observations on the Breeding System

Based on examination of hundreds of herbarium specimens, observations of live plants in the field and the greenhouse, the dioecious breeding system in the *Scirpinae* is stable. Some variation occurs whereby a few staminate flowers may appear among the pistillate flowers on a pistillate spike, or 1-few pistillate flowers which set seed, may occur at the base of a staminate spike or in the axil of the involucral bract.

Observations made in the field and the greenhouse on *Carex gigas* and *C. scabriuscula*, showed that the breeding system of these taxa was more variable than in taxa in the section *Scirpinae*. Plants of *C. gigas* and *C. scabriuscula* often possesses androgynous spikes and differed phenologically from the taxa in the section *Scirpinae*; in the greenhouse *C. gigas* and *C. scabriuscula* flowered at the end of the flowering period of *C. scirpoidea*, overlapping for only a few days.

Once plants were brought from dormancy into the greenhouse, anthesis commenced within 7 to 14 days, and flowering continued for approximately three weeks. Anthesis was synchronized in staminate and pistillate plants of the same taxon and between subspecies of *C. scirpoidea*. Individual pistillate spikes matured from the base to the apex over a period of seven days. Receptive stigmata were white, moist and fleshy. Based on crosses made in the greenhouse, stigmata of non-pollinated flowers remained receptive up to ten days, during which time the stigmata continued to elongate. Additionally the perigynia of these non-pollinated flowers enlarged, sometimes becoming equal in length to perigynia with fully mature achenes, but remained flattened. Once pollination took place, styles withered, but persisted on the achene.

Pollen dehiscence was generally basipetally in the anthers of this group.

Gender was not labile in the section Scirpinae. Based on observations in the greenhouse over four years, plants remained the same gender from year to year. Observations from the field showed that sex ratios in natural populations were approximately 1:1. Sex expression is genetically determined in taxa in this section.

Interbreeding Relationships

Pollen Viability. Pollen viability was generally high. In 1986, all pollen samples (n=66) had above 90% viability with the exception of four samples (60%, 70%, 85%, 87%). Interestingly, the sample that had the lowest viability (60%) did not result in a lowered value of seed set. This sample was used in three crosses resulting in 88%, 95% and 95% fertility. In 1987 all (n=53) but one pollen sample (80%) had over 90% viability. Pollen samples collected in 1988 (n=33) were all above 90%, except two samples having 85% fertility.

Controls. Only three achenes developed in 4510 control flowers. These probably represented pollen contamination not evidence for agamospermy.

Within taxon crosses. Percent seed set is expressed as percent fertility. Crosses within Carex scirpoidea ssp. pseudoscirpoidea were 94% fertile and 86% within Carex scirpoidea ssp. convoluta (Table 16). However, fertility within Carex scirpoidea ssp. scirpoidea and ssp. stenochlaena, was lower with 68% and 66% respectively. Such differential fertilities may reflect differences in pollen and ovule sources. For example, crosses in which the seed and pollen parents originate from the same population may result in higher fertility. Such appears to be the case in C. scirpoidea ssp. pseudoscirpoidea where the 94% figure represents 127 pollinations on one pistillate spike where the pollen originated from the same population as the seed parent (Table 20). Yet, lower fertilities often resulted from other within-population crosses.

Between taxon crosses. There was much variation observed in the results of crosses made between subspecies of Carex scirpoidea. Crosses of ssp. pseudoscirpoidea (pistillate) X ssp. stenochlaena (staminate) and of ssp. scirpoidea (pistillate) X ssp. pseudoscirpoidea (staminate) resulted in much higher fertility values than other combinations (Tables 16, 17). Reciprocal crosses such as ssp. scirpoidea (pistillate) X ssp. stenochlaena (staminate), compared with ssp. stenochlaena (pistillate) X ssp. scirpoidea staminate) resulted in differential seed set

(83% versus 61%) (Table 17). Fertility also appeared to differ depending on the source of the pollen or ovule. A pairwise comparison showed less fertility in crosses of *C. scirpoidea* ssp. *pseudoscirpoidea* (pistillate) X ssp. *scirpoidea* as well as in ssp. *stenochlaena* (pistillate) X ssp. *scirpoidea* when ssp. *scirpoidea* was the pollen donor (Table 17).

Observations made in natural populations and those obtained from herbarium specimens of *Carex scirpoidea* ssp. *scirpoidea* showed that seed set was noticeably lower in plants of western populations than in eastern populations. This trend was also evident in greenhouse crosses (Table 18). Crosses of *C. scirpoidea* ssp. *scirpoidea* in which the pistillate plant was from a western population, resulted in fertility of 57% in contrast to 82% fertility in pistillate plants from eastern populations (Table 19). This trend is observed regardless of the pollen source.

For some populations the subspecific crosses resulted in a markedly different reproductive success. Crosses of *Carex scirpoidea* ssp. *pseudoscirpoidea* (pistillate) X ssp. *scirpoidea* (staminate) or X ssp. *convoluta* (staminate) resulted in low fertility when the pistillate plants were from Dana Plateau, California (Table 20). Crosses using pistillate plants from this population consistently yielded the lowest percent fertility (3-63%), while all subspecific crosses using pistillate plants from Mt. Peale, Utah were above 90% (Table 20). Factors affecting pistillate reproductive success between populations may be numerous. It should also be noted that perhaps the reduced fertility in pistillate plants from the Dana Plateau may be related to the genetics of this disjunct, isolated Sierra Nevada population.

Since most plants of *C. curatorum* collected and transplanted from the field did not survive in the greenhouse, no crossing data are available for this taxon.

Between section crosses. A limited number of crosses were made with *C. gigas* and *C. scabriuscula* because few plants survived in the greenhouse. Additionally, plants were not always dioecious and the greenhouse flowering period overlapped little with plants in the section *Scirpinae*.

Although *Carex gigas* and *C. scabriuscula* have been excluded from the section, breeding data show that the few crosses made between taxa of the section *Scirpinae* and *C. gigas* and *C. scabriuscula* are highly fertile (Tables 16 and 23). A few F_1 hybrids grew to seedling stage, but soon died. Plants of *C. gigas* and *C. scabriuscula* have chromosome numbers of n=29, but they are apparently similar enough genetically to successfully cross with plants in the section *Scirpinae*, where n=31.

F_1 Hybrids. The results of the F_1 hybrid test are limited to the following general observations since every container of achenes became contaminated with a fungus, even after repeated sterilizations. Only 106 achenes germinated (20%) out of the total 528 recovered from 31 crossing treatments made within the section and with *C. gigas* and *C.*

scabriuscula. Germination varied in each treatment: 1-12 achenes germinated from each of the crosses made in 1986. Those crosses included pollinations between all the subspecies and six crosses using pollen from *C. scabriuscula*.

From the 1986 crosses using *C. scirpoidea* ssp. *scirpoidea* as the pistillate parent, five achenes germinated. The hybrid plants were maintained for a three year period and flowered in the second year. Of the six crosses using pollen from *C. scabriuscula*, 23 out of 74 achenes germinated (31%). Seedlings resulting from crosses using *C. scabriuscula* pollen grew for six months and reached heights of 15 centimeters, then all plants suddenly yellowed and died. This behavior was unusual and was not observed in other seedlings. Perhaps due to a developmental problem.

The results of the experimental breeding study are limited in value without extensive comparative crosses with taxa outside of the section. Except for the crosses with *C. gigas* and *C. scabriuscula*, it is not known if taxa in the section *Scirpinae* are interfertile with taxa of other sections. An attempt was made to cross *Carex scirpoidea* ssp. *scirpoidea* with plants of the section *Montanae* since other cyperologists have postulated a close relationship with this section. However, the monoecious nature of the taxa of the section *Montanae* made crossing experiments difficult and only one plant was emasculated successfully. A test cross between *Carex pensylvanica* (pistillate) and *Carex scirpoidea* ssp. scirpoidea (staminate) did not result in any fertile achenes.

Conclusions

Based on observations of the breeding system it is clear that the taxa of the section Scirpinae (excluding C. gigas and C. scabriuscula) are consistently dioecious, that sex expression is fixed, that sex ratios in natural populations are about 1:1, and that the subspecies of Carex scirpoidea, although rarely sympatric, are highly interfertile. Crosses show that there is a tendency toward a lower fertility in western populations of ssp. scirpoidea than in eastern populations.

Table 16. Summary of percent fertility of taxa in the section *Scirpinae* and excluded taxa.

	Carex scirpoidea							
pistillate parent	ssp. *scirpoidea*		ssp. *convoluta*		ssp. *pseudoscirpoidea*		ssp. *stenochlaena*	
	F/P[1]	%	F/P	%	F/P	%	F/P	%
staminate parent								
Carex scirpoidea								
ssp. *scirpoidea*	2439/3582	68	441/619	72	381/546	70	272/447	61
ssp. *convoluta*	480/608	79	350/405	86	106/200	53	49/64	76
ssp. *pseudoscirpoidea*	209/227	92	179/184	97	120/127	94	186/194	96
ssp. *stenochlaena*	422/506	83	109/111	98	58/60	95	187/285	66
Carex gigas	61/68	90	———		8/68	12	———	
Carex scabriuscula	274/337	81	91/109	83	———		77/90	86

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[1] F/P = number of mature achenes divided by the total number of perigynia to yield percent fertility (%).

Table 17. Pairwise comparison of percent fertility between reciprocal crosses.

pistillate	x	staminate	%
Carex scirpoidea ssp. *scirpoidea*	x	*Carex scirpoidea* ssp. *convoluta*	= 79
Carex scirpoidea ssp. *convoluta*	x	*Carex scirpoidea* ssp. *scirpoidea*	= 72
Carex scirpoidea ssp. *scirpoidea*	x	*Carex scirpoidea* ssp. *pseudoscirpoidea*	= 92
Carex scirpoidea ssp. *pseudoscirpoidea*	x	*Carex scirpoidea* ssp. *scirpoidea*	= 70
Carex scirpoidea ssp. *scirpoidea*	x	*Carex scirpoidea* ssp. *stenochlaena*	= 83
Carex scirpoidea ssp. *stenochlaena*	x	*Carex scirpoidea* ssp. *scirpoidea*	= 61
Carex scirpoidea ssp. *scirpoidea*	x	*Carex gigas*	= 90
Carex gigas	x	*Carex scirpoidea* ssp. *scirpoidea*	= *
Carex scirpoidea ssp. *scirpoidea*	x	*Carex scabriuscula*	= 81
Carex scabriuscula	x	*Carex scirpoidea* ssp. *scirpoidea*	= *

Note: * = cross not made

Table 18. Summary of crossing data for *Carex scirpoidea* spp. *scirpoidea* (pistillate parent).

X staminate taxon	F	P	%	♀ locality
X *Carex scirpoidea* ssp. *convoluta*				
Drummond Island, Michigan	192	263	73	NH
Drummond Island, Michigan	150	189	79	CO
Thunder Bay Island, Michigan	138	156	88	CO
Total =	480	608	79	
X *Carex scirpoidea* ssp. *scirpoidea*				
Cannon Mt., New Hampshire	75	146	51	PL
Cannon Mt., New Hampshire	115	173	66	CO
Cannon Mt., New Hampshire	132	139	95	NV
Cannon Mt., New Hampshire	365	458	80	NH
Mt. Equinox, Vermont	105	159	66	PL
Mt. Equinox, Vermont	136	160	85	NH
No. Newfoundland	156	191	82	VT
No. Newfoundland	32	102	31	CO
Horseshoe Cirque, Colorado	440	477	92	NH
Horseshoe Cirque, Colorado	88	103	85	VT
Horseshoe Cirque, Colorado	395	746	53	CO
Pine Lake, Utah	36	126	29	VT
Pine Lake, Utah	60	94	64	CO
Pine Lake, Utah	31	217	14	PL
Monte Neva, Nevada	22	30	73	CO
Monte Neva, Nevada	151	156	97	NV
Ruby Mts., Nevada	100	105	95	NH
Total =	2439	3582	68	
X *Carex scirpoidea* ssp. *pseudoscirpoidea*				
Goat Flats, Montana	209	227	92	NH
X *Carex gigas*				
Carmen Lake, California	61	68	90	NV

Table 18. continued

X staminate taxon	F	P	%	♀ locality
X *Carex scirpoidea* ssp. *stenochlaena*				
Beverly Creek, Washington	155	179	87	NH
Eldorado Creek, Washington	13	22	59	CO
Eldorado Creek, Washington	20	35	57	NV
Bailey Lake, Montana	100	114	88	NH
Bailey Lake, Montana	54	62	87	NV
Storm Lake, Montana	80	94	85	NH
Total =	422	506	83	
X *Carex scabriuscula*				
Snowcamp Mt., Oregon	126	139	94	NH
Snowcamp Mt., Oregon	96	140	69	VT
Snowcamp Mt., Oregon	52	58	90	NV
Total =	274	337	81	

F = number fertile achenes
P = number pollinations

Table 19. Geographic trends in percent fertility between eastern populations and western populations of *Carex scirpoides* ssp. *scirpoides*.

pistillate population	x	staminate population	range percent fertility	fertile / total pollinated	%
east	x	east	80-85	657/ 809	81
east	x	west	29-95	664/ 811	82
				Total = 1321/1620	82
west	x	east	31-95	459/ 719	64
west	x	west	14-97	659/1243	53
				Total = 1118/1962	57

Table 20. Crossing data for *Carex scirpoidea* ssp. *pseudoscirpoidea* from Dana Plateau, California (DP), Goat Flats, Montana (GF) and Mt. Peale, Utah (MP).

X staminate taxon population	F	P	%	♀ locality
X *Carex scirpoidea* ssp. *convoluta*				
Drummond Island, Michigan	38	73	52	DP
Thunder Bay Island, Michigan	2	60	3	DP
	66	67	98	MP
Totals =	106	200	53	
X *Carex scirpoidea* ssp. *scirpoidea*				
Cannon Mt., New Hampshire	56	134	42	DP
	23	31	74	GF
	111	124	90	MP
Mt. Equinox, Vermont	17	48	35	DP
	44	49	90	MP
Horseshoe Cirque, Colorado	33	52	63	DP
Pine Lake, Utah	58	64	91	MP
Seigh Creek, Montana	39	44	88	MP
Totals =	381	546	70	
X *Carex scirpoidea* ssp. *pseudoscirpoidea*				
Mt. Peale, Utah	120	127	94	MP
X *Carex scirpoidea* ssp. *stenochlaena*				
Storm Lake, Montana	58	60	95	MP
X *Carex gigas*				
Carmen Lake, California	8	68	12	DP

F = number of fertile achenes
P = number of pollinations
% = percent fertility

Table 21. Crossing data for *Carex scirpoidea* ssp. *convoluta* (pistillate parent).

X staminate taxon population		F	P	%
X *Carex scirpoidea* ssp. *convoluta*				
Drummond Island, Michigan		242	263	92
Thunder Bay Island, Michigan		108	142	76
	Totals =	350	405	86
X *Carex scirpoidea* ssp. *scirpoidea*				
Cannon Mt., New Hampshire		154	172	90
Horseshoe Cirque, Colorado		35	81	43
Pine Lake, Utah		207	256	81
Monte Neva, Nevada		25	30	83
Marble Mountain, Newfoundland		56	72	77
Winslow Ledge, New Hampshire		34	52	66
Ruby Mts., Nevada		20	80	25
	Totals =	441	619	72
X *Carex scirpoidea* ssp. *stenochlaena*				
Beverly Creek, Washington		43	45	95
Eldorado Creek, Washington		66	66	100
	Totals =	109	111	98
X *Carex scirpoidea* ssp. *pseudoscirpoidea*				
Goat Flats, Montana		179	184	97
X *Carex scabriuscula*				
Snowcamp Mt., Oregon		91	109	83

F = number of fertile achenes
P = number of pollinations
% = percent fertility

Table 22. Crossing data for *Carex scirpoidea* ssp. *stenochlaena* (pistillate parent). Combined data from Beverly and Eldorado Creek (BC, EC), Washington, and Bailey and Storm Lake (BL, SL) Montana.

X staminate taxon population		F	P	%	♀ locality
X *Carex scirpoidea* ssp. *scirpoidea*					
Cannon Mt., New Hampshire		143	229	62	BC
Mt. Equinox, Vermont		35	37	95	BC
Horseshoe Cirque, Colorado		39	49	89	BC
Monte Neva, Nevada		29	47	61	BC
Marble Mountain Newfoundland		26	85	31	
	Totals =	272	447	61	
X *Carex scirpoidea* ssp. *convoluta*					
Drummond Island, Michigan		49	64	76	BC
X *Carex scirpoidea* ssp. *pseudoscirpoidea*					
Goat Flats, Montana		112	116	97	SL
Mt. Peale, Utah		74	78	95	BL
	Totals =	186	194	96	
X *Carex scirpoidea* ssp. *stenochlaena*					
Beverly Creek, Washington		97	160	60	BC
Eldorado Creek, Washington		90	125	72	EC
	Totals =	187	285	66	
X *Carex scabriuscula*					
Snowcamp Mt., Oregon		77	90	86	BC

F = number of fertile achenes
P = number of pollinations
% = percent fertility

Table 23. Crossing data for *Carex gigas* and *C. scabriuscula* (staminate plants).

	Carex gigas			*Carex scabriuscula*		
	F	P	%	F	P	%
X *Carex scirpoidea* ssp. *convoluta*						
Thunder Bay Island, Michigan				25	38	66
X *Carex scirpoidea* ssp. *scirpoidea*						
Cannon Mt., New Hampshire				126	139	91
Pine Lake, Utah				66	184	36
Monte Neva, Nevada	61	67	91	52	58	90
Seigh Creek, Montana				14	25	56
Total =				244	381	64
X *Carex scirpoidea* ssp. *pseudoscirpoidea*						
Dana Plateau, California	8	68	12			
X *Carex scirpoidea* ssp. *stenochlaena*						
Beverly Creek, Washington				77	90	86

F = number of fertile achenes
P = number of pollinations
% = percent fertility

VII. EDAPHIC CHARACTERISTICS

Taxa in the section Scirpinae have been considered as calcicoles by many authors (Mackenzie, 1935; Hermann, 1957; Thieret, 1963, 1964; Porsild and Cody, 1980) since plants occur in areas of limestone and marl deposits. However, this correlation has never been documented or confirmed using soil analyses.

Soil samples were taken from widely scattered sites for C. scirpoidea ssp. scirpoidea, ssp. pseudoscirpoidea, ssp.stenochlaena, C. gigas and C. scabriuscula. Seventeen analyses were done by personnel at the Suburban Experiment Station in Waltham, MA. Interpretation of these results are tentative because so few samples were analyzed and since there is considerable variability in the soils in which these taxa grow (Table 24).

Carex scirpoidea ssp. scirpoidea grows in weakly acidic to basic soils, with high calcium content, and variable levels of magnesium. Three western sites had highly calcareous soils (Pine Lake, UT, Monte Neva and Ruby Valley, NV). These sites were low elevation sites relative to the others and one, Monte Neva, NV, was a hot spring. Soil from the latter site was strongly basic, had high levels of calcium, boron and arsenic (12.7 ppm in contrast to 0.1-0.5 ppm arsenic in other sites). Plants were also collected on serpentine sites in Newfoundland where soil samples were not taken.

Only three samples were analyzed for *Carex scirpoidea* ssp. *pseudoscirpoidea*. This taxon tends to occur in relatively weakly acidic soils with moderately high levels of calcium.

Three samples were analysed at sites from *C. scirpoidea* ssp. *stenochlaena*. These plants occurred on weakly acidic to circumneutral soils, with low levels of calcium, high levels of magnesium hence low calcium to magnesium ratios (Table 24).

Specific soil analysis information was not obtained for *Carex scirpoidea* ssp. *convoluta* nor *C. curatorum*. It was possible to visit only one site of *C. curatorum*. A meager soil sample was taken, but not analyzed. Plants at this site grew on vertical sandstone canyon walls and were rooted in a thin, wet mat of organic material containing conspicuous spherical colonies of an alga, perhaps *Nostoc*.

Limited soil information is available on *C. gigas* and *C. scabriuscula*. Three analyses indicate that these taxa grow on soils high in magnesium. One of the sites has the lowest calcium to magnesium ratio. Serpentine or periodite soils are evident in the vicinity of these sites (Whittaker, 1960). Walker (1954) describes serpentine soils as essentially a magnesium iron silicate formed from a metamorphosized periodite. Serpentine soils are characterized by low levels of major nutrients and high toxicity of certain metals. Many plants have adapted to the serpentine soils in northern California and southwestern

Oregon where they have formed edaphic ecotypes (Kruckerberg, 1951; Walker, 1954).

All the soil test data were analyzed using Principal Components Analysis to determine if parameters of the soil chemistry might correlate with taxonomic units recognized in this treatment. The three factors with the highest loadings on component I were boron, pH and calcium, where the latter two were highly correlated, while on component II, NO_3, Zn and P had the highest loadings. When the first two prinicpal components were plotted (Fig. 18), all the sites clustered on the negative end of Axis I, with the exception of one distant outlier, the Monte Neva hot spring site. On Axis II, two clusters formed, one at the positive end and one at the negative end. Clusters in this analysis did not correlate specifically with any taxonomic units recognized in this treatment of the section Scirpinae.

Table 24. Values and ranges for sixteen soil parameters in some taxa of the section *Scirpinae* and two excluded taxa.

site	pH	CEC[1]	P[2]	K	Ca[3]	Mg	NH4	NO3	B	Mo	Zn	Cu	Fe	Mn	organic	Al	Ca/Mg
low range[4]			3	25	300	20	3	15	0.1	0.1	0.1	0.3	1.0	3.0	%	0	ratio
high range			18	110	1600	150	24	235.0	2.0	3.0	70	8	40	20		200	
Carex scirpoides ssp. *scirpoides*																	
Horseshoe Cirque, CO	5.9	24.4	6	52	2194	250	6.0	235.0	.3	.1	2.9	.1	1.4	12.0	21.25	9.0	8.8
Pine Lake, UT	8.2	14.8	0	58	2.34%	527	6.0	15.0	.5	.1	.5	.1	1.5	21.0	3.22	2.0	44.4
Monte Neva, NV	8.4	24.2	0	334	2.52%	829	6.0	90.0	3.3	.4	.1	.3	.7	1.0	5.99	1.0	30.4
Ruby Valley, NV	8.2	22.9	0	135	3.21%	899	6.0	15.0	1.4	.1	.1	.1	.3	1.5	9.55	0.0	35.7
Ruby Mts. NV	7.2	19.6	1	110	3210	132	6.0	15.0	.4	.1	.4	.1	3.2	32.0	21.96	11.0	24.3
Lunch Creek, MT	6.7	28.3	4	45	2120	129	6.0	15.0	.1	.1	.4	.1	3.9	9.9	21.13	12.0	16.4
Hidden Lake, MT	6.8	25.1	5	91	2058	201	6.0	30.0	.1	.1	1.0	.1	2.1	20.0	28.04	32.0	10.2
Winslow Ledge, NH	6.2	5.0	3	28	871	55	6.0	30.0	.1	.1	.8	.1	2.7	7.9	6.00	10.0	15.8
Carex scirpoides ssp. *pseudoscirpoides*																	
Mt. Peale, UT	5.7	10.8	6	87	1492	167	12.0	150.0	.1	.1	1.1	.1	6.0	51.0	9.27	35.0	8.9
Dana Plateau, CA	5.9	7.7	5	120	1013	76	6.0	15.0	.1	.1	1.5	.1	2.1	8.3	12.62	24.0	13.3
Goat Flat, MT	6.1	15.9	1	96	2196	107	6.0	90.0	.1	.1	.3	.1	1.5	12.0	8.70	7.0	20.5
Carex scirpoides ssp. *stenochlaena*																	
Bailey Lake, MT	5.5	4.4	5	51	305	29	6.0	30.0	.1	.1	.5	.1	10.0	5.8	5.69	58.0	10.5
Beverly Creek, WA	7.1	10.2	3	5	372	887	6.0	15.0	.1	.1	.1	.1	2.1	8.4	7.64	8.0	0.4
Eldorado Creek, WA	6.2	9.8	2	42	355	905	6.0	15.0	.1	.1	.4	.1	2.6	61.0	8.71	15.0	0.4

Table 24. Soil parameters continued.

site	pH	CEC[1]	P[2]	K	Ca[3]	Mg	NH4	NO3	B	Mo	Zn	Cu	Fe	Mn	organic	Al	Ca/Mg
low range[4]			3	25	300	20	3	15	0.1	0.1	0.1	0.3	1.0	3.0	%	0	ratio
high range			18	110	1600	150	24	235.0	2.0	3.0	70	8	40	20		200	
EXCLUDED TAXA																	
C. gigas																	
Scott Mt. CA	6.8	29.6	2	41	2063	636	6.0	15.0	.1	.1	.4	.1	2.0	11.0	29.87	10.0	3.2
Deadfalls Lake, CA	6.1	17.8	5	105	1055	770	6.0	15.0	.2	.1	.3	.1	16.0	21.0	18.20	10.0	1.4
C. scabriuscula																	
Snow Camp Mt., OR	7.0	13.7	2	10	119	1330	6.0	15.0	.1	.1	.2	.1	5.2	60.0	10.81	14.0	0.8

Note:

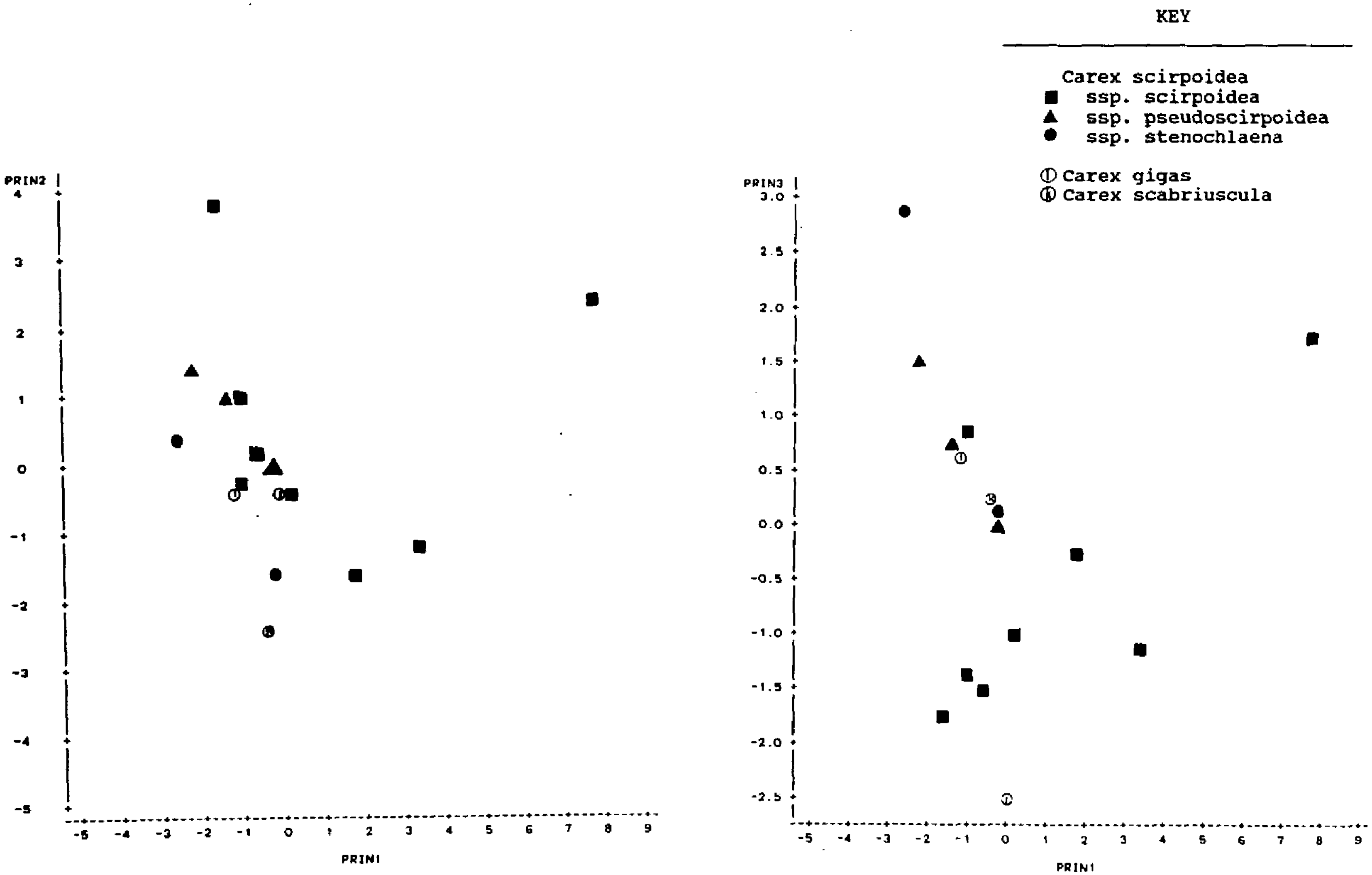
[1] MEQ/100 g.

[2] all nutirents values in parts per million.

[3] Three samples had such high calcium values that they are presented as percentages.

[4] The low and high range values given for P, K, Ca, Mg, and NH$_4$ are values considered low and high for soils by the testing service and not the range for these samples. All others are the actual range.

Figure 18. PCA of seventeen soil samples. A. Axis I and axis II. B. Axis I and axis III. Key: squares = *Carex scirpoidea* ssp. *scirpoidea*, circles = *Carex scirpoidea* ssp. *pseudoscirpoidea*, triangles = *Carex scirpoidea* ssp.*stenochlaena*, open circles with I = *C*. *gigas*, open circles with K = *C*. *scabriuscula*.


KEY
Carex scirpoidea
■ ssp. scirpoidea
▲ ssp. pseudoscirpoidea
● ssp. stenochlaena
① Carex gigas
⑤ Carex scabriuscula
PRIN2
4
3
2
1
0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
PRIN1
PRIN3
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
PRIN1

VIII. TAXONOMIC TREATMENT

Carex L. section *Scirpinae*

Scirpinae (Tuckerm.) Kükenthal in Engler, Pflanzenreich 38 (IV:20):81. 1909. TYPE - *Carex scirpoidea* Michx.

Scirpinae Tuckerman, Enum. Meth. Caricum Quarunum, 1843, as subsection. *Scirpoideae* Pax in Engler and Prantl, Nat. Pflanzenfamilien 2(2):123 1887, as subsection.

Trysanolepis V. Krecz. in Komarov, Flora of the USSR 3: 243. 1935.

Cespitose and rhizomatous plants, with red-brown, lignescent roots. Culms arising from current year shoots (lacking the withered persistent leaf bases of the previous year) or from shoots of the previous year, triangular, scabrous on the angles, height exceeding the length of the leaves. Pistillate culms 5-94 cm tall. Staminate culms 3-74 cm tall. Leaves of the flowering shoot attenuate, adaxial surface glabrous or pubescent, scabrous with marginal prickles. Vegetative leaves similar to leaves of the flowering shoot; mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules semicircular to triangular. Inflorescences unisexual, rarely with flowers of the opposite sex, then only with few staminate flowers interspersed in the pistillate spike or 1-2 perigynia in the axils of the involucral bract at the base of a staminate spike. Inflorescences unispicate, very rarely with a small lateral sessile spike of the same sex, erect or on lax culms, linear to clavate, densely-flowered to loosely-flowered at the base. Involucral bract usually present, foliaceous or scale-like, shorter than the inflorescence, inserted below spike. Perigynia ovate, obovate, oblong, lanceolate, narrower than, equal to or as wide as the subtending scale, tightly or loosely enveloping the achene, pale green, tawny, red-brown to purple-black, hirsute to villose with white-golden brown hairs. Achenes dark brown, trigonous, 1-2.5 mm long, 0.8 - 1.5 mm wide, rarely with a short stipe, filling the full length and width of the perigynia or filling only one 1/2 to 1/3 length and width. Stigma 3. Rachilla absent or present. Anthers 1.5-3.0 mm long.

KEY TO THE SECTION SCIRPINAE

1. Achenes not filling the full length or width of the perigynia, occupying 1/3 the width of the perigynia such that the sides of the perigynia are compressed; adaxial leaf surfaces sparsely pilose with fine white hairs; plants of low elevations in n. Arizona and s. Utah ....*C. curatorum*

1. Achenes filling the perigynia on all sides or at least all but the upper 1/3 of the perigynia; adaxial leaf surfaces glabrous; plants widely distributed especially in calcareous soils in arctic, alpine habitats, cliffs, and ledges 2

   2. Plants rhizomatous, with culms arising from shoots of the previous year such that withered leaf bases of the previous year persist and sheath the base of the culm; scale leaves absent at the base of the culm; blades of the sheathing leaves of the flowering shoot diverge in the same region from shoot axis .... *C. scirpoidea* ssp. *pseudoscirpoidea*

   2. Plants cespitose, with short creeping rhizomes with culms arising from shoots of the current year, lacking withered leaf bases from the previous year; red-brown (anthocyanic) scale leaves conspicuous at base of the culm; leaves of the flowering shoot diverge from intervals scattered along the shoot axis.

3. Perigynia lanceolate to oblanceolate, (2.8)3-4 (5) mm long, greater than 2.5 times as long as wide; culms often lax causing the spike droop .... *C. scirpoidea* spp. *stenochlaena*

3. Perigynia ovate to obovate, (1.8)2-2.5(3) long, less than 2.5 times as long as wide; culms stiff, spikes erect 4

   4. Widest leaves of the flowering shoots of pistillate plants more than 1.5 mm wide, leaves flat or widely V-shaped in cross-section .... *C. scirpoidea* spp. *scirpoidea*

   4. Widest leaves of the flowering shoots of pistillate plants less than 1.5 mm. wide, leaves mostly convolute or narrowly V-shaped in cross-section .... *C. scirpoidea* spp. *convoluta*

1. ***Carex scirpoidea*** Michx.

1a. ***Carex scirpoidea*** Michx. spp. ***scirpoidea***, Fl. Bor. Am. 2:271. 1803. *C. michauxii* Schwein., Ann. Lyceum Nat. Hist. N.Y. 1:64. 1824 (refers to Michaux's taxon). *C. scirpina* Tuckerman, Enum. Meth. Caricum Quarundum 8. 1843 (spelling change, refers to Michaux's taxon). TYPE: boreal Canada, *Michaux s.n*. (HOLOTYPE: P, microfiche P!, photo MT!).

C. wormskiolidiana Hornemann, Fl. Dan. 9:6 pl. 1528. 1816. Type: Greenland, Mallenefield (PLATE 1528).

C. scirpoidea forma *basigyna* Lange, Consp. Fl. Groenl. ed. 2 132. 1890. TYPE: not known.

C. scirpoidea var. *europaea* Kükenthal, in Engler, Pflanzenreich 38(IV:20):81. 1909. TYPE: Norway, Solvaagtind, *Kneuker 181*. (TYPE: not seen).

C. scirpiformis Mackenzie, Bull. Torrey Bot. Club 35:270. 1908. *C. scirpoidea* var. *scirpiformis* (Mackenzie) O'Neill & Duman, Rhodora 43:417. 1941. TYPE: Alberta, Banff, damp ground near Middle Spring, 28 June 1899, *McCalla 2348* (HOLOTYPE: NY!, ISOTYPE: CU! WTU!).

C. athabascensis Hermann, Leafl. W. Bot. 8:111. 1957. TYPE: on mossy rocky shelf on marl upper shore of Athabaska River above Athabaska Falls, alt. 3800 ft., 20 miles southeast of Jasper, Jasper National Park, August 28, 1956, Hermann 13498. (HOLOTYPE: US!, ISOTYPES: ALTA!, CAN!, MICH!, NA).

Cespitose perennials, with short creeping rhizomes, with red-brown, lignescent roots. Culms one to several per node, arising from current year shoots (lacking the withered persistent leaf bases of the previous year), triangular, scabrous on the angles, especially at apex, height exceeding the length of leaves. Pistillate culms 0.3-1 mm wide at top, (0.6)0.8-1.7 mm at base, (5)10-35(40) cm tall. Staminate culms 0.5-1 mm wide at the top, 0.8-1.4 mm at base, (3)9-14(26) cm tall. Leaves of the rhizome and the culm bases lacking blades, red-brown to brown-black, glabrous, shiny, coriaceous. Leaves of the flowering shoots 2-5, arising along the stem, attenuate, adaxial surface glabrous, margins scabrous especially towards apex; in pistillate plants (3.5)11-20 cm long, 1.5-3(3.4) mm wide; in staminate plants 8-25 cm long, 0.8-2.6 mm wide. Vegetative leaves similar to those of the flowering shoots, 5-8 per shoot; in pistillate plants (5)13-24(31) cm long, (1.1)1.5-2.5(2.7) mm wide; in staminate plants 8-25 cm long, 0.8-2.6 mm wide. Mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules semicircular, tan to light red-brown, ciliate, (0.5)1-2(2.3) mm in height, 0.2-0.4 mm wide. Inflorescences unisexual, unispicate, (very rarely with a short sessile lateral spike of the same sex), erect, linear, densely- flowered; pistillate spikes (7.5)10-30(37) mm long, 3-5 mm wide; staminate spikes 10-25 cm long, 0.5-0.8 mm wide. Involucral bracts usually present, foliaceous or scale-like, shorter than the inflorescence, 3.5-20 cm long, attenuate, with base inserted 2.5-17.5 mm below spike, auriculate. Pistillate scales ovate, (1.5)1.8-2.5(2.9) mm long, 1-1.5 mm wide, shorter than, equal to, or longer than the perigynia, apically acute to obtuse, red-brown to brown-black with narrow to broad hyaline margins; central midrib narrow, green-tawny to dark brown, shorter than or extending to apex; margins entire, often ciliate. Staminate scales, similar to pistillate, 3.5-4.3 mm long, 1-1.3 mm wide. Perigynia ovate, (1.8)2-2.5(3) mm long, (0.9)1-1.2(1.5) mm wide, as wide as the subtending scale, abruptly contracted to a beak, generally lacking a short basal stipe with few obscure short nerves on adaxial surface at base, marginal veins not evident, pale green to tawny, becoming red-brown towards apex, hirsute to villose with white hairs; body tightly enveloping the achene; beak 0.1-2 mm long, hyaline, orifice entire and circular. Achenes dark brown, trigonous, (1)1.5-1.8 mm long, (0.6)0.8-1.2(1.5) mm wide, lacking a stipe, filling the full, or at least 3/4, the length and width of the perigynia. Stigmata 3. Rachilla absent. Anthers 1.5-2.5 (3) mm long. Chromosome number n=31.

Distribution and ecology:

Carex scirpoidea ssp. scirpoidea is the widest ranging taxon in the section *Scirpinae*. It is distributed across northern North America from Greenland, Labrador and Newfoundland west to Northwest Territories and Alaska, south to northern New England, New York, Ontario, northwest to Minnesota, North Dakota and west to mountain ranges in Colorado, Utah, Nevada, Montana, Idaho, Wyoming, eastern Oregon and British Columbia. A number of populations occur in the U.S.S.R. on the Kamchatka and Chukotskiy Peninsulas (Fig. 19). One disjunct locality occurs on Solvagtind Mountain in Norway.

Most often ssp. *scirpoidea* occurs on substrates with a high level of calcium (2058 ppm. to 2.52 %). In New England, ssp. *scirpoidea* occurs in widely scattered sites where there is some influence from calcareous parent material, and with associated calcicoles such as *Potentilla fruticosa* and *Juniperus horizontalis*. Based on observations in the field in Newfoundland, ssp. *scirpoidea* grows on both calcareous and serpentine substrates.

Representative Specimens:

Representative specimens are listed in the Appendix.

Comments:

Michaux (1803) cites the type locality for *C. scirpoidea* as "*ad sinum Hudsonis*", whereas a photo of the type shows a label bearing the locality as "*in borealibus Canadae*".

In the early 1800's, some caricologists (Schweintz, 1824; Tuckerman, 1843) rejected Michaux's name, apparently because it was too similar to the epithet *scirpoides* used by Willdenow for another species (*C*. *scirpoides* Willdenow = *C*. *interior* Bailey) or possibly because it was thought to be lexigraphically incorrect. Tuckerman (1843) changed the suffix, using the name *C*. *scirpina*, but clearly referred to Michaux's plant, which in his 1843 treatment is footnoted with: "*Nomen 'scirpoides'* *a Vahlio, Michauxio*. *Schkuhrio lapsu forsam, receptum, plane barabarum est*. *Haud licet 'humano capiti cervicem equinam jungere'*", which translates: "the name '*scirpoides*' accepted by Vahl, Michaux, Schkuhr, perhaps erroneously, is clearly barbarous. It is not at all permitted to 'join a horse's neck to a human head'" (R. Clairmont, translation).

Carex scirpoidea ssp. *scirpoidea* is the most widespread taxon in this section and includes a number of taxa formerly recognized by other caricologists. Kükenthal recognized *C*. *scirpoidea* var. *europaea* from a single disjunct locality in Norway. Although these plants are short in stature, like plants of *C*. *scirpoidea* ssp. *scirpoidea* from alpine habitats, values for most morphological characters fall within the normal range for *C*. *scirpoidea* ssp. *scirpoidea*. I have found no justification for distinct taxonomic recognition for this population.

Another taxon, *C*. *scirpiformis*, had been previously recognized by Mackenzie (1908) and treated at the varietal rank by O'Neill and Duman (1941) based on wide pistillate hyaline scale margins and light colored pubescence, in contrast to those of C. scirpoidea. However, the width of the hyaline portion of the scale margin and the color of pubescence are extremely variable characters in the group and therefore C. scirpiformis is treated in synonymy.

Hermann (1957) recognized Carex athabascensis as a separate species based on the overall robust habit and small ovoid achenes in contrast to C. scirpoidea. These specimens appear to represent a group of robust plants that produce some achenes that fall at the wide end of the range of variation of achene width in C. scirpoidea.

The taxa in section Scirpinae may have originated in western North America. Present day distributional patterns reveal that most of the diversity occurs there, with C. scirpoidea ssp. convoluta as the only taxon not represented in the west. Carex scirpoidea ssp. scirpoidea is widely distributed in western North America but only occurs north of the glacial boundary in eastern North America. In order to explain the present-day distribution pattern of C. scirpoidea ssp. scirpoidea it is necessary to postulate where this taxon may have survived glaciation. Based on the present-day distributional pattern of Carex scirpoidea ssp. scirpoidea, three hypotheses may explain the post-glacial migration of this taxon into the glaciated areas of eastern North America.

Carex scirpoidea ssp. scirpoidea may have survived in unglaciated Beringian areas of Alaska. Another possibility is that it may have survived south of the ice in the Cordilleran region. A third hypothesis is that ssp.

scirpoidea may have been well-established in eastern North America prior to glaciation and survived periglacially.

The first hypothesis is that ssp. scirpoidea may have survived in the Beringian area of Alaska. Much of northern Alaska, northeast Siberia and Beringia was unglaciated during the Wisconsin glaciation (Hultén, 1937; Velichko et al., 1984) and may have served as refugia for plants. Downie and Denford (1986) have postulated the survival of plants in the Arnica frigida - louiseana complex in unglaciated refugia of Alaska and even along ice-free corridors in Alberta. Present-day distribution patterns show that Carex scirpoidea ssp. scirpoidea is well established in northern Alaska and Beringia suggesting that this taxon may have survived in unglaciated refugia in Alaska and migrated southward and eastward into new glaciated soils on retreat of the glacier.

In the Soviet flora, Khokhriakov (1986) considered C. scirpoidea ssp. scirpoidea a subcontinental element (less than 100 km from the coast) and suggested that it migrated westward across the Bering Strait during the Pliocene-Pleistocene, as this land bridge repeatedly appeared and disappeared.

The second hypothesis is that ssp. scirpoidea may have survived south of the ice in the Cordilleran. A number of elements in the northeastern North American flora have distributions or taxonomic affinities with western North America. Iltis (1965) proposed that Gentianopsis procera, a

Cordilleran element in the eastern flora, survived in unglaciated areas of the Rocky Mountains and migrated, following the retreat of the glacier, across the continent, north of the glacial boundary, into suitable eastern habitats. *Carex scirpoidea* ssp. *scirpoidea* may have survived glaciation in refugia in the West and migrated eastward however, this taxon is less represented in the present-day flora of the southern Rocky Mountains than in unglaciated Alaska and Beringia.

The third possibility is that ssp. *scirpoidea* may have survived as a periglacial element. The distribution of ssp. *scirpoidea* may have once been more widespread in the Northeast prior to glaciation and plants may have survived the Pleistocene at the edge of the glaciers in opened, disturbed soils of suitable habitats and recolonized newly opened sites after glaciation. The rarity of present day populations in the northeastern United States may be in part due to limited number of suitable sites, a result of the acidification of glacial soils and restriction of populations to sites with suitable edaphic conditions.

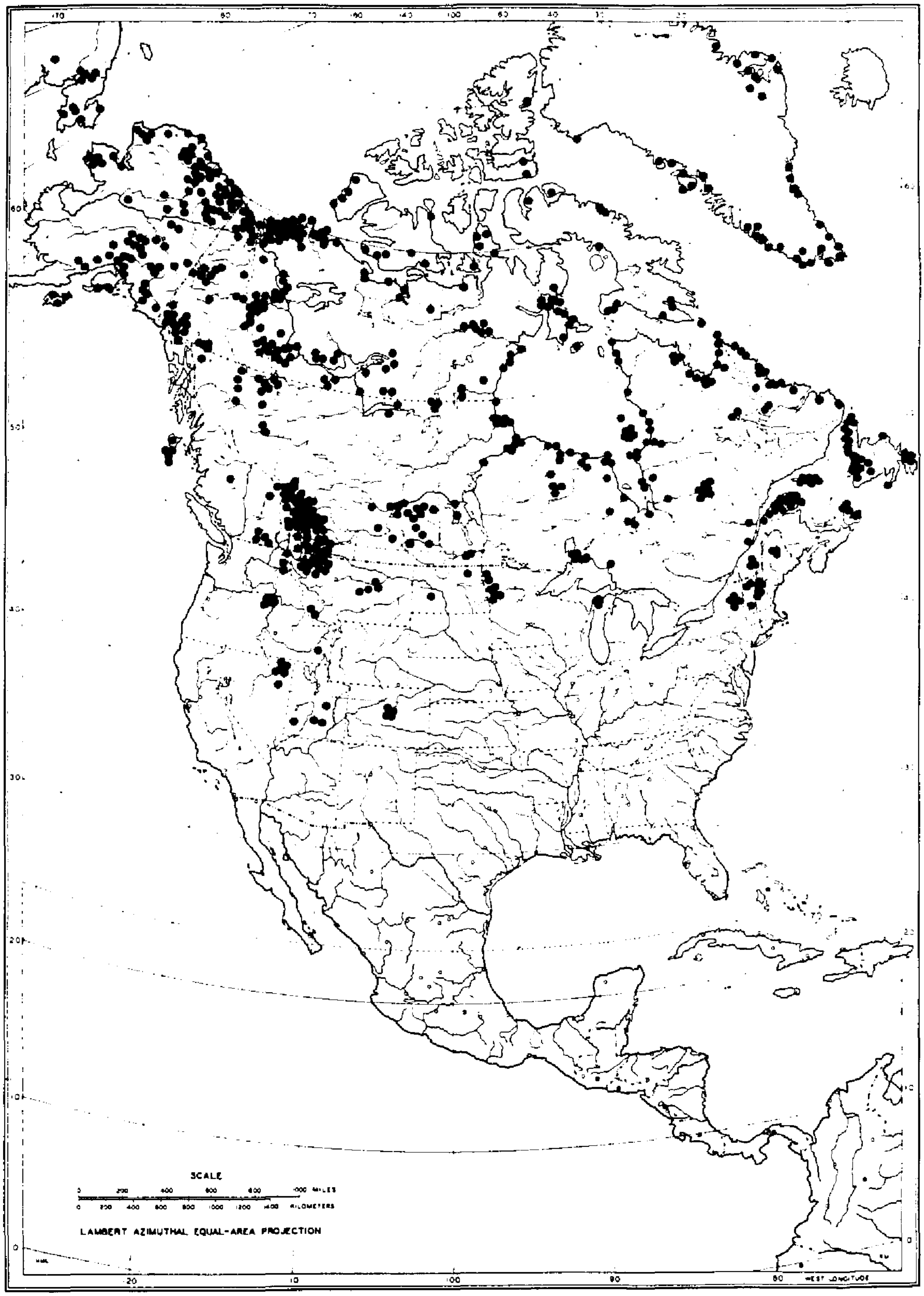
Evidence supporting this third hypothesis comes from plant macrofossils dating from late-glacial floras, particularly those of *Dryas drummondii* and *Elaeagnus commutata*. Fossil data show that a number of calcicoles with western distributions were once more widely established in the glaciated Northeast during this late-glacial period (Miller, 1989). Miller suggests that, despite the nature of the bedrock, newly glaciated soils were calcareous. As the post-glacial soils acidified due to various factors of soil genesis, invasion by spruce and the development of boreal forests, the distribution of some of the arctic-alpine plants, calcicoles or western elements (all of which apply to ssp. *scirpoidea*) became fragmented. Present populations of these calcicoles persist in a few scattered habitats where there is a strong influence of calcareous parent material.

Regardless of where *Carex scirpoidea* ssp. *scirpoidea* survived glaciation, a number of factors influence the distribution of this subspecies. Plants may not be obligate calcicoles since they appear to grow quite normally in a standard potting medium in the greenhouse, as well as in acidic New England garden soils when planted out. Biological factors, such as the presence or absence of competition from woodland plants, may influence their distribution. Miller and Thompson (1979, p. 205) suggested that sites which lack competition from woodland plants and trees may favor the presence of calcicoles and help explain the "localization of calcicolous plants on calcareous cliffs and ledges in the New England area where they form "islands" surrounded by communities of different composition".

Characteristics that might have facilitated eastward migration into glaciated soils may have also facilitate northward migration from eastern or southern periglacial environments (Miller and Thompson, 1979). Plants of *Carex scirpoidea* ssp. *scirpoidea* possess many features that may have facilitated migration into newly glaciated territories. This taxon is an invader or pioneer in open, exposed and disturbed habitats. Plants grow primarily in sites where there is little competition from other plants and where frost action is prevalent in the loose gravelly soils. Short rhizomes of C. scirpoidea ssp. scirpoidea expand into open soils from the periphery of small clumps, rarely forming dense mats since the older portions die back annually.

The mode of dispersal in this species is in not known. Achenes and perigynia do not readily disarticulate from the culm, but remain attached to the spike axis. Year old spikes, retaining most of the perigynia and achenes, were often found on erect culms or in the debris at the base of the plants. It is unlikely that the short hairs on the perigynia aid in dispersal. Potential local dispersal agents are wind, water and/or animal. Plants often grow in close proximity to streams and water courses. Rodents or large mammals may ingest achenes while grazing on the vegetative parts. Some mode of long distance dispersal was required to establish the one Norway population. Perhaps it originated from achenes dispersed by a migrating arctic bird, since the nearest populations are in Greenland.

Figure 19. Distribution of *Carex scirpoidea* ssp. *scirpoidea* (excluding one site in Norway).


SCALE
0 200 400 600 800 1000 MILES
0 200 400 600 800 1000 1200 1400 KILOMETERS
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION
120
110
100
90
80
WEST LONGITUDE
60
50
40
30
20
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1b. **Carex scirpoidea** Michx. spp. **pseudoscirpoidea** (Rydberg) Dunlop, stat. nov. Carex pseudoscirpoidea Rydberg, Mem. N.Y. Bot. Gard. 1:78. 1900. Carex scirpoidea var. pseudoscirpoidea (Rydberg) Cronquist, Univ. Wash. Publ. Biol. 17:(1):325. 1969. TYPE: Montana, Spanish Basin, July 1896, Rydberg 3064 (LECTOTYPE: NY! designated by Mackenzie).

Rhizomatous perennials, with yellow-brown to red-brown lignescent roots. Rhizomes elongated, with regularly spaced shoots, internodes 1-2 cm long. Culms usually 1-few per node, arising from shoots of the previous year and retaining the withered, persistent leaf bases of the previous year, triangular, scabrous on the angles towards apex. Pistillate culms 0.5-1.5 mm wide at top, 0.8-2 mm wide at the base, 5-31 cm tall, exceeding the leaves. Staminate culms 0.9-1.3 mm wide at top, 1.2-2 mm wide at the base, 9-27 cm tall. Leaves of the rhizome and culm base red-brown to brown-black, becoming fibrous with age. Leaves of the flowering shoots 3-5, clustered, sheathing, blades diverge from one region up to 20 mm above the culm base, attenuate, adaxial surfaces glabrous, scabrous along the margins; in pistillate plants 7-19 cm long, 1.2-3.5 mm wide; in staminate plants 9-12 cm long, 1.5-2.8 mm wide. Vegetative leaves similar to those of the flowering shoots, 5-8 per shoot; in pistillate plants 7-21 cm long, 1.6-3 mm wide; in staminate plants 9-13 cm long, 1.5-2.5 mm wide. Mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules semicircular, tan to light red-brown, 1-1.4 mm in height, 1.7-3 mm wide. Inflorescences unisexual, unispicate, (very rarely with a short sessile lateral spike), erect, linear to oblong, densely-flowered; pistillate spikes 10-34 mm long, 3.5-5 mm wide; staminate spikes 10-20 mm long, 3.5-4 mm wide. Involucral bracts often absent but if present, foliaceous, shorter than the inflorescence, 6-40 mm long, attenuate, or occasionally scale-like (less than 1 mm and similar to inflorescence scales), inserted on culms 10-47 mm below spike, base occasionally auriculate. Pistillate scales ovate, 2-2.6(3) mm long, 1.1-1.5 mm wide, longer and wider than the perigynia, apically obtuse, red-brown to brown-black with narrow to wide hyaline margins, central midrib dark brown not extending to the scale apex; margins ciliate. Staminate scales like those of the pistillate plants, 2.8-4.5 mm long, 0.8-1 mm wide. Perigynia ovate, (1.5)2-2.8(3) mm long, 1-1.6 mm wide, abruptly contracted to a beak, lacking a stipe, nerveless, white to light green, becoming red-brown to dark brown towards the apex, hirsute with white to tan hairs; body tightly enveloping the achene; beak 0.1-0.3 mm long, orifice entire, dark with hyaline tip. Achenes light brown, trigonous, 1.5-1.8 mm long, 0.9-1.2 mm wide. Stigmata 3. Rachilla absent. Anthers 3 mm long. Chromosome number n=31.

Distribution and ecology:

Carex scirpoidea ssp. pseudoscirpoidea is widely distributed in the higher elevations of the western mountains; chiefly the San Juan Mts., Colorado, Uinta and La Salle Mts., Utah, the Sierra Nevada Range, California, Steen Mts., Oregon, the Sawtooth Range, Idaho, the Little Belts, Anaconda-Pintlar Range and Beartooth Plateau, Montana and the Okanagan Range in Washington and southern British Columbia (Fig. 20).

This subspecies appears to occupy habitats that differ ecologically from ssp. scirpoidea. Based on herbarium specimen label data, plants of ssp. pseudoscirpoidea occur at higher elevations from 3,300 to 3,900 meters (11,000-13,000 feet), perhaps on drier ridge sites and fellfields with gravely and non-calcareous soils in contrast to the relatively lower elevations and wetter sites with calcareous soils of ssp. scirpoidea in the West.

Representative specimens:

Representative specimens are listed in the Appendix.

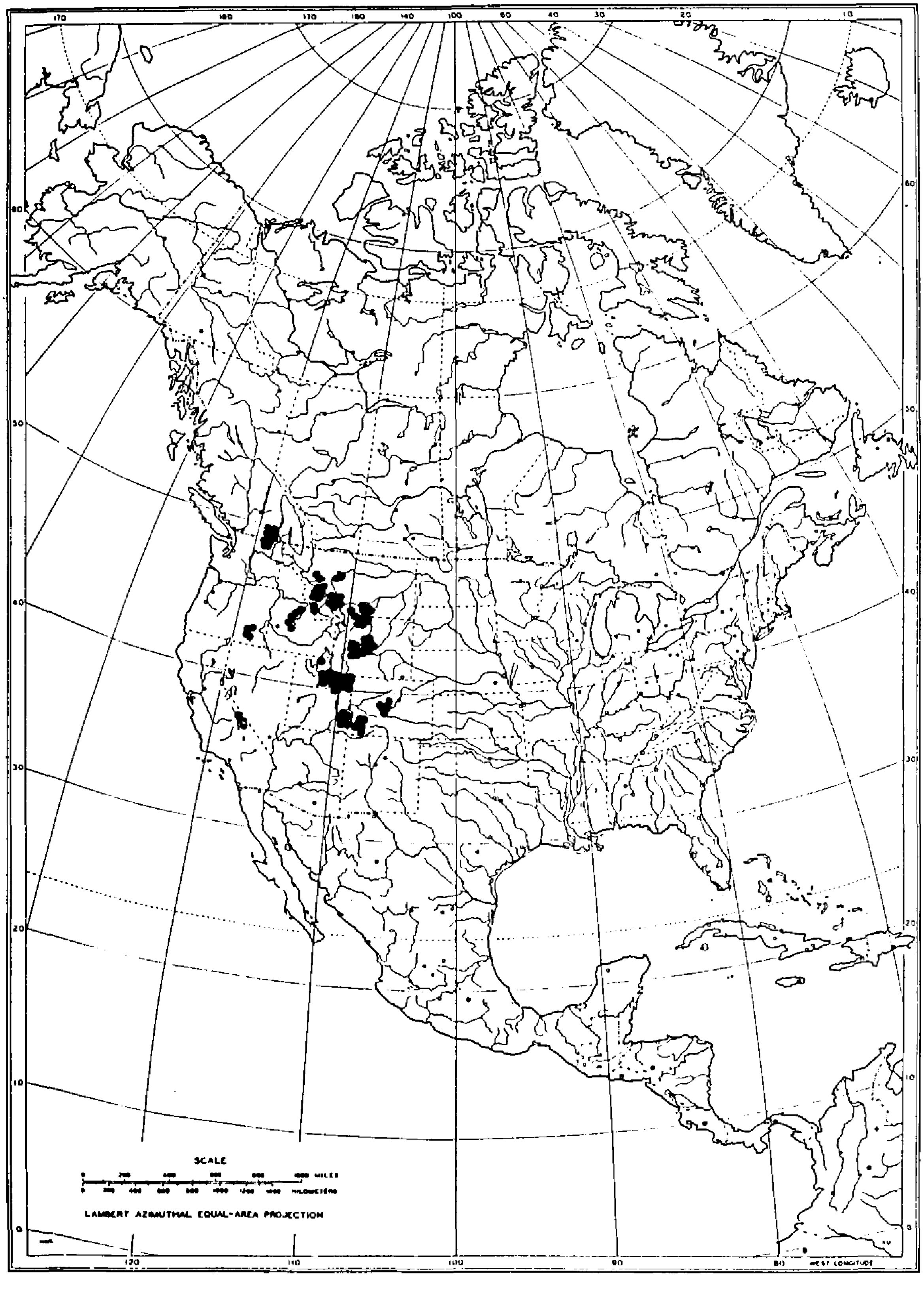
Comments:

Subspecies pseudoscirpoidea is a distinct ecological entity occurring chiefly in high elevation sites in various mountain ranges in the West. This taxon is distinguished by culms that arise from second year shoots that are clothed at the base by the withered and persistent leaf bases of the previous year. Generally, one culm arises from a single node and internodes of the rhizome are elongated, typically 1-2 cm. The leaves are clustered, diverging from the shoot axis at one point approximately 10-20 mm above the rhizome, in contrast to other taxa in which the leaves diverge from the stem at scattered intervals along the shoot axis. The plants generally have shorter and wider leaves than those of ssp. *scirpoidea*.

In lectotypifing *C. pseudoscirpoidea*, Mackenzie (1935) chose *Rydberg no. 3064* (NY) as the lectotype. Unfortunately, this is a staminate plant and does not possess some of the diagnostic features of the taxon. One of the syntypes, *Rydberg no. 3412*, 22 August 1896 (NY), includes both staminate and pistillate material and best represents this taxon. In fact, Mackenzie used this specimen for his illustrations (Mackenzie, 1940).

Comments made about the dispersal mechanism for ssp. *scirpoidea* are also pertinent here. In two populations, (Hidden Lake, MT, and Goat Flats, MT) there was evidence in the field of grazing by a large mammal, perhaps big horn sheep or reintroduced mountain goats. Animal dispersal may be a possible mode of dispersal within mountain ranges, as a number of herbarium specimens showed that prior to collection, specimens had been grazed. Some other mode of long distance dispersal, perhaps wind or bird, is required to explain the rather wide western distribution.

Figure 20. Distribution of Carex scirpoidea ssp. pseudoscirpoidea.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LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION
120
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WEST LONGITUDE
60
50
40
30
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1c. ***Carex scirpoidea*** ssp. ***convoluta*** (Kükenthal) Dunlop, *stat*. *nov*. *C*. *scirpoidea* var. *convoluta* Kükenthal, in Engler, Pflanzenreich 38(IV:20):81. 1909. TYPE: Michigan, Thunder Bay Island, 18 August 1895, *Wheeler s.n.* (LECTOTYPE: GH! designated herein; ISOLECTOTYPES: BH! CAN! GH! MICH! MIN! MSC! NY! POM! VT!)

Cespitose perennials with red-brown, lignescent roots. Culms one to several per node, arising from current year shoots (lacking any withered persistent leaf bases of the previous year), triangular, scabrous on the angles, especially at the apex. Pistillate culms 0.4-0.7 mm wide at the top, 0.8-2.2 mm wide at base, (9.2)19.5-35(38) cm tall, exceeding the leaves. Staminate culms 0.5-0.9 mm at the top, 0.9-1 mm wide at the base, 9-31 cm tall. Leaves of the rhizome and the culm base red-brown to brown-black, glabrous, shiny, coriaceous with acute hard tips. Leaves of the flowering shoots 2-4, arising along the stem, attenuate, adaxial surface glabrous, margins scabrous; in pistillate plants 7-18 cm long, (0.8)1.1-1.5(2) mm wide; in staminate plants 6-15 cm long, 1-1.5 wide. Vegetative leaves similar to those of the flowering shoots, 4-9 per shoot, in pistillate plants 10.5-23.4 cm long, (0.7)1-2 mm wide, in staminate plants 11-16 cm long, 1-1.7 mm wide. Mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules semicircular, tan to red-brown, ciliate, 0.2-2(3) mm in height, 1-2 mm wide. Inflorescences unisexual, unispicate, (very rarely with a short lateral, sessile or subsessile spike), erect, linear, densely flowered; pistillate spikes slender, (10.6)15-21(30) mm long, 2.5-3.5(4) mm wide; staminate spikes 13-30 mm long, 2-3.5 mm wide. Involucral bract usually absent, when present, single, foliaceous, shorter than the inflorescence, 5-21 mm long, attenuate; base inserted on culm 5-12 mm below spike, auriculate. Pistillate scales ovate to obovate, (1.5)2-2.4 mm long, (0.9)1-1.2 mm wide, equal to or shorter than perigynia, apex obtuse to acute, red-brown to dark brown with narrow to broad hyaline margins, central midrib narrow green-tawny to dark brown, extending to scale apex; margins entire, apex ciliate. Staminate scales, similar to pistillate, 2.5-3.2 mm long, 0.7-0.9 mm wide. Perigynia ovate to obovate, 1.5-2.6 mm long, (0.7)1-1.2 mm wide, as wide as the subtending scale, abruptly contracted to a beak, nerves absent, basally light green, becoming tawny to red-brown towards apex, hirsute with white to tan hairs, body tightly enveloping the achene; beak 0.1 mm long, orifice entire, red-brown and hyaline at tip. Achene dark brown, trigonous, 1-1.5 mm long, 0.6-0.9 mm wide, sessile or with 0.25 mm stipe. Stigmata 3. Rachilla absent. Anthers 1.5-2 mm long. Chromosome number $n=31$.

Distribution and ecology:

This is the most restricted geographically subspecies. It occurs only along the shores of Lake Huron on the Bruce Peninsula and on islands of the Manitoulin District, Ontario and on Drummond Island and Thunder Bay Island, Michigan (Fig. 21). Subspecies *convoluta* is associated with alvar communities, characterized by Catling *et al*. (1975) and Stephenson (1984), as thin, till-free soils overlying limestone substrates and bearing sparse vegetation. These open alvar communities contain a number of plant species that are calcicolous, and often drought resistant, that grow in treeless openings, rooted in cracks of outcropped limestone "pavements".

Representative Specimens:

Representative specimens are listed in the Appendix.

Comments:

Subspecies *convoluta* is distinguished by narrow vegetative and convolute leaves of the flowering shoot, a strongly cespitose habit and conspicuously more flowering culms per plant than other subspecies. Plants from the type locality have the narrowest leaves while some plants from the Drummond Island population, close to the Canadian Shield, have leaves which tend to overlap in with those of subspecies *scirpoidea*.

These narrow-leaved plants were first described as a variety of *C. scirpoidea* by Kükenthal based on specimens collected by Wheeler in 1895 from Thunder Bay Island, Michigan. A lectotype is designated herein and was selected from isotypes of Wheeler's 1895, Thunder Bay Island, Michigan collections since Kükenthal's *Carex* herbarium, presumably including the holotype of var. *convoluta*, was sent to Berlin (B) which was destroyed during World War II (Stafleu & Cowan, 1979).

Stephenson (1984) suggested that species of these alvar communities may represent the remnants of an earlier more extensive pre-Pleistocene flora that advanced during the Holocene into these newly glaciated areas. Stephenson inferred that the open communities at Drummond Island, Michigan were never forested following glaciation, but this has not been substantiated with paleobotanical evidence. The lack of competition from woody vegetation is surely important in the survival of these habitat specific species. Thus, the lack of competition from woody vegetation could also be an important factor in the continued existence of ssp. *convoluta* on Thunder Bay Island, Michigan, where the populations occur on a different substrate and the locality reflects a different geologic history than those on the Niagara Escarpment (Voss, pers. comm.).

Based on present-day distributions and the relatively little morphological differentiation between ssp. *convoluta* and ssp. *scirpoidea*, it is possible that ssp. *convoluta* may be derived from *Carex scirpoidea* ssp. *scirpoidea*. Populations may have become fragmented and restricted to a few open, limestone habitats. Such fragmentation and isolation of populations may have facilitated the differentiation of a local ecotype that may have been adapted to the unique, drier, environments such as the limestone pavements on the Niagara Escarpment. Narrow leaves, such as those of ssp. convoluta are often correlated with such drought-stressed environments.

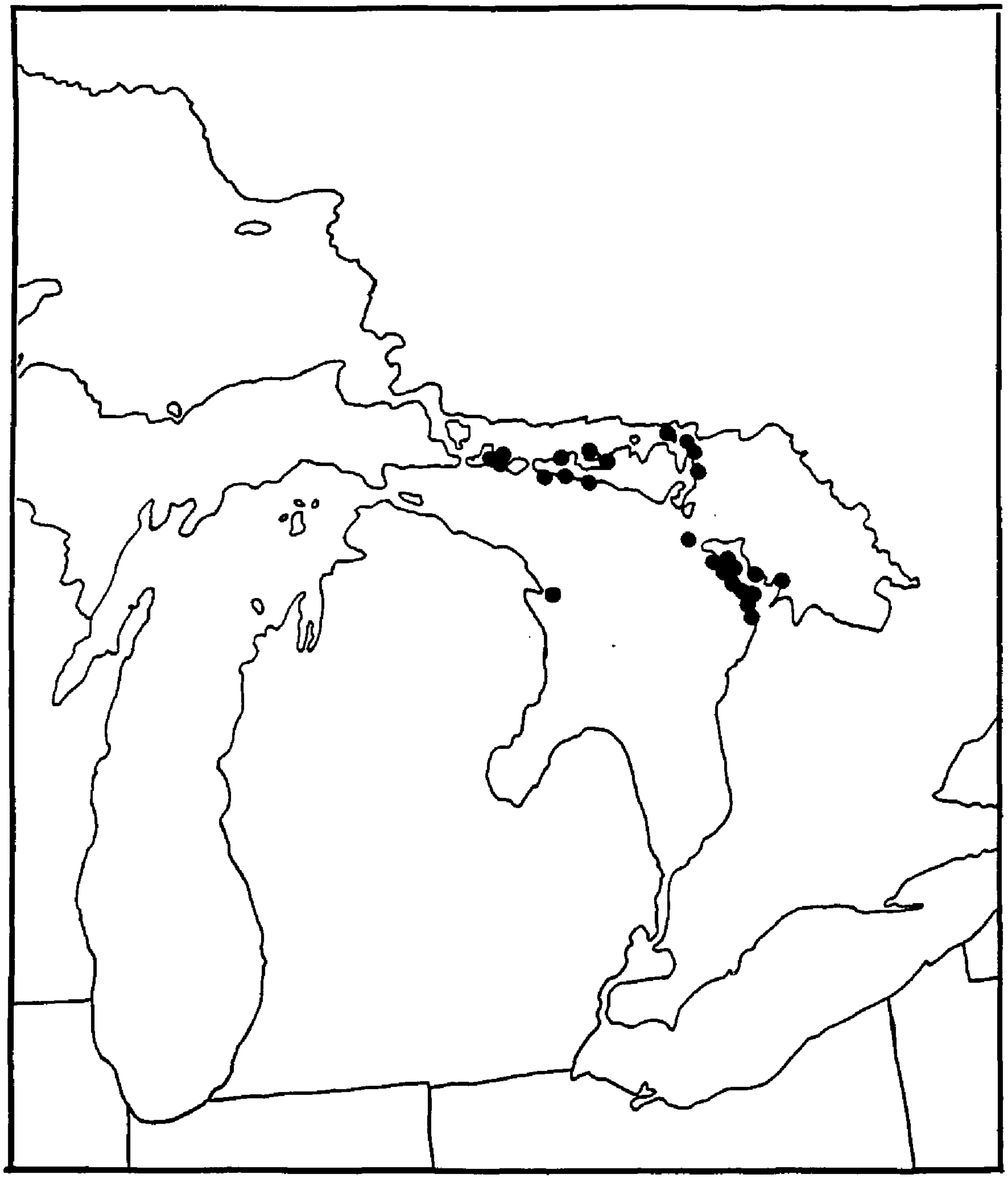

Figure 21. Distribution of Carex scirpoidea ssp. convoluta.

1d. **Carex scirpoidea** Michx. ssp. **stenochlaena** (Holm) Löve and Löve, Taxon 13:202. 1964. C. scirpoidea Michx. var. stenochlaena Holm, Amer. J. Sci. IV 18:20. 1904. C. stenochlaena (Holm) Mackenzie, Bull. Torrey Bot. Club 35:269. 1908. TYPE: Canada, British Columbia, Chilliwack Lake, by a rivulet, 4000 ft., 12 July 1901, Macoun 33728. (LECTOTYPE: CAN! acc. no. 21326, designated herein, ISOLECTOTYPES: CAN! MO! MSC! NY! US!).

Cespitose perennials, with short rhizomes with red-brown, lignescent roots. Culms, many per node, arising from shoots of the current year, (lacking any withered persistent leaf bases of the previous year), triangular, scabrous on the angles toward the apex. Pistillate culms 0.6-1 mm wide at the top, 1.4-2.1 mm wide at base, 24-34 cm tall, exceeding the leaves. Staminate culms 0.5-0.8 mm wide at the top, 2.2-3 mm wide at the base, 14-26 cm tall. Leaves of the rhizome and the culm base lacking blades, red-brown to brown-black, glabrous, shiny, coriaceous. Leaves of the flowering shoot 3-5, arising along the stem, attenuate, adaxial surface glabrous, margins scabrous; in pistillate plants 12.5-25 cm long, 1.4-2.1 mm wide; in staminate plants 14-20 cm long, 1.5-2.4 mm wide. Vegetative leaves similar to those of the flowering shoots, 5-6 per shoot; in pistillate plants 10-28 cm long, 1-2.5 mm wide, in staminate plants 19-24 cm long, 1.4-2.5 mm wide. Mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules semicircular, tan to light red-brown, 0.8-1.5 mm in height, 1-2.5 mm wide. Inflorescences unisexual, unispicate, (occasionally with a single, short lateral spike), drooping on lax culms, mostly clavate, loosely-flowered especially at base; pistillate spikes 25-30 mm long, 3.5-6.5 mm wide; staminate spikes (few seen) 18-25 mm long, 4-5 mm wide. Involucral bract single, foliaceous, shorter than the inflorescence, 4-40 mm long, attenuate, scabrous at apex; base inserted on culms 10-33 mm below spike, scale-like, brown, auriculate. Pistillate scales oblong-lanceolate, 2.4-3.5 mm long, 1-1.5 mm wide, equal to or shorter than perigynium, apically subacute to acute, red-brown to black, without hyaline margins; central midrib obscure, only slightly raised, red-brown, but lighter in color than rest of scale, extending to the apex; margins ciliate. Staminate scales, similar to pistillate, (3.5)4.5-5(6) mm long, (0.7)1-1.4 mm wide. Perigynia lanceolate to oblanceolate, (2.8)3-4(5) mm long, 0.9-1.4(1.6) mm wide, as wide as subtending scale, tapering gradually to beak, with short basal stipe, nerveless or with few short obscure basal nerves, red-brown to black, rarely tan, hirsute with tan-yellow-brown hairs, loosely enveloping the achene in upper 1/3; beak 0.3-0.5 mm long, dark brown, reflexed at maturity, orifice entire and abaxially oblique. Achenes light brown, trigonous, 1.2-2 mm long, 0.8-1 mm wide, with 0.25-0.50 mm stipe, filling 1/2 to 2/3 the length of the perigynium. Stigmata 3. Rachilla absent. Anthers 3-3.5 mm long. Chromosome number n=31.

Distribution and ecology:

This taxon occurs in the Cascade Mountains of Washington, the Bitterroot Mountains of Montana and the coastal ranges of southern British Columbia, and at a few localities in Alaska and the Yukon (Fig. 22). In Montana it grows on bedrock terraces between 1615-2620 meters (5300-8600 feet) elevation and especially at 2133-2438 meters (7,000-8000 feet) in the Bitterroot Mountains of Ravalli County. In Washington it grows between 610-2440 meters (2,000 to 8,000 feet) elevation mostly at 1460-2010 meters (4800-6600 feet).

This taxon seems to be associated with weakly acidic soils, which have high levels of magnesium and low levels calcium. These appear to be significant ecological differences and perhaps an important isolating factor for this subspecies. More detailed studies of habitat requirements and microenvironments are required before one can speculate on the history of this taxon and how it relates to the other subspecies.

Representative specimens:

Representative specimens are listed in the Appendix.

Comments:

Subspecies stenochlaena is distinguished by lanceolate perigynia which are greater than 3 mm long, tapering gradually to a beak and are over 2.5 times as long as wide.

The pistillate spikes are clavate, loosely flowered at the base and borne on slender, lax culms causing the spikes to droop. The pistillate scales are over 3 mm long subtending hirsute perigynia with tan, yellow or golden brown hairs. Both perigynia and pistillate scales are dark brown to black. Beaks are dark and reflexed on maturity with an oblique mouth.

A lectotype has been designated from Macoun's specimens, since a holotype was not chosen by Holm. The lectotype (CAN acc. no. 21326) is a Macoun specimens bearing a "Geologic Survey of Canada" label, as opposed to others which bear "Ex. Herb. Geologic Survey of Canada" labels. The latter are isolectotypes bearing the same number as the lectotype, but having a slightly different wording of the locality data.

Some geographically based variation was observed within this taxon. Specimens from the Bitterroot Range in Ravalli County, Montana have the longest perigynia, often reaching 4.3 mm, and are most distinct from ssp. _scirpoidea_. On the other hand, specimens from Washington, northern British Columbia and the Banff/Jasper areas exhibit tendencies towards ssp. _scirpoidea_. Fifteen percent of these specimens have perigynia just under 3 mm long (high end of ssp. _scirpoidea_ range) and length to width ratios over 2.5 (unlike those of ssp. _scirpoidea_ which are less than 2.5 times as long as wide) and lack the clavate, loosely flowered spikes characteristic of plants of ssp.

stenochlaena in northern Washington and Ravalli County, Montana. The intergradation observed in plants from British Columbia might be the result of hybridization between ssp. *stenochlaena* and ssp. *scirpoidea* at localities where their ranges overlap. Subspecies *stenochlaena* is recognized at the subspecific level, rather than the specific level due to the tendency to intergrade with ssp. *scirpoidea* in parts of its range.

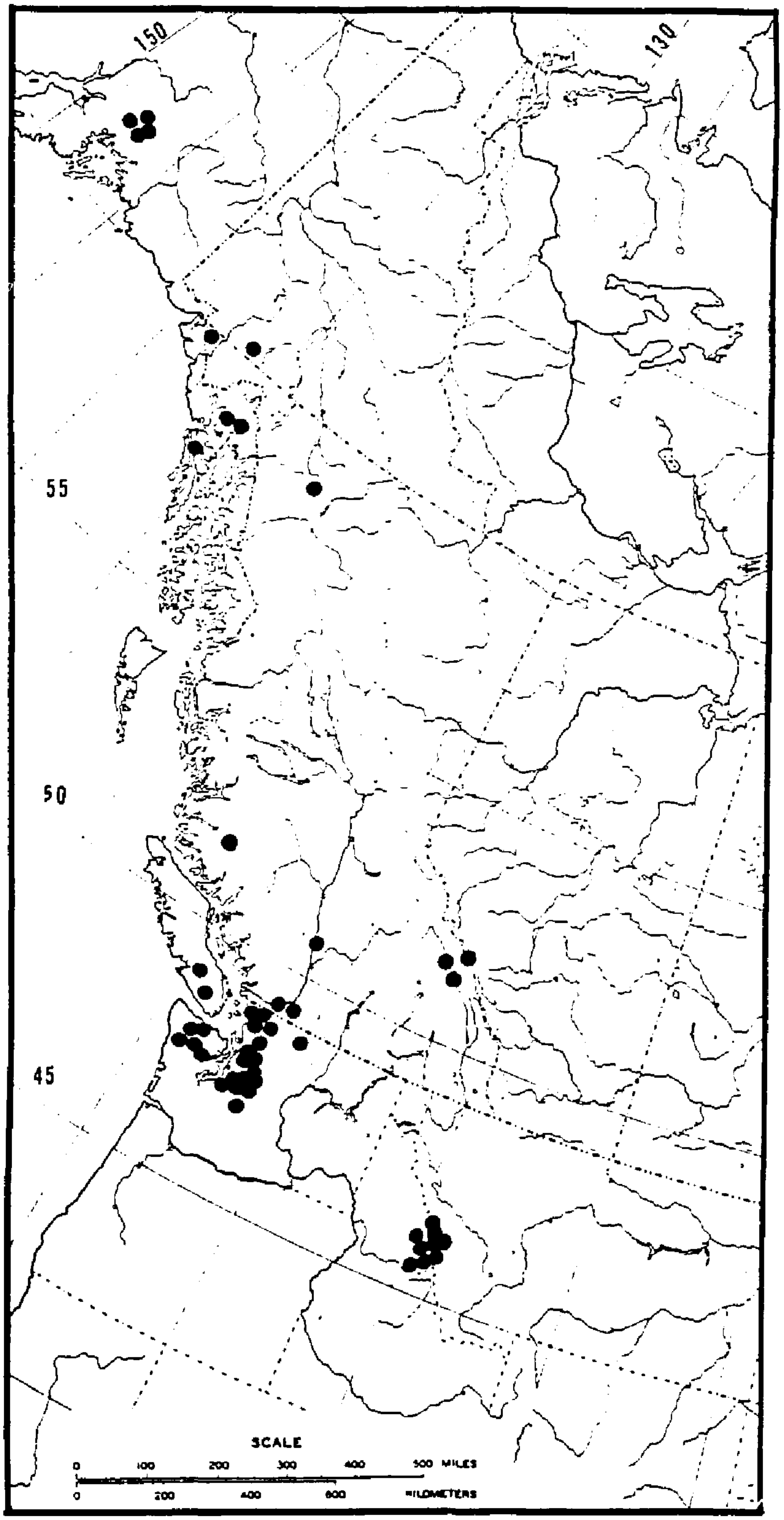

Figure 22. Distribution of Carex scirpoidea ssp. stenochlaena.

2. *Carex curatorum* Stacey, Leafl. W. Bot. 2:13. 1937. *C. scirpoidea* var. *curatorum* (Stacey) Cronquist Intermountain Flora 6:113. 1977. TYPE: Arizona, Grand Canyon National Park, Kaibab Trail to Roaring Springs, June 23, 1933, *Eastwood & Howell 1100*. (LECTOTYPE: CAS! acc. no. 204972, designated herein).

Cespitose perennials, with short rhizomes, forming mats, with red-brown lignescent roots. Culms one to several per node, arising from current year shoots, triangular, strongly scabrous the full length of culm, exceeding the length of the leaves. Pistillate culms 0.4-1.2 mm wide at the top, 0.7-3.5 mm at the base, (23)35-91 cm tall. Staminate culms 0.5-1 mm wide at the top, 0.9-4.5 mm wide at the base, 20-74 cm tall. Leaves of the rhizome and culm bases reduced, lacking blades, light brown to purple-black, glabrous, often with hyaline margins, loosely sheathing the culm base. Leaves of the flowering shoots 2-6, arising from the base and along the shoot axis, attenuate, adaxial surface sparsely pilose especially along median adaxial groove and veins, margins strongly scabrous; in pistillate plants 12-57 cm long, 1.5-2.3 mm wide; in staminate plants 12-25 cm long and 1.2-3.1 mm wide. Vegetative leaves similar to those of the flowering shoots, 4-11 per shoot; in pistillate plants 14-55(79) cm long, 1.1-2.3 mm wide; in staminate plants 18-55 cm long, 1.2-1.9 mm wide. Mouth of the leaf sheaths concave, entire to erose; sheath front membranous, scabrous, white to tan; dorsal surfaces coriaceous, glabrous, pale green to red-brown; ligules triangular, tan to light red-brown, ciliate, 1.4-4.2(5) mm in height, 1.1-2.3 mm wide. Inflorescences unisexual generally, but not strictly unispicate, (occasionally with 1-2 short lateral spikes of the same sex in the axil of the involucral bract or subtending the terminal spike), erect or drooping on lax culms, linear, loosely to densely-flowered; pistillate spikes 17-43 mm long, 2.5-5 mm wide, staminate spikes 13-37 cm long, 2-5 mm wide. Involucral bract rarely absent, usually single foliaceous or scale-like, shorter than or equal to length of the inflorescence, 6-11 cm long, 0.5-1.5 mm wide, attenuate; base inserted 5-75 mm below spike, auriculate. Pistillate scales oblong-lanceolate, 2-3.5 mm long, 0.7-1.9 mm wide, half as long as to equaling the perigynia, apically acute, red-brown with narrow to broad hyaline margins; central midrib extending to apex, occasionally prolonged into a short awn; margins entire, sometimes ciliate. Staminate scales similar to pistillate, 3.5-4.3 mm long, 1-1.3 mm wide. Perigynia obovate to ovate, 2-3(4) mm long, 1.5-1.8 mm wide, wider than subtending scale, tapering gradually or abruptly contracted to a beak, with few obscure nerves on the adaxial surface over the achene, marginal nerves evident, pale green to tawny becoming red-brown towards apex, hirsute with white hairs; body not tightly enveloping the achene; beak 0.1-0.5 mm long, hyaline, orifice entire and adaxially oblique, red-brown and hyaline at tip. Achene dark brown, trigonous, 1.2-2 mm long, 0.8-1.2 mm wide, stipe 0.25 mm, filling only 1/3-

1/2 the length of the perigynia and 1/3 the width such that the perigynia sides are compressed and contracted at the base. Stigmata 3. Rachilla often present. Anthers 1.7-2.4 mm long. Chromosome number n=31.

Distribution and ecology:

Carex curatorum is limited to southern Utah and adjacent northern Arizona, with populations occurring in riparian or hanging garden communities along the Colorado and San Juan Rivers and a few tributaries (Fig. 23). This taxon may have been represented by more populations before the damming and flooding of the Colorado River. It occurs on Navajo sandstone, described as a crossbed of fine grained sandstone and gray limestone (Lohman, 1975), and on the Kayenta formation, both of which are widespread substrata in Utah.

Representative specimens:

Representative specimens are listed in the Appendix.

Comments:

Carex curatorum is a distinct southwestern endemic. It is distinguished by sparsely pilose adaxial leaf surfaces, most obvious with the scanning electron microscope but visible with a dissection microscope. Achenes are not tightly enveloped by the perigynia and the pistillate scales are mostly shorter than the perigynia. The scale and perigynia are characteristically lighter in color than other taxa of the section Scirpinae.

Plants flower from April to May. Upon maturity the achenes and perigynia disarticulate from the spikes, and are readily dispersed, unlike the taxa of C. scirpoidea which retain achenes and perigynia sometimes until the next growing season. Generally, maximum culm height is greater than other taxa of C. scirpoidea and the achene fills only a small portion of the perigynium. Its unique achene micromorphology and sparsely pilose adaxial leaf surfaces segregate it from all other taxa.

In naming this species Stacey (1937) selected the epithet "curatorum" to honor Alice Eastwood and J. T. Howell, curators at the California Academy of Sciences, and the collectors of the type specimens.

The Code (Article 7.3, Grueter et al., 1988) states that the holotype must consist of only one specimen. If more than one specimen has been designated to serve as type specimen by an author, then a lectotype must be selected from among them. Since Stacey (1937) designated both a staminate and pistillate plant to serve as the types, I have selected the pistillate specimen (CAS acc. no. 204973, Eastwood & Howell 1100), to serve as the lectotype, since it possesses the diagnostic features of this taxon. The staminate plant specimen (Eastwood & Howell 1101, CAS acc. no. 204973) and two other specimens (Eastwood & Howell 1045, 1089) collected along with the type, remain as important original material from the type locality. Duplicates of the latter two collections had been distributed bearing labels the determination *C. pseudoscirpoidea* Rydberg (Stacey 1937).

This taxon is represented by only sixteen known populations. In Arizona, plants were first collected in the Grand Canyon in 1933 by Alice Eastwood and Thomas Howell. In 1941, plants were collected by Cottam from the Grand Canyon at Saddle Horse Springs and again in 1949 and 1952, but this population could not be relocated when searched for in 1985. Four other sites have been documented along the Colorado River from the early 1970's. The first record for Utah was made in 1972. Nine additional sites have been discovered, mainly by Dr. Standley Welsh and colleagues.

A distribution along water courses suggests that *C. curatorum* may be adapted largely to dispersal by water. The achenes do not fill the perigynia completely, such that this broad disseminule, although not inflated, may function as a flotation device.

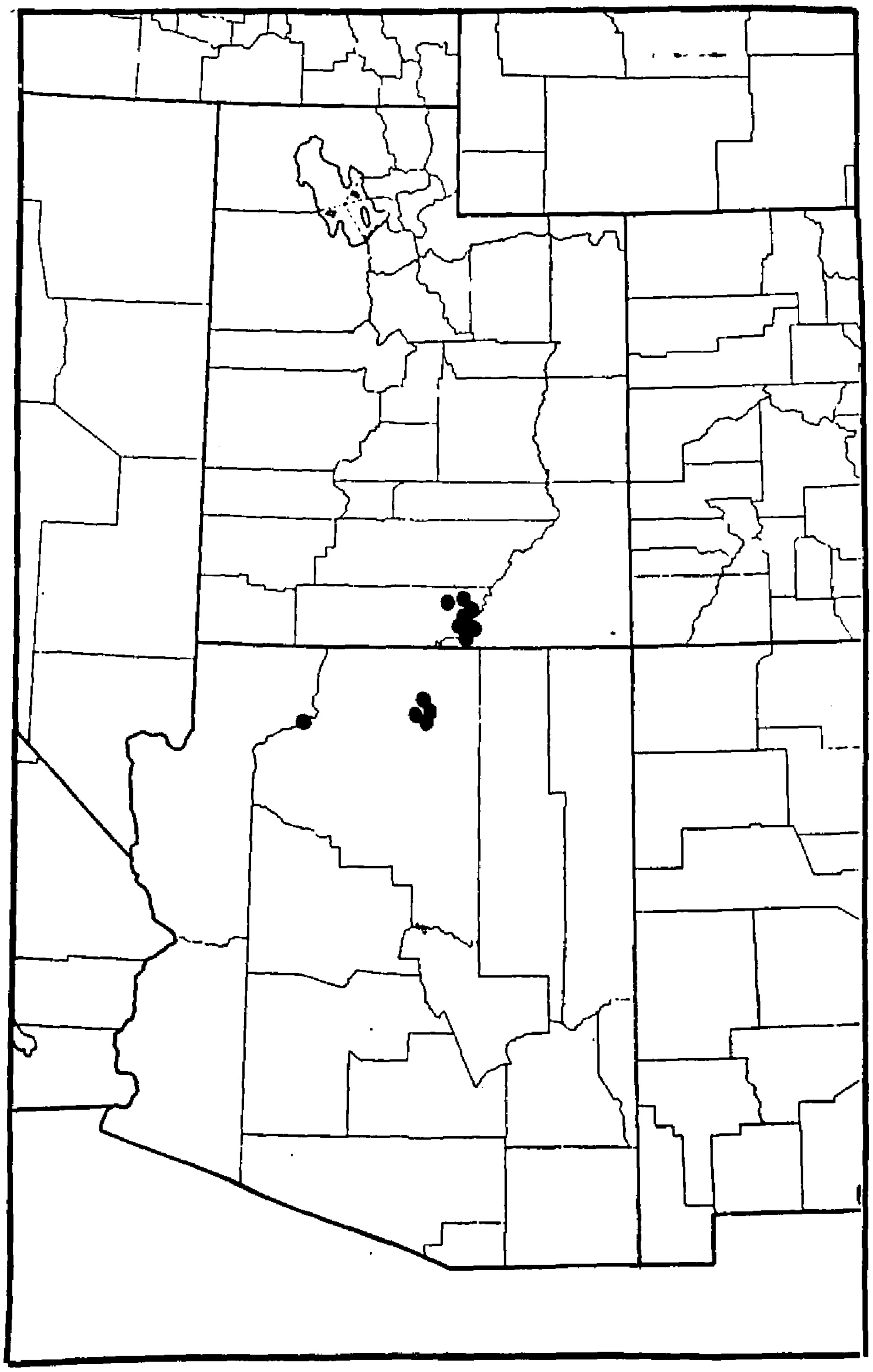

Figure 23. Distribution of Carex curatorum.

IX. EXCLUDED TAXA

Carex gigas (Holm) Mackenzie, Bull. Torrey Bot. Club 35:268. 1908. *Carex scirpoidea* var. *gigas* Holm, Amer. J. Sci. IV 18:20. 1904. TYPE: California, Siskiyou County, Mt. Eddy. (not known).

Carex scabriuscula Mackenzie, Bull. Torrey Bot. Club 35:268. 1908. Type: Wet meadow in the Cascade Mountains. 30 June 1902, *Cusick #2849*. (HOLOTYPE: NY! ISOTYPES: CU! DS! ORE! OSC! POM! UC! WS!).

The taxonomic status of *Carex gigas* and of *Carex scabriuscula* remains problematic. Descriptions of both taxa have been based on only a few specimens collected from the type localities. Futhermore, the type locality for *C. scabriuscula* is not known and therefore could not be revisited. Initially, staminate material of the latter was not described and relatively few specimens have been collected since the early 1900's. Of the existing specimens, there is a greater amount of morphological variation exhibited within these taxa than within those of the entire section *Scirpinae*.

Although the taxonomic status of these two taxa is still questionable, based on information gathered in this study they should not be included in the section *Scirpinae*. They have been excluded from the section *Scirpinae* because they are rarely unispicate, are often not dioecious, and do not possess the characteristic pubescence of the perigynia in the section. Exclusion is further supported by evidence from chromosome numbers, leaf surface features and their ecology.

Carex gigas

In 1904, Holm described Carex gigas as a variety of Carex scirpoidea. He did not designate a holotype nor did he cite a particular specimen. He merely indicated that the taxon occurred on Mt. Eddy, Siskiyou County, California. In 1908, when Mackenzie raised the taxon to the specific level he referred to Cyrus Pringle's specimen from 8,000 feet, Siskiyou County, California, 18 August 1881, but did not lectotypify this taxon.

I have not chosen a lectotype since it is unclear as to what specimens Holm may have had in his possession when he described C. gigas. I have located five of Pringle's specimens from Siskiyou County, all dated 19 August 1881, but some bear different localities. Although one specimen is from Mt. Eddy, it is not known whether this is the specimen refered to by Holm.

Holm felt this taxon was distinct from Carex scirpoidea as it was a robust plant, with mostly two densely-flowered spikes. The perigynia were broader than C. scirpoidea, were many nerved and described as loosely pubescent. The beak was described as bidentate.

Of the twenty flowering culms on these five specimens of Pringle's, all are pistillate, mostly unispicate and possess mature achenes in fully developed perigynia.

A survey of culms from specimens from Siskiyou, Trinity and Del Norte Counties, California, that fit the concept of *C. gigas*, showed that there was a tremendous amount of variation. Of the 159 culms examined, only 39% were unispicate. The remaining 61% possessed 2-3 spikes per culm. The lateral spikes were short, peduncled and sheathed at the base by an involucral bract that was greater in height than the inflorescence. This contrasts to the occasional occurrence of a sessile lateral spikes in plants of *Carex scirpoidea* in which case the involucral bract is rarely greater in height than the inflorescence. One population, Scott Mountain, Siskiyou County, California, presumably near the type locality, possessed 63% unispicate culms.

The amount of gender variation in this taxon is problematic. Often these spikes were not entirely unisexual. Some pistillate spikes possessed a few staminate flowers intermingled with pistillate flowers, while others were androgynous. There was much variation in the arrangement of female and male flowers.

Several dioecious specimens from Plumas County, California specimens, often identified as *C. gigas* (Munz, 1970), are probably misidentified but if included in *C. gigas* add further to the variation in the perigynia morphology. Perigynia from this location are distinctly nerved and bidentate.

The taxomonic status of *Carex gigas* is further problematic in that only 10% of the specimens possess fully developed achenes. Perigynia lacking mature achenes are obovate, tawny to light brown, slightly pubescent, flattened and subtended by light colored scales. In contrast, plants with mature achenes possess perigynia that are purple-black, almost glabrous, lanceolate, round in cross-section, conspicuously clustered in one area of the spike and subtended by dark purple scales.

In contrast to the published descriptions (Holm, Munz, and Mackenzie) my study of the type material reveal that beaks of the perigynia are entire and the beak orifice may be elongated abaxially, but is not bidentate. Additionally the perigynia are scarcely pubescent, rather they are almost scabrous with only a few short stubby hairs on the upper 1/3 of the perigynia.

Herbarium specimens with staminate material is very limited for this taxon.

Carex scabriuscula

Mackenzie (1908) described this species from specimens collected by William Cusick, #2849, 20 June 1902, which were initially distributed as *Carex feta*. Mackenzie designated a specimen at the New York Boatnical Garden (NY) as the type. I have located seven additional specimens bearing *Cusick 2849*. It is quite probable that many more specimens are in existence since Cusick was known to collect in large numbers and that those particular specimens may be filed in herbaria under the name *Carex feta*.

Unfortunately, a specific locality was not stated on Cusick's specimens. The labels merely read "a wet meadow, Cascades". Based on biographical information (St. John, 1923) and information from Cusick's field notebook deposited at the University of Oregon (ORE) (D. Wagner, 1989, pers. comm.), the type locality is thought to be near present day state highway Route 66 close to the border of Jackson and Josephine Counties, Oregon. In Cusick's notebooks, the page bearing the entry for the collection #2849 is missing. However, the subsequent entries place Cusick "near the summit of the Cascade Mountains, near, but just west of the crest, along the Klamath Falls-Ashland Road" (now state highway Route 66)" (information and interpretation from Cusick's notebook provided by Wagner, OS).

An additional specimen was found at the Gray Herbarium that I believe to be an isotype. This specimen, (Cusick, #2949, from the summit of the Dead Indian), was initially identified as Carex luzulina, but annotated later by Stacey to C. scabriuscula. This specimen is clearly similar to those regarded as the isotypes, and I believe it to be another duplicate, one that had been mislabeled and differing numerically by only the second digit.

There are very few specimens of this taxon. In addition to the Cusick specimens, there are only seven known sites for C. scabriuscula from Curry and Josephine Counties, Oregon. The exact locations are not known since specimens bear contradictory label data. Three specimens collected by

Peck (Peck 8140), collected in 1918 near Waldo, Oregon bear different localities and two different dates. Labels of duplicate specimens collected by R. Van Deventer from Pine Flat cite both Oregon and California. The California Academy of Science (CAS) specimens of R. Van Deventer cite Del Norte County, California, while those from Humboldt State University (HSC) cite Josephine County, Oregon. There is a Pine Flat in each county. Two known sites occur near Snow Camp Mountain, Oregon (Denton, 3106, 1972 and Dunlop and Orlando 2234, 1985). Reconnaissance work by Veva Stanstell and others in the summer of 1989, turned up two additional sites in this same area.

Little is know about this taxon's habitat. Most specimens are from dry slopes in serpentine areas. A survey of the specimens from Josephine and Curry Counties, Oregon, show that of the 54 culms, 57% of them were multispicate. This percentage is similar to that of the eight type specimens.

Phenetic relationship between C. gigas and C. scabriuscula.

The differences between C. gigas and C. scabriuscula are minor. Vegetatively they are indistinguishable. Characters that seem to separate them involve the shape, color and size of the perigynia. However, there is much variation in these characters. Additionally, the number of specimens bearing mature achenes is small, compared to the number of specimens with immature fruits. The authors of these taxa did not address this problem when they described them as new species since the types are unique in having a high proportion of mature achenes.

Mature perigynia of *C. scabriuscula* are lanceolate, taper to a beak, purple-black, almost glabrous and the achenes fill the lower one half of the perigynia. In contrast, the perigynia of *C. gigas* are obovoid, contract abruptly to a beak, tawny, almost glabrous and the achene fills only 1/3 of the perigynia.

Statistical data for the dimensions of 40 perigynia of both *C. gigas* and *C. scabriuscula* are shown in Figure 25. Dimensions from five populations of *C. scabriuscula* show greater variation than those from eight populations of *C. gigas*. The length of perigynia of *C. scabriuscula* show a bimodal distribution with higher frequencies at 3.0 and 3.6 mm. Both sizes can be found within all populations. I found that my measurements did not correspond to those in the published descriptions.

Table 25. Comparison of perigynia length and width of *C. gigas* (40 individuals from 8 populations) and *C. scabriuscula* (40 individuals from 5 populations).

		length		
	min	mean	max	sd
C. gigas	2.4	3.0	2.8	0.30
C. scabriuscula	2.0	3.7	3.9	0.41

		width		
	min	mean	max	sd
C. gigas	1.4	1.7	2.1	0.18
C. scabriuscula	0.9	1.5	2.3	0.25

Relationship of the excluded taxa to the section Scirpinae.

Phenetically *C. gigas* and *C. scabriuscula* are very dissimilar to taxa in the section *Scirpinae*. These taxa are excluded because they are not generally dioecious, not unispicate, and lack hirsute perigynia, possess a chromosome number of *n*=29 and differ significantly in habit.

From a phylogenetic viewpoint, many characters listed for *C. gigas* and *C. scabriuscula* could be considered pleisomorphic. A dioecious breeding system, is considered apomorphic and derived from monoecious ancestors. Unispicate sedges are thought to be derived from multispicate ancestors. Lower chromosomes are viewed as more primitive that higher ones. The enervate condition is probably apomorphic since the perigynium is thought to have been derived from a sterile bract with veins. These two taxa possess characteristics that one might expect in an ancestral group from which taxa in the section *Scirpinae* could have evolved. Are *Carex gigas* and *C. scabriuscula* progenitors from which the *C. scirpoidea* complex arose or do they share a common ancestor?

I do not think *C. gigas* and *C. scabriuscula* are related to the progenitors of this section nor even closely related to the section *Scirpinae*. Based on the low numbers of specimens, lack of staminate specimens, the low incidence of mature achenes, the extreme amount of variation, their distribution and ecology, they appear to be aberrant specimens of some otherwise monoecious taxon or possibly some hybrid. A survey of the sedge flora of northern California and Oregon, using existing floras and examing specimens at the Gray Herbarium, Harvard University, has yielded few clues. Additional field work is required to fully understand the status and affinities of these two taxa.

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APPENDIX

REPRESENTATIVE SPECIMENS FOR *CAREX SCIRPOIDEA* SSP. *SCIRPOIDEA*

CANADA: ALBERTA: Athabaska River, 23 July 1917, Macoun s.n. (UC); Athabaska River, 26 July 1917, Macoun 97970 (UC, US), 97969 (CAN), 30 July 1917, Macoun 97971 (CAN, US), along Athabaska River, 11 July 1918, Macoun 98078 (CAN, US); Athabaska River Valley, T48 R28, 53°10'N, 117°58'W, 25 August 1974, Skoglund 982 (SASK). Athabaska River, near discharge Beauvert Lake, 23 June 1917, Macoun & Franklini 97968 (US); Brazeau National Forest, Whitehorse Creek, 26-28 August 1957, Porsild 20824 (CAN); Bow River near Pilot Mt., 19 & 26 June 1945, Porsild & Breitung 12304 (CAN): Bow River, Canmore, 7 August 1956, Hermann 13167 (ALTA, CAN, MICH); Bow River, Lake Louise Station, 6 July 1956, Hermann 12700 (CAN); Bow River, near Eisenhower, 4 June 1968, Mosquin & Seaborn 7016 (DAO); Bow River, near Vermillion Lakes w. Banff, 17 August 1945, Porsild & Breitung 14327 (CAN); Bow River, s. Alberta Bow River Bridge, 50°53'N, 113°59'W, 27 May 1976, Johnson 1383 (CAN); 10 miles s. Cadomin, 13 August 1968, Dumas & Anderson 4252b. (ALTA); Cadomin, T45 R23 S16, 21 August 1967, Pegg 2730 (DAO); Cameron Lake trail, 16 June 1935, Moss 3112 (ALTA); Cameron Creek, 7 September 1939, Moss 634 (DAO); Cardinal Divide, s. of Mountain Park, 7 July 1970, Dumais & Haber 5138a (CAN); Cline River, on David Thompson Hwy, 27 mi. e. Jasper-Banff Park Boundary, 3 July 1968, Dumais & Anderson 2930 (CAN); Chair Mt. summit, nw. Banff, 11 August 1956, Hermann 13263 (MICH); Clearwater Forest Preserve, Coliseum Mt., 12 August 1945, Cormack 613 (DAO); Craigmyle, 2 July 1923, Brinkman 639 (DAO); Coleman, The Gap, 3 August 1957, Russel 559367 (USAS); Crystal Lake, 31 July 1953, Breitung 17007 (NA); Dome Mt., 31 August 1960, Stelfox s.n. (BRY); Elbow Flats near Elbow River, 50°54'N, 114°41'W, 10 August 1979, Lee s.n. (ALTA); Exshaw Creek Canyon, 1.5 km. nne. of Exshaw, 1 June 1979, Crins 1596 (CAN, TRTE); Hinton, s. Hwy 16, 1 km. Valley District exit, 15 August 1983, Crins 5945 (TRTE); 2 miles e. station, 14 July 1969, Parmelee 4301a (DAO); 6 mi. s. station, 2 July 1956, Porsild & Porsild 19270 (CAN); Hycluck Creek, near Ball Int. Banff Park, 3 August 1967, Fodor 573 (UBC); Kananaskis Lakes, along Trans-Canada Highway, upper Marmot Creek Basin, 1 July 1963, Mosquin & Benn 5206 (DAO, SASK); Kananaskis Road, 10 miles n. Highwood Pass, Coleman, 26 July 1976, Kershaw 39 (WAT); Highwood Summit, on Kananaskis Road, 30 August 1964, Calder 37268 (DAO); Laggan, 11 July 1904, Macoun 64.054 (CAN), Laggan, 29 July 1904, Macoun 64053 (GH, US), 64053 (US), Laggan, 23 August 1902, Rosendahl 1058 (MIN, RM); Laggan, Lakes of the Clouds, 30 June 1903, Barber 127 (GH); Morley District, near Morley, 9 September 1929, Brinkman 4653 (NY, PAC); 10 miles s. Nordegg, crossing of North Saskatchewan River, Smith 585 (MICH); Nordegg, 16 August 1945, Cormack 732 (DAO); Nordegg, 25 July 1925, Malte & Watson 1521 (GH), 1531 (CAN), 1532 (CAN); Pincher Creek, 20 May 1941, Moss. 1220 (NA); Plateau Mt., e. Wilkinson summit, Kananaskis Road, 50°13'N, 114°32'W, 30 August 1964, Calder 37292 (DAO); Peyto Lake, 66 miles n. Banff, 12 July 1941, Weber 2427 (CAN, COLO, GH, WS, UBC); Quartz Ridge, 51°02'42"N, 115°46'10"W, 21 August 1972, Hudson & Scotter 2789 (SASK); Rampart Creek Campground, 7 mi. n. junction David Thompson Hwy, and Jasper Hwy., 12 June 1968, Dumais & Anderson 2209 (CAN); Saskatchewan Crossing, 30 July 1946, Boivin 5159 (DAO); 29 July 1946, Boivin 5071 (DAO); Sheep Mt., 49°05'W, 28-31 July 1895, Macoun 10770 (GH); Simpson Pass, 26 July 1916, Lewis s.n. (ALTA); Twin Tree Shelter, 23 July 1939, Knowlton s.n. (GH); Willow Valley Schoolhouse, ca. 17 miles ne. Burmis, 15 July 1956, Hermann 12809 (ALTA, MICH, US); Windy Point, 30 miles w. Nordberg on the David Thompson Hwy., 52°15'N, 116°23'W, 16 June 1974, Dumais 6810 (WAT); Wood Buffalo Peak, Kolenosky s.n. (WIS); Yellow Head Pass, 6 July 1898, Spreadborough 20882 (CAN) 20883 (F); White Mud Creek, near Edmonton, 25 May 1940, Turner 1687 (SASK); Wiseton, 27 May 1978, Hudson 3513 (SASK). Waterton Lakes National Park, 7 September 1939, Moss 534 (NA), 14 July 1953, Breitung 16020 (NA); WLNP, e. of Buffalo Paddock, 49°N, 113°50'W, Kuijt, Gadd, Nagy 3098 (ALTA); WLNP, Camp Columbus, 49°04'N, 113°53'W, 16 June 1969, Nagy & Blais 1071 (CAN, UBC); WLNP, Cameron Creek, 7 September 1939, Surry & Hermann 634 (ALTA); WLNP, Chief Mt., 23 July 1953, Breitung 16632 (NY), 14 July 1953, Breitung 16020 (UC); WLNP, Crypt Lake, 31 July 1953, Breitung 17007 (F); Waterton Lake, 1 August 1895, Macoun 10770 (CAN); : Banff, 8 August 1926, Knowlton s.n. (GH), no date, Farr s.n. (PH), 26 June 1903, Barber 284 (CAN), August 1902, Holm s.n. (WS), 21 August 1972, Hudson & Scotter 2789 (SASK), 12 July 1941, Weber 2427 (UC), 5 August 1915, Malte s.n. (CAN); Banff National Park, marsh below C.P.R.R. hotel, 1 August 1902, Sanson s.n. (BH); Banff National Park, 10 August 1898, Fletcher 2047 (DAO), 30 August 1891, Macoun s.n. (NY), 30 August 1891, Macoun 14063 (CAN), 22 August 1918, Johnson 1191 (US), 20 July 1916, Hunnewell 4393 (MIN), 18 July 1941, Eastham 9645 (DS); Banff National Park, Banff-Jasper Highway, 17 July 1940, Fraser s.n. (SASK); Banff-Jasper Park Boundary on David Thompson Hwy., 2 July 1968, Dumais & Anderson 2867 (CAN); Bow Peak, 22 July 1941, Hitchcock & Martin 7728 (CAS, DAO, WTU), 7734 (DS); Banff National Park, Brule, July 1938, Knowlton s.n. (GH); Banff National Park, Cove Basin, 7 September 1943, McCalla 7963 (UBC); Banff National Park, road to Cave and Basin, 2 July 1925, Malte & Watson, 780 (UC, RM); Banff National Park, Hector Lake, 8 September 1975, Dyck 5084 (DAO); Banff National Park, Hot Springs, 5 August 1902, collector not known, (BH); Banff National Park, Eagle Mt., 51°05'50"N, 115°455'40"W, 18 August 1969, Scotter 12091 (SASK); Banff National Park, 2 miles nw. Kootenay Park Rd. & Banff-Lake Lousie Rd. junction, 21 August 1953, Calder & Savile 12193 (DAO); Banff National Park, Lake Agnes, 11 July 1925, Malte & Watson 1140 (CAN); Lake Louise Station, 6 July 1956, Hermann 12700 (MICH); Banff National Park, Lake Louise, 17 July 1906, Brown 552 (DAO, NY), 20 July 1946, Breitung, Porsild & Boivin 3359 (DAO), 12 August 1927, Malte 107689 (CAN), 20 July 1946, Porsild & Breitung 15735 (CAN); Banff National Park, Lake Louise Region, Wenkchemna Trail, near Eiffel Lake, September 1952, Leschke s.n. (CAS); Banff National Park, Middle Spring, 28 July 1899, McCalla 2348 (CU, NY, WTU); 17 July 1928, Brinkman 3654 (NY); Banff National Park, Moraine Lake, 16 August 1941, Rose 41398 (CAS), 5 August 1949, Ewan 18675 (DAO), 23 August 1946, Moss 7266 (CAN); Banff National Park, Mt. Borugeau, 1 August 1969, Scotter 11989 (SASK); Banff National Park, Mt. Brewster, near lodge, 14 July 1946, Breitung 2977 (DAO); Banff National Park, Mt. Louis, July 1916, Lewis 91713 (CAN); Mt. Rundle, near Banff, 2 August 1952, Jenkins 1501 (DAO); Banff National Park, Mt. Norquay, 11 August 1956, Hermann 13263 (CAN, US), 22 August 1953, Calder & Savile 12235 (DAO); Muleshoe Lake, 3 July 1949, Mair 118 (UBC); Parker Ridge, 20 August 1968, Scotter 10035 (DAO); Pearson Point, 2 July 1946, Fredeen 131 (DAO); N. Saskatachewan River, between Mt. Athabaska and Saskatchewan Glacier, near mile 114, 22 August 1945, Porsild & Breitung 14542 (CAN); N. Saskatchewan River, 23-28 August 1945, Porsild & Breitung 14785, 14786 (CAN); N. Saskatchewan River, valley of Mistaya River, between Saskatchewan Crossing and Waterfowl Lakes, 23-28 August 1945, Porsild & Breitung 14675 (CAN); N. Saskatchewan River, 30 July 1946, Porsild &

Breitung 16082 (CAN); Sawback Range, above Hillsdale, 27 June 1951, Porsild 17973 (CAN); Sulphur Mt., 31 July 1940, Ledingham s.n. (PAC, USAS, WIS), Ledingham 1435 (DAO), 11 August 1952, Jenkins 1574 (DAO); Sulphur Spring, w. of Banff, Turner 3950 (DAO, GH, UBC); Sulphur Mt. 24 July 1952, Jenkins 1435 (DAO); Sunshine Ski Lodge, s. Healy Creek, 13-22 July 1946, Porsild & Breitung 15881 (CAN); 26-29 July 1945, Porsild & Breitung 13464 (CAN); Sunshine Chalet, 51°04'28"N, 115°47'22"W, 22 August 1972, Hudson & Scotter 2809 (SASK); Sunshine Region, 28 July 1970, Scotter 13916 (SASK), 13 August 1968, Scotter 9816 (DAO), 5 August 1971, Scotter 17224 (DAO); Sundance Canyon, 30 July 1940, Ledingham s.n. (PAC, USAS); Sundance pass near Sulfur Mt., 10 August 1954, Ledingham 1954 (USAS); Sundance bog, 30 July 1940, Ledingham s.n. (USAS); Tunnel Mt. Trail, 18 July 1941, Eastham s.n. (DAO); "Weeping Wall", near Cataract Creek, 13 1/2 m. south park boundry, 29 August 1964, Calder 37251 (UBC, UC); Elbow bridge, 20 July 1944, Turner 4148 (DAO, MT); s. Elbow River, 5 July 1944, Turner 4126 (UBC, ALTA); Elbow Drive bridge, sw. of, 18 July 1944, Turner 4181 (NY, UBC); Great Sand Hill region, 10 June 1978, Townley-Smith 78169 (SASK); Sunnyside, 1 June 1944, McCalla 8137 (GH, UBC); Wireless School, private road, 21 May 1944, McCalla 8137, 8136 (UBE). Calgary, 10th St. and below 13th Ave N.W., 21 May 1944, McCalla 8136 (UBC), 18 July 1945, 8793 (UBC); w. Calgary, ditch, 15 May 1930, McCalla 3728 (ALTA); boggy places, 5 June 1897, Macoun 25559 (CAN); Bow Valley, no date, Moodie s.n. (NY); Calgary, North Hill, June-July 1944, McCalla 8136 & 8137 (MT); Craigmyle District, 27°32', 16°4'W, 2 July 1922, Brinkman 639 (MICH, VT), location not specified, 4 July 1922, Brinkman s.n. (NY), 22 July 1922, Brinkman s.n. (NY), NW 28°32' 16°4'W, 19 June 1924, Brinkman 1281 (CU, PH). Jasper National Park: Angel Glacier, Mt. Edith Cavell, 4 August 1941, Scamman 2428 (GH); Mt. Edith, 2 July 1900, Macoun 22454 (CAN); Mt. Edith Cavell, 27 August 1917, Macoun 98072 (CAN, GH, UC, US); Jasper National Park, swampy ground, 6 July 1939, Moss 4835 (ALTA); Devona, 13 August 1943, Scamman 3133 (GH); Jasper, river flats, 15 June 1939, Moss 4757 (ALTA, MT, UBC, WS), 6 July 1939, Moss 4836 (UBC); Jasper, 8 July 1931, Kujala & Cajander s.n. (CAN); Jasper National Park, Athabaska River, Athabaska Fall, 20 mi. se. Jasper, Hermann 13498 (CAN, MICH); Jasper Lake, 53°06'N, 118°01'W, dunes, 7 August 1976, Sharp A199 (ALTA); Jasper Lake, 15 July 1960, Porsild 22539 (CAN); Jasper, 30 July 1917, Malte 107671 (CAN); Athabaska Fall, 17 mi. sse. Jasper, 29 August 1964, Calder 37218 (DAO); Athabaska Glacier, Columbia Ice Field, 21-22 August 1941, Scamman 2733 (GH); Athabaska River, ca. 3 miles n. Jasper, 5 July 1955, Jenkins 5902 (DAO); Athabaska River, Beauvert Lake, 23 July 1917, Macoun 97968 (CAN); along Athabaska River, 26 July 1917, Macoun 97970 (CAN, US), 11 July 1918, Macoun 98078 (CAN), 30 July 1917, Macoun 97971 (CAN), 26 July 1917, Macoun 97969 (CAN); low ground, e. Jasper, 29 August 1957, Moss 10932 (DAO); Jasper, Athabaska Mtn., 10 July 1939, Moss 4933 (ALTA, MT, US); 1 mile n. Coleman Glacier, 53°14'N, 119°03'W, 18 August 1956, Jenkins 7179 (DAO); Columbia Ice fields, 17 July 1940, Fraser s.n. (NA); Snake Indian River, 29-31 August 1957, Porsild 20878 (CAN); Shovel Pass, 9 August 1918, Macoun 98077 (CAN, GH, US); Sunwapta River, 4 miles nw. Poboktan Creek, 29 August 1964, Calder 37227 (DAO); Talbot Lake, 6-7 July 1960, Porsild 22359 (CAN); Tonquin Valley trail from Warden's cabin, 52°41'30"N, 118°14'W, 8 July 1971, Scotter 16834 (DAO); Whistler Mt., Indian Pass, 5 July 1967, Packer 5154 (ALTA). **BRITISH COLUMBIA:** Alaska Highway, Summit Pass, foot Mt. St. George, M. 392, 10 August 1962, Eastham 118/62 (UBC); Alaska Highway, Summit Pass, Mile 392, 11 June 1956, Szczawinski & Bell

159 (UBC); Alaska Highway, Muncho Lake, 27 July 1962, Szczawinski 45/62 (UBC); Alaska Highway, mile 397, 20 July 1961, Szczawinski s.n. (UBC); Arrowsmith, 27 July 1903, Fletcher 2060 & 20601/2 (DAO); Ashnola Range, Red Mt., Cathedral Lakes chain, 10 September 1960, McLean 60-166 (DAO); Red Mt., w. end Quiniscoe Lake, 49°04', 120°13'W, 4 August 1956, Calder & Parmelee & Taylor 19782 (DAO, WTU, MIN); Quiniscoe Lake, 49°04'N, 120°12'W, 2 August 1956, Calder & Parmelee 19626 (DAO); Atlin, 8 July 1966, Anderson 162 (MSC), 10 June 1955, Eastham 250 (DAO); along trail to Ashnola Range, 49°04'N, 120°12'W, 5 August 1956, Calder & Parmelee 19818 (DAO); stream from Big Dog Mt., Lillooet area, 31 July 1961, Beamish & Vrugtman 510645, 610655 (UBC), 610645 (DAO, OSU), 6106555 (DAO); Baldy Mt., Cassiar Dist., 1 August 1943, Brink s.n. (UBC); Burgess Pass, Hitchcock 11526 (US); Dease Lake, 4 August 1941, McCabe 8734 (DAO); Elisabeth Mine, Blue Creek, Lillooet area, 28 July 1961, Beamish & Vrugtman 610612 (DAO, UBC), 27 July 1961, 61054 (DAO, UBC); Ellis Park, near Mt. Apex, ne. Hedley, 20 July 1960, Mclean 60-146 (DAO); 14.5 mi. w. Golden, 6 July 1948, Eastham s.n. (UBC); Fairmont Hot Springs, 17 July 1947, Eastham (DAO, UBC), 11 July 1947, (UBC), 30 June 1953, Calder & Savile 11204 (CAS, DAO, MICH, WS); Fern Lake, 57°45'N, 124°47'W, 4 August 1977, Argus & Haber (CAN); Field, 11 June 1904, Farr (PH), 3 June 1947, McCalla 9572 (UBC), 19 July 1941, Eastham s.n. (NA), 18 July 1941, Eastham 9647 (DAO), 22 July 1982, Brunton 3625 (CAN); Field, Kicking Horse Pass, 14 August 1949, Ledingham 49-597 (USAS); Field, Kicking Horse River, 28 July 1943, McCalla 7751 (UBC); Field, Mt. Stephen Auto Camp, 19 July 1941, Eastham s.n. (UBC); Finch Ridge, Tenquille, 27 July 1931, Davidson s.n. (UBC); Glacier, 17 July 1913, Butteas 768 (MIN); Glacier Camp, 59°46'N, 136°35'W, 27 July 1971, Brayshaw s.n. (CAN); Good Hope Lake, 20-25 mi. n. Cassiar, 59°N, 129°E, 9 July 1973, Beamish, Wade & Pojar 730365 (UBC); Haines Road, Squaw Creek w. of Talbot Creek, Szczawinski 37 (UBC); Kicking Horse Pass, 13 September 1884, Macoun 31845 (CAN); 24 mi. e. Golden, Kicking Horse River, 25 May 1938, McCabe 6297 (CAS, UC); 24 mi. e. Golden, 26 May 1938, McCade 6325 (CAS, UC), 2 mi. n. Golden, 51°17, 116°59°W, May 29 1966, Kendrick s.n. (WAT); Blue Canyon Creek, Taylor et al. 6059; Katharine Lake, 57°26'N, 126°48'W, 25 July 1977, Gillett & Boudreau 17441 (CAN); Lake Agnes, 17 August 1897, Brainerd s.n. (VT); Lower Kicking Horse River, Palliser to Glenogle, 30 July 1906, Brown 768 (GH, PH, US); Kicking Horse Lake, 12 August 1890, Macoun s.n. (BH); Kinbasket River delta, along ne. side lake on Big Bend Hwy; 17 August 1953, Calder & Savile 11963 (DAO); Kinaskan Lake along Steward-Cassior road, 7 July 1973, Krajina, Annas & Klinka s.n. (UBC). Kootenay National Park: 18 July 1940, Daubenmire s.n. (CAS), 4042 (WS), 17 July 1951, Eastman 9644a (DAO); Banff-Windermere Road, near Vermilion Crossing, 11 July 1944, McCalla 8429 (DAO, UBC), 8430 (UBC); Floe Lake Trail, T24 R16 S29, 14 July 1963, Seel E-13 (DAO); Joe Lake, slopes Mt. Flatiron, Ashnola River Distirct, 49° 119', 19 August 1969, Morrison s.n. (UBC); Hawk Creek, 3 August 1967, Fodor 572 (UBC); Marble Canyon, 30 June 1951, Porsild 18330 (CAN); Vermilion Crossing, 11 July 1944, McCalla 8429, 8430 (MT); Vermilion Pass, 10 August 1964, Scoggan 16238 (MIN); Summit Pass, MacDonald Creek, 58°31'N, 124°34'W, 14 July 1943, Raup & Correll 10539 (AA, CAN, MICH, RM, SASK, UBC), 20 July 1943, Raup & Correll 10710 (CAN, GH, MICH, RM, SASK, UBC), 11 June 1956, Eastham 159 (DAO), 25 July 1943, Raup & Correll 10821 (GH), 18 July 1943, Raup, Correll & Denny 10652 (AA); Summit Pass, 58°31'N, 124°34'W, 22 July 1943, Raup & Correll 10730 (GH). Liard River Basin, Fairy Lake, 25 July 1977, Argus & Haber 11017 (CAN, BRY, RSA); Wokkpash Lake, 58°27'N, 124°53W', 19

July 1977, Argus & Haber 10737 (CAN), 21 July 1977, 10840 (CAN); 2.7 mi. from McGrath Ave. on Sabine Mt. road, 26 August 1970, Maze 683 (UBC); Maroon Mt., 54°47'N, 128°40'W, 18 September 1977, Foster 9 (UBC); 3/4 mi. ne. Monument 104, 24 August 1972, Douglas 4591 (WIS); Mt. Apex, 11 August 1964, McLean & Marchand 65-63 (DAO); Mt. Assiniboine, 32 mi. Banff, Sunburst Lake Camp, 7-17 August 1952, Scamman 6590, 6591 (CAN); Muncho Lake, 2 June 1944, Porsild 9023 (CAN); Mount Robson Prov. Park, Mt. Ann Alice, above Berg Lake, 53°10'N, 119°11'W, 19 August 1956, Jenkins 7235 (DAO); above Berg Lake, opposite Mt. Robson, 17 August 1956, Jenkins 7153 (DAO, MSC); Mt. Selwyn, 56°01'N, 123°30'W, 13 July 1932, Raup & Abbe 3782 (CAN, GH, NY), 26 July 1932, 4126 (CAN, GH, NY), 19 July 1932, 976 (GH), 3901 (GH); Noaxe Lake, 9 August 1957, Bird (UBC), 6 August 1957, Bird 3485 (UBC); Noaxe Lake, Mt. Moor, 7 August 1957, Bird 3396, 3494 (UBC); Mt. Moor, middle Blue Creek, 8 August 1957, Bird 3375 (UBC); Noaxe Lake, Lillooet area, 1 August 1961, Beamish & Vrugtman 610726, 610747 (UBC); Penticton, Mt. Apex, 11 August 1953, Calder 11775 (MT); Peterson Creek, at mile 445 on Hwy 97, 28 July 1968, Morton 1992 (WAT); Peace River Basin, Robb Lake, 30 July 1977, Argus & Haber 10233 (WAT). Queen Charlotte Island: Canoe Pass, 26 July 1910, Spreadborough 83090 (CAN); Lake Takakia, 10 miles s. Moresby Logging Camp, Morseby Island, 25 July 1964, Calder & Taylor 36290 (WS); 25-30 July 1964, Calder & Taylor 36292 (COLO, DAO, DS, GH, MO, OSU, RSA, NY, UBC, UC) [2n=62]; Ells Point & Mercer Point, w. Skidegate Channel, Graham Island, Calder & Savile 22870 (DAO, DS, GH, NY, RSA, UC, WS, WTU); Echo Harbor, off Darwin Sound, e. Moresby Island, 9 July 1957, Calder, Savile & Taylor 22358 (DAO, UBC); Mosquito Lake, near Cumshewa Inlet, Moresby Island, 24 August 1957, Calder & Taylor 23693 (DAO); 2.5 mi. w. of Cumshewa Inlet, below Mt. Moresby, Moresby Island, 31 July 1964, Calder & Taylor 36444 (DAO). Red Mt., 49°04'N, 120°13'W, 4 August 1956, Calder, Parmelee & Taylor s.n. (MIN), Robb Lake, 56°54'N, 123°48W, 30 July 1977, Argus & Haber 10233 (CAN); Selkirk, 22 June 1906, Brown 279 (GH, MO, NY), 24 June 1904, Shaw s.n. (NY, US, WS); near 51°30'N, Emerald Lake, 24 June 1904, Shaw s.n. (RM); near 51°30'N, 27 July 1904, Peterson s.n. (MO, PH, US); e. slopes Spermophilus Saddle above Marmont Valley, 57° 35'N, 128°47'W, 20 July 1975, Pojar s.n. (UBC); Sheep Mt., Waterton Lake, 49°05', 28-31 July 1895, Macoun 10770 (US); Spillimachean Valley, 51°30', Petersen s.n. (PH); Spinel Lake, 57°50'N, 126°23'W, 4 August 1977, Gillett & Bourdreau 17735 (CAN); Spy Hill, on Grand Trunk Pacific Railway, 3 July 1906, Macoun & Herriot 72765 (CAN); Summit Lake, w. of Ft. Nelson, 7 August 1943, Brink s.n. (UBC); Suwapta below Potoctan Creek, 28 July 1908, Brown 1361 (PH); Toby creek, ca. 1/2 mi w. Athalmer, 2 August 1953, Calder & Savile 11355 (DAO); n. side Two Lakes of Twin Lake Basin, 51°12'N, 123°04'W, 13 July 1977, Selby 178 (UBC); Toad River at mile 430 on Rt. 97 between Summit & Muncho Lakes, 28 July 1968, Morton 1978 (WAT); Toad River Bridge, 14 June 1944, Nowosad 121 (DAO); Vermilion Range, between Radium Hot Spring & Vermilion Pass, 10 August 1964, Scoggan 16238 (CAN); Wicked River, 56°3'N, 123°40'W, 16 July 1932, Raup & Abbe 3863 (CAN, F, GH, MIN, MT, NY, US); Windermere, slopes Paradise Mine, 31 July 1953, Calder & Savile 11273 (DAO), 28 August 1944, Hardy s.n. (UBC); Yedhe Creek, near 58°33'N, 125°23'W, 10 July 1971, Annas s.n. (DAO). Yoho National Park: Emerald Lake, 4 June 1947, McCall 9591 (ALTA, UBC), Emerald Lake, 24 June 1904, Shaw s.n. (MO, PH), 22 July 1933, Benson 5411 (POM), 3 July 1903, Barber 65 (GH); Lake Wapta, 11 July 1937, Rose 37488 (CAS); Mt. Stephen at Field, 1931, Kujala & Cajander s.n. (CAN); Ross Lake, 9 September 1943, McCalla 7996 (ALTA); e. Twin Falls Lodge, 6

September 1957, Calder & Taylor 23832 (DAO); Yoho River, 1941, Hitchcock & Martin 7713 (UC); Yoho River opposite Takakkaw Falls, 18 July 1941, Hitchcock & Martin 7713 (CAS, DAO, DS, UBC), 18 August 1953, Calder & Savile 11998 (DAO); Yoho Valley, 6 September 1904, Macoun 64051 (CAN); Haines Road Flora, 59°30'N, 136°30'W, 5 July 1956, Taylor, Szczawinski & Bell 747 (GH, DAO); 59°38'N, 136°28'W, 24 June 1948, Raup, Drury & Raup 13192 (CAN, GH), 24 June 1948, Raup, Drury & Raup 13184 (AA). **LABRADOR**: Anchorstok Bay, 1934, Potter & Brierly s.n. (US); Battle Harbour, 1892, Waghorne s.n. (MIN), 8 July 1893, (BH); Battle Harbour, Rawson- MacMillan Expedition, 1927, Sewall 195 (GH, F); Cape Mugford Trickle, 19 July 1934, Potter & Brierly s.n. (UC); Cape Mugford, 57°55'N, 61°55'W, 11 August 1939, Dutilly, O'Neill & Duman s.n. (DAO); Cape Mugford, 17 July 1934, Potter & Brierly 2443 (GH), 13 July 1934, Potter & Brierly 2441 (GH); Crater Lake Vicinity, ca. 52 mi. sw. Hebron 58°02'N, 64°02'N, 29 July 1954, Gillett 8732 (DAO); Cut Throat Island, 30 July 1939, Dutilly, O'Neill & Duman (USAS); Fraser Canyon, Lake Tasisuak, 100 km from Nain, 10 August 1973, Shepard & Mathews 82 (CAN); Gerin Mt., 55°04'N, 67°14'W, 21 July 1955, Viereck 666 (CAN); Hamilton Inlet, Rodney Mundy Island, Indian Head, 54°27', 57°12', 8 July 1931, Abbe & Hogg 132 (CAN, GH); Hebron, 58°15', 62°40', 17 July, 1939, Oldenburg 38a (MIN); Hebron, 21 July 1936, Polunin 1019 (CAN); Hopedale, 10 July 1937, Potter (US); Hopedale, 55°27', 60°12', 25 July 1928, Bishop 147 (CAN, GH); Komaktorbik Fjord, 59°17'N, 63°45'W, 19 July 1937, Wynne-Edwards (CAN); Knob Lake, Schefferville area, 54°45'W, 66°40'W, 23 June 1963, Hustich & Kalio 213 (CAN); Mt. Brane, Cape Mugford, 9 August 1934, Potter & Brierly 24417 (PH); Marble Lake, 54°25'N, 66°26'W, 12 July 1967, Mäkinen 67-503 (CAN); Nain, 12 July 1937, Potter 7421 (WIS), 16 August 1937, 7425 (WIS); Nain, 56°33'N, 61°40'W, 8 August 1928, Bishop 146 (CAN); Okkak, near Cut-throat Tickle, 57°40'N, 62°00'W, 12-14 August 1937, Wynne-Edwards 7520 (CAN); Port Manvers, 26 July 1933, Gardner 283 (GH); Razorback Harbor, 59°14', 63°23', 17 August 1931, Abbe 136 (CAN, GH); Rodney Mundy Island, Indian Harbor, 54°27', 57°12', 8 July 1931, Abbe & Hogg 132 (GH); Saglek, 58°29'N, 62°40'W, 19 August 1954, Gillett 9071 (DAO, GH, US); September Harbor, Rawson-MacMillan Subarctic Expedition 1927-1928, June 27 1928, Sewall (F); Sleeper Island, Dutilly, O'Neill & Duman 87568 (NA); Torngate Mountains, 58°35'N, 63°30', Rousseau 1019, 1033 (MT); Torngate Region, summit of "K-2", n. side Komaktorvik, 59°16'W, 63°45'N, Abbe 134 (CAN); Torngate Region, Kangalaksiorvik, 59°25', 63°40', 6 August 1931, Abbe 135 (CAN); Rowsell Harbor, 58°58', 63°15', 20 July 1931, Abbe & Odell 133 (GH); Windy Tickle, 18 August 1937, Walker 1126 (PH). **MANITOBA**: Brandon, 15 July 1951, Stevenson 366 (DAO); Cowan, 30 mi. e. Swan Lake, 12 July 1950, Scoggan & Baldwin 7966 (CAN); Churchill, Hudson Bay, near hospital, 12 July 1954, Ritchie (MT); Hudson Bay, 13 June 1950, Brown 631 (NHA); Churchill, 22 July 1938, Duman 1144 (DAO, USAS), 25 July 1938, Duman 1246 (NA), 22 July 1938, Duman 1144 (CAN, US), 27 July 1938, Duman 131 (US); 58°46'N, 94°10'W, 8 August 1938, Duman 1466 (CAN, US); Churchill, 17 July 1968, Rowe 1322 (SASK), 13 July 1958, Argus s.n. (SASK), 14 July 1958, Argus s.n. (SASK), 9 August 1958, Argus 443-58 (SASK), 27 July 1958, Argus s.n. (SASK), 21 July 1949, Hyde 51 (SASK), 17 August 1933, Gardner 464 (MICH), Gillett & Cody 1760 (UC), 1761 (DAO, RM, VT), 3 July 1940, Grinnell s.n. (CU), 3 July 1934, Heydweiller & Cope s.n. (CU), 10 August 1969, Beetle 14635 (RM), 30 July 1910, Macoun 79003 (CU, F); 58°46', 94°10'W, 16 July 1956, Schofield & Crum 6752 (F, MIN), 29 July 1956, Schofield & Crum 7068 (DS), Army camp, Fosberg 40004 (POM); east. of R.C. Mission, 58°45'N, 94°10'W, 22 July 1938, Duman 1144 (USAS); Twin Lakes,

e. Fort Churchill, 9 May 1962, Voss 9002 (MICH); Twin Lakes, Churchill, 9 August 1972, Hunt 45 (CAN); Fort Churchill, near Naval radio tower, 21 July 1949, Hyde 51 (DAO); Fort Churchill 28 July 1949, Hyde 35 (CAN), 30 July 1910, Macoun 79003 (CAN), 8 August 1956, Ritchie 2152 (CAN), 29 July 1956, Schofield & Crum 7068 (CAN); Fort Churchill, near camp, 11 July 1949, Dore 10061 (DAO); Fort Churchill, 4 August 1948, Gillett 2392 (CAS, DAO, BH, MAINE, WS), 9 August 1958, Argus s.n. (CAN, SASK); Irvine 716, 718 (SASK), 718 (CAN); 57°45'N, 94°05'W, 21 June 1948, Gillett & Cody 1761 (VT); Fort Churchill, 4 August 1948, Gillett 2392 (MAINE); Gillam, 21 August 1950, Schofield 1523 (CAS, DAO, NY, WS); Ilford, 56°20'N, 95°60'W, July 1976, Sims 1108 (CAN); Lake Winnipegosis, between Cedar Lake and Lake Winnipegosis, 17 August 1948, Scoggan 4651 (CAN); Landing Lake, 23 July 1951, Irvine 761 (DAO); Moosehorn, 110 mi. w. Winnipeg, 9 July 1951, Scoggan 9299 (CAN); Nelson River, Gillam Island near head of tide about 15 miles above Port Nelson, 30 July 1949, Scoggan 6267 (ALTA, CAN, GH, MIN, MT), 4-12 September 1946, Tryon & Dahl 129 (MIN); Nelson River, Roblin River, 31 July 1949, Scoggan 6380 (CAN); Warkworth Creek, 57°38N, 94°05W'W, 21 June 1948, Gillett & Cody 1760 (DAO), 28 June 1948, Gillett 1878 (DAO), 28 July 1949, Hyde 35 (DAO), 29 June 1950, Howe 88 (CAN); 58°46'N, 94°10'W, 16 July 1956, Schofield & Crum 6752 (MIN). **NEW BRUNSWICK**: Aroostook River Basins, Aroostook Falls, ledges, (both sides of river according to label), 15 June 1940, Chamberlain 1579 (MAINE, UC). **NEWFOUNDLAND**: Avalon, Conception Bay, Topsail, 12-19 August 1901, Howe & Lang 1207 (GH, NY); Bear Head, 26 July 1951, Rouleau 2072, 2074 (DAO, MT); 24 July 1948, Rouleau 271 (DAO, MT); Bellburn's, 4.3 mi. N. on Hwy. 430, 21 July 1981, Crins 3475 (TRTE); Bellburn's limestone barrens on w. Rt. 430, 19 August 1986, Dunlop & Orlando 2505 (NHA); 0.5 mi. s. of Big Brook on Rte. 73, 23 June 1963, Rouleau & Morisset 8536 (MT); Blomidon Mt., 6 August 1940, Penson s.n. (MT); Blomidon Brook Bridge, 28 July 1962, Rouleau 7674 (MT); Blomidon Mts., 30 July 1908, Eames & Godfry s.n. (PH, NY); Blomidon Mt., mouth of Blomidon, 18 July 1921, Mackenzie (NY); Blomidon Mt. w. Blomidon Brook between Lark Harbour & Frenchman's Cove, 20 July 1979, Hellquist & Crow 13591 (NASC); Blowmidon Mts., roadside, 1.8 miles w. Rattling Brook on Rt. 460, 19 August 1986, Dunlop & Orlando 2473 (NHA); Bonne Bay, Shag Cliff, 9 August 1929, Fernald, Long & Fogg 1404 (GH, MT, NY), 29 July 1952, Rouleau 3310 (DAO); Bonne Bay, West Arm, on Lookout Mt., 15 August 1929, Fernald, Long & Fogg s.n. (PH), 1405 (GH), 27 August 1910, Fernald & Weigand 2865 (GH); Bonne Bay, Woody Point, 5 August 1919, Kimball 128 (GH); Bonne Bay, Shag Cliff, 29 July 1952, Rouleau 3310 (MT); Bonne Bay, Tucker's Head, 30 July 1952, Rouleau 3351 (MT); Bonne Bay, The Tablelands, 29 July 1953, Rouleau 3764 (MT); Barachois Pond Provincial Park, 7 September 1964, Rouleau (MT); BPPP, Erin Mt., 13 August 1985, Standley 1468 (WELC); Brig Bay, 6 August 1924, Fernald, Long & Dunbar 26413 (GH, NY, PH); Cape Degrat, Quirpon Island, 7 August 1925, Fernald & Long 27646 (CU, GH, PH); 3.5 mi. s. of Cooks Harbour, 23 June 1963, Rouleau & Morisset 8517 (MT); Cremaillere Bay, 18 July 1951, Savile & Vaillancourt 2382 (DAO); Cornor Brook, where Red Gulch Brook enters lake, Morton & Venn 5365 (WAT); Chimney Cove, 7 Auguust 1950, Rouleau 1368 (MT); Eagle's Nest Brook, Mine Brook, York Harbor Mine, 12 July 1952, Rouleau 3064 (MT); Eddies Cove, 28.4 miles w. junct. Rt 345 and new Rt. 430, 23 August 1986, Dunlop & Orlando 2524 (NHA); Englee, Canada Bay, Bide Head and Handy Harbor, 29 July 1958, Rouleau 4693 (MT); Fox Island River, Lewis Hills, 23 August 1965, Rouleau 10107 (MT); Fox Island River Road, 25 July 1953, Rouleau 3720 (MT); Frenchman's Cove, 19 August 1965, Rouleau 9946 (MT); French Island, (Tweed Island);, 2 September 1926, Fernald, Long & Fogg 130 (PH); Frenchman's Cove, 18 July 1921, Mackenzie & Griscom s.n. (US), 10148 (GH); Northwest Gander River, Rt. 360, 1.9 mi. s. of river, 15 July 1986, Crow & Hellquist 86-800 (NHA), 17 July 1986, Crow & Hellquist 86-864, 86-865 (NHA); Gander River, Fourth Pond, 8 July 1960, Rouleau 5479, 5499, 5500 (MT); Glenwood, 12 July 1911, Fernald & Wiegand 4903 (GH); Grand Falls, Valley of Exploits River, 4 July 1911, Fernald & Wiegand 4902 (CU, GH, PH); Gregory Plateau, Court a Mountain, 25 July 1952, Rouleau 3253 (MT); Gregory Plateau, Cape Copper Mines, 23 July 1952, Rouleau 3187 (MT); Goose Arm, Raglan Head, 25 July 1950, Rouleau 1020 & 1021 (MT), 1020 (DAO); Goose Arm, Blue Cliff, 8 July 1952, Rouleau 2976 (MT); Hannah's Head, 12 July 1929, Fernald, Long & Fogg 1401 (GH, MT, PH, US); Hill, 16 June 1896, Waghome s.n. (BH, MIN); Holyrod, Butter Pot, 14 July 1958, Rouleau 4548, 4549 (CAN, DAO, MT, NY, US); Humber River Valley between Mt. Musgrave & Humber mouth, 18 July 1910, Fernald & Wiegand s.n. (CU, GH, PH);, 2863 (CAN, US); Lark Mt., 1 September 1926, Long & Fogg 129 (PH); Lewis Hills, 17 July 1951, Rouleau 1925 (MT); Little Bonne Bay Pond, Fire Tower Mountain, 30 July 1953, Rouleau 3808 (DAO, MT); Lloyds River, 6 July 1957, Damman s.n. (MT); Marble Mt. along Rte. 1, ca. 1 mile w. Steady Brook, 19 July 1979, Hellquist & Crow 13555 (BOSC); Marble Mt., s. side facing Humber River on Rt. 1, 19 August 1986, Dunlop & Orlando 2480 (NHA); Middle Arm, Penguin Head, 16 July 1929, Fernald, Long & Fogg 1402 & 1406 (GH, MT, PH, US); Middle Arm, 25 July 1950, Rouleau 1068 & 1069 (MT); Middle Arm, Raglan Head, 10 July 1951, Rouleau 1681, 1682 (MT); New World Island, southern shore of Notre Dame Bay, 20 July 1911, Fernald & Wiegand 4904 (CU, NY); Nipper's Harbour, 49°47'N, 55°52"W, 7 August 1977, Shepanek & White 2877 (CAN); North Arm, 4 September 1926, Long & Fogg (PH); North Arm Mountain, 12 August 1972, Wells 1878 (CAN); North Arm, southerly slopes of ridge, 18 July 1950, Rouleau 882, 887, 891 (MT), 4 September 1926, Long & Fogg 131 (GH); North Arm, Stony Brook, 17 July 1950, Rouleau 811, 812, 813, 814 (MT), 813 (DAO); North Arm, Flagstaff Point, 17 July 1950, Rouleau 827 (MT) Old Port Au Choix, 19 July 1929, Fernald, Long & Fogg 1403 (MT); Penguin Arm, Deep Cove, 24 July 1950 Rouleau 1003 & 1004 (MT), 1003 (DAO); Pic a Tenereffe, 13 July 1974, Hay & Bouchard 74-187 (MT); Pistolet Bay, n. Burnt Cove, 17 July 1925, Fernald et al. 27643 (PH), 27645 (GH); Point Riche Peninsula, 2 July 1974, Hay & Bouchard 74-190 (CAN, MT); Point Riche Peninsula, 16 July 1979, Hellquist & Crow 13536 (NASC); Point Ritchie, Port aux Choix, August 1986, Dunlop & Orlando 2510 (NHA); Port au Port, Table Mountain, 25 July 1953, Rouleau 3732 (MT); Port au Port, South Branch, Codroy River, 2 July 1949, Tuomikoski 92 (CAN, MT); Portland Head, 4 July 1974, Hay & Bouchard 74-189 (CAN, MT); Port au Choix Peninsula, 1 July 1974, Hay & Bouchard 74-188 (CAN, MT); Port Saunders Harbour, 1 August 1910, Fernald & Weigand 2864 (GH); Rencontre West, Burgeo, La Poile, 15 June 1949, Tuomikoski 33 (CAN, MT); Rock Marsh, Flower Cove, 30 July 1924, Fernald, Long & Dunbar 26412 (CU, GH, PH, NY, US); Saddle Mt., Tompkins, 5 July 1939, Pease & Edgeton 27195 (GH); St. Albans, Rencontre Bay, 14 July 1965, Rouleau 9532 St. Anthony, 22 July 1951, Savile & Vaillancourt 2456 (MT); St. Anthony, south side of Rt. 430, 10.4 mi. w. of junct. of Rt. 435. 24 July 1986, Crow & Hellquist 86-1010, 86-1011 (NHA); St. Anthony, Fishing Head, 30 June 1931, Abbe & Brooks 131 (GH, MIN); St. John Island, 31 July 1925, Fernald et al. 27644 (GH); St John's Bay, 19 July 1929, Fernald, Long & Fogg 1403 (PH); Serpetine Lake, 11 July 1967, Rouleau 10689 (MT), 29 August 1964, Damman 64127 (MT); Serpentine River, The Desert, serpentine barrens, 17 July 1951, Rouleau 1986, 2008 (MT);

Serpentine River, 22 August 1965, Rouleau 10024 (MT); Shag Cliff, 1 August 1973, Bouchard & Hay 73-506 (CAN, MT); Shoal Cove East, between Savage Cove and Green Island Cove, 23 August 1986, Dunlop & Orlando 2522 (NHA); South Branch, 21 August 1957, Rouleau 4357 (MT); Table Mt., s. end near road to summit, 21 July 1979, Hellquist & Crow 13630 (NASC), 1 July 1982, Hellquist & Crow 82-94 (NASC); Table Mountain radar site, 4 km. w. 18 August 1986, Dunlop & Orlando 2440 (NHA); Table Mt., near Shoal Brook, sw. of Woody Point, 12 July 1979, Crow & Hellquist 13458 (NASC); Topsail Head, August 1939, Penson s.n. (MT); Toad River, 16 July 1896, Waghome s.n. (BH); Trout River, 2 mi. e. village, 12 July 1969, Argus & McPherson 7538 (CAN); Trout River, Big Pond, Rock Brook, 26 July 1952, Rouleau 3283 (MT); Trout River, Hummock Hill, 28 June 1953, Rouleau 3521, 3527 (DAO, MT); Trout River, ca. 10 mi. s. Bonne Bay, 11 July 1976, Hellquist 11575 (NASC); Weebald Island, 23 August 1950, Rouleau 1581 (MT); Wild Cove, White Cliffs, 12 June 1956, Rouleau 4166 (DAO, MT), 5 July 1950. Rouleau 613, 622, 623, 624, 625, 626 (MT), 6 July 1948, Rouleau 119 (DAO, MT); Wigwam Pond, about eight mi. n. Goose Arm Road, 3 August 1966, Rouleau & Rast 10171 (MT); Winterhouse Brook, Dunlop & Orlando 2481 (NHA). NORTHWEST TERRITORY: Adelaide Peninsula, near e. side Sherman Basin, 12 July 1957, Macpherson 66 (CAN); Alexander Falls, Andersen River, Reindeer grazing preserve, 69°40'N, 128°57'W, 23 July 1965, Scotter 7070, 7089 (DAO); Andersen River, Reindeer grazing preserve, 68°33'N, 128°40'W, 4 July 1965, Scotter 7112, 7114 (DAO); Grizzly Bear Creek, Reindeer grazing preserve, 69°42'N, 129°12'W, 22 July 1965, Scotter 7113 (DAO); Andersen River, Reindeer grazing preserve, 69°39'N, 128°43'W, 21 July 1965, Scotter 7073 (DAO); Dolomite Lake, Reindeer grazing preserve, 68°18'N, 133°26'W, 6 August 1965, Scotter 7071 7072, 7094 (DAO); Dolomite Lake, 19 July 1965, Krajina; Artillery Lake, 1 August 1954, Oldenburg 54-50 (MIN); Arctic Coast, Liverpool Bay, Nicholson Island, 70°N, 129°W, 15-16 August 1927, Porsild & Porsild 2841 (CAN); Atkinson Point, 70°, 131°W, 1-3 August 1927, Porsild & Porsild 2572 (CAN); Boothia Isthmus, Tunudlik, 1 August 1953, Laverdiere 24 (CAN), Boothia Isthmus, Ikpik, 11 August 1953, Laverdiere 42 (CAN), Boothia Isthmus, Padliajuk, 21 July 1953, Laverdiere 104 (CAN); Brunside Harbour, 12 August 1944, Oldenburg 44-729 (MIN); Baffin Island: Apex Hill, 63°45'N, 67°15'W, 7 August 1964, Swales s.n. (RM); Arctic Bay, Admiralty Inlet, 12 August 1927, Malte 118543 (CAN); Baird Expedition, 1950, Dansereau 500627-3260, 500731-0278, 500726-1482, 500827-1167, 500827-1167, 500803-0861, 500703-0861, 500720, 0252, 0357, 0659 (MT); DEW Line site: Fox 2 (Longstaff Bluff), 68°56'N, 75°18'W, 7 August 1967, Parmelee & Seaborn 4060, 4056 (DAO), 8 August 1967, Parmelee & Seaborn 4105 (DAO); Acadia Cove, Resolution Island, 27 July 1937, Potter s.n. (WIS); Clyde Inlet, 3 July 1950, Wynne-Edwards 8904 (CAN); Cape Dorset, 28 August 1934, Polunin 258 (CAN); Dorset, 64°10', 76°40, 27 July 1939, Oldenbury s.n. (MIN), 25 August 1936, Polunin s.n. (CU, F, NY, PH), 31 (WIS), 2380 (US), 1413 (UC); Dorset Island, 64°12'N, 76°32'W, 28 July 1970, Hainault 5635 (CAN); Frobisher Bay, 28 July 1948, Calder 2203 (CAS, DAO, MT, NA), 2178 (DAO), 22 July 1948, 2105 (DAO, RSA), 7 July 1948, Senn & Calder 3814 (DAO), Calder & Senn 1995 (DAO); Federal Bldg., airport site, 26 July 1964, Swales s.n. (RM); Frobisher Bay, 16 July 1965, Bartley 138 (CAN); Frobisher Bay, Point Brewster, 3 August 1937, Potter 8294 (CAS); Foxetrot Lake, 400m from shore of Suttie Bay, 31 July 1963, Webber 253 (CAN); Lake Harbour, 25-26 August 1927, Malte 11854 (CAN, CU, DAO), 22 July 1933, s.n. (NY), 22 July 1933, Malte 126889

(CAN); Inugsuin Fjord, 8 August 1965, Hainault 4014 (CAN); Peter Force Island, 4 August 1937, Wynne-Edwards 7626 (CAN); Yorke Island, 2 August 1937, Wynne-Edwards 7343 (CAN); Baille and Back Rivers, 65°08'N, 104°35'W, 1-2 August 1955, Tener 377 (CAN); Bathurst Inlet Region, 66°51'N, 108°02'W, 29 July 1979, Scotter & Zoltai 31484 (DAO), 20 August 1951, Campbell 51 (DAO); Bathurst Inlet Region, 66°38'N, 107°50'W, 2 August 1979, Scotter & Zoltai 31963 (DAO); Bathurst Inlet Region, 66°52'N, 108°18'W, 2 August 1979, Scotter & Zoltai 32026 (DAO); Bathurst Inlet, 8 July 1950, Kelsall & McEwen 88 (CAN); Baker Lake, 64°30'N, 97°03W, 31 July 1938, Dutilly 6212 (MT), 6201a (MIN); Baker Lake, 20 July 1963, Choque s.n. (MT), 10 August 1947, Freeman s.n. (DAO); Baker Lake, August 1966, Lesiuk s.n. (DAO), July 1966, Lesiuk s.n. (DAO), 26 June 1975, Gubbe, Maddison & Burr 1167, 1177, 1178, 1179, (SASK), 27 August 1975, Gubbe, Maddison & Burr 1006 (SASK); Baker Lake village, 64°19'N, 96°02'W, 30 July 1965, Rossbach 6951 (CAN); Banks Island, 71°12'N, 122°,35'W, 16 August 1971, Stirling s.n. (CAN); Banks Island, 73°48'N, 120°13'W, 25 July 1979, Scotter & Zoltai 31380 (DAO); Banks Island, Bernard River, 73° 22'N, 121° 467'W, 23 July 1963, Maher & Machean s.n. (RM), 106 (CAN, SASK); Banks Island, Sachs Harbour, 14 July 1955, McEwen 308 (CAN); Belcher Island, 56°30', 79°20', s. Flaherty Island, 21 July 1959, Freeman 5078 (CAN); Belcher Island, sw. shore Kasegelik Lake, 12 August 1959, Freeman 5062 (TRTE); Belcher Island, Eskimo Harbour, 28 August 1960, Maycock 4273 (CAN, TRTE); Belcher Island, 1 mi. sw. Robertson Bay, 10 August 1960, Maycock 4813 (TRTE); -Bernard River, 73°22'N, 121°47'W, 23 July 1963, Maher & MacLean s.n. (SASK); Bylot Island, 72°47'N, 79°31'W, 29 July 1982, Scotter & Zoltai 67207 (DAO); Colonel Mt., 28 July 1939, Raup & Soper 9626 (CAN, MIN, PH, RM, SASK, WS), 9395 (CAN, UBC); Red Mt., 21 June 1939, Raup & Soper 9231 (CAN); Campbell Lake, e. Point Separation, 68°20'N, 133°30'W, 15 June 1927, Porsild & Porsild 1888 (CAN); Canol Road, Mile 111, Bolstead Creek, 25 July 1944, Wynne-Edwards 8252 (CAN); Cape Dalhousie, 70°13'N, 129°40'W, 31 July 1963, Cody 13137 (DAO); Cape Parry Peninsula: near Paulatuk, 69°21'N, 124°07'N, 18 July 1978, Scotter & Zoltai 25656b (DAO), 67°38'N, 123°27'W, 19 July 1978, Scotter & Zoltai 25815 (DAO), 67°21'N, 124°07'W, 18 July 1978, Scotter & Zoltai 25662 (DAO), 25663 (DAO), 69°20'N, 124°55'W, 18 July 1978, Scotter & Zoltai 25684 (DAO), 69°323N, 125°18'W, 20 July 1978, Scotter & Zoltai 25842 (DAO), 70°10'N, 124°40'W, 15 July 1978, Scotter & Zoltai 25505a (DAO), 25581 (DAO); Cache Creek, 68°16'N, 136°22'W, 20 June 1973, Welsh & Rigby 12042 (CAN). Cli Lake, 10 August 1961, Cody & Spicer 12204 (DAO, US); Colden Lake, 2 August 1954, Oldenburg 54-113 (MIN); Coppermine, 67°50'N, 115°10'W, 23 June 1951, Findlay 31 (DAO); mouth of Coppermine River, 68°N, 115°, 15 July 1928, Pierce 10 (UBC); Chesterfield Inlet, 63°21'N, 90°42'W, 17 August 1950, Savile & Watts 1514 (BH, CS, US), 1462 (DAO, CAS, NA), 1514 (DAO); Chick Lake, 65°53'N, 128°07'W, 15 August 1973, Gubbe 310(100), 315(99) (ALTA, SASK), 290 (80), 302-a (DAO), 18 July 1973, Gubbe 121(43) (ALTA, SASK), 22 July 1973, Gubbe 167(61) (ALTA, SASK), 24 July 1973, Gubbe 274(66) (SASK), 29 July 1973, Gubbe 279(79), 298(75) (ALTA, SASK); Chick Lake, 65°51'N, 128°08'W, 30 August 1974, Gubbe & Burr 674 (ALTA); Coat's Island, Cairn Cove, 26 July 1975, Gillett 16900 (CAN, RSA); Coat's Island, Cairn Cove, 62°49'N, 81°56'W, 24 July 1975, Gillett 16802 (CAN, RSA), 22 July 1975, 16757 (CAN, RSA); Char Lake, Victoria Island, 15 August 1954, Oldenburg 54-657 (MIN); Devon Island, Truelove Inlet, 75°41'N, 84°40'W, 16 July 1974, Mackenzie 18 (CAN); North Devon Island, 74°33'N, 82°12'W, 27-28 July 1927, Malte 118546 (GH); DEW line site, Pin

2, (Cape Young), 68°56'N, 116°56'W, 4 August 1963, Parmaelee 3093 (DAO), 3078 (DAO); Digges Island, 62°32'N, 77°45'W, 8 July 1980, Gaston 36 (CAN); Dismal Lakes, 67°29'N, 117°36'W, 8 August 1949, Stock s.n. (DAO); Eldorado, 26 July 1945, Oldenburg s.n. (MIN); Eskimo Lake, 68°57'N, 132°43'W, 6 August 1957, Cody & Ferguson 10489 (DAO); Eskimo Lake, 68°54'N, 133°14'W, 9 August 1957, Cody & Ferguson 10615 (DAO); Eskimo Lake, 68°56'N, 132°56'W, 7 August 1957, Cody & Ferguson 10538 (DAO); Eskimo Lake Basin, 68°20'N, 132°20'W, 24 August 1927, Porsild & Porsild 3130-31 (ALTA, CAN). Ellesmere Island, 78°53', 75°50', 14 July 1979, Gillett & Schepanek 18105 (COLO), 18261 (COLO), 29 July 1980, Hill 235 (TRTE); Ellesmere Island, Alexander Fjord, 19 July 1980, Hill 184, 178 (TRTE), 225 (TRTE), July 1980, Svoboda s.n. (TRTE); Ellesmere Island, Caledonia Bay, 79°57'N, 81°15'W, 8 August 1972, Waterston 199a/72 (CAN); Enterprise-Mackenzie River Highway, Thieret & Reich 4927 (US), 4981 (NY, US), 4996 (CAN, NY, US), 13 August 1958, Thieret 4255 (F), 11 July 1959, Thieret & Reich 5175 (CAN, DAO, F), mile 28.5, 2 July 1959, Thieret & Riech 4927 (DAO), near Kakisa Lake, 7 July 1959, Thieret & Reich 4981, 4996 (DAO, F), 2 July 1959, 4927 (F), 19 July 1959, 5482 (F); Flat River, South Nahannie River, 61°25'N, 126°36'W, Scotter 12718 (SASK); Fort Smith, 20 July 1962, Kolenosky s.n. (SASK); Fort Good Hope, 7 August 1951, Lindsey 621a (CAN); Foxe Basin, 68°08'N, 74°12'W, 23-25 August 1949, Baldwin 1984 (CAN); Great Slave Lake, 6 July 1974, Johnson, Harris & Traynor 709 (SASK), Fairchild Point, 62°43'N, 109°10'W, 22 July 1927, Raup 308, 309, (CAN), 310, 311 (GH); Great Bear Lake, Sawmill Bay, Leith Peninsula, 15-16 July 1948, Shacklette 3032, (MICH, MT, US), 3073 3074 (CAN, MT, US); Great Bear Lake, n. shore Dease Arm, 67°2'N, 119°50'W, 23-26 June 1928, Porsild & Porsild s.n. (ALTA); Kinsey Lake, 62°35'N, 109°38'W, 2 August 1966, Cody 15783 (DAO); 62°24'N, 110°45'W, 12 August 1965, Cody 14695 (DAO); King William Island, Gjoa Haven, 21 August 1955, Cooper 235 (CAN); Kugong Island, 56°11'N, 80°W, 5 July 1971, Manning s.n. (UBC); Port Radium, McTavish Arm, Eldorado Mine, 10 July 1948, Shacklette 2908, 2924, (CAN, MICH, MT, US); Great Bear Lake, Hunter Bay, McTavish Arm, 29 July 1948, Shacklette 3219 (MICH, MT, US); Great Bear Lake, Cape McDonnel, 66°22'N, 120°35'W, 2 August 1928, Porsild 5111 (GH, MT, US); Great Bear Lake, McTavish Arm, Sloan River, 29 July 1948, Shacklette 3219 (CAN); Glacier Lake, 62°05'N, 127°35'W, 3 July 1939, Raup & soper 9364 (MIN); Godlin Lakes, 63°49'N, 128°48'W, 21 July 1975, Miller 153 (DAO); near Gilbraltor Hill, 12 July 1948, Shacklette 2924 (MICH); Sawmill Bay, ne. Leith Peninsula, 16 July 1948, Shacklette 3032, 3073, 3074 (MICH); Great Bear Lake, McTavish Arm, base Labine Bay, 21 July 1948, Shacklette 3129 (MICH), McTavish Arm, Harrison River, 30 July 1948, Shacklette 3226 (MICH); Hunter Bay, e. end McTavish Arm, 30 July 1948, Shacklette 3226 (CAN); Hare Indian River, 66°21'N, 127°04'W, 21 July 1974, Rigby 136 (CAN); Hay River, near Alexandra Falls, 13 July 1949, Moss 8868 (DAO); 60°30'N, 116°17'W, 13 June 1951, Lewis 292, 293 (DAO); Heart Lake Fire Tower, ca. 1 mi. ne. of, 60°51'N, 116°38'W, 16 June 1972, Talbot 2223 (ALTA, DAO); Horn Lake, 37 mi. nw. McPherson, McDougall Pass, 67°46'N, 136°2'W, 7 July 1962, Youngman & Tessier 39 (CAN); Horn Plateau, 40 mi. e and n. Fort Simpson, 61°58'N, 119°05'W, 17 July 1971, Rowe 1936 (DAO, SASK); Horn Plateau, unnamed lake, 61°59'N, 119°22'W, 3 July 1970, Cody 18618 (DAO); Hudson Bay, Tukarak Island, 56°08'N, 78°53'W, 22 July 1971, Manning s.n. (DAO); Hudson Bay, Kugong Island, 56°11'N, 80°05'W, 29 June 1971, Manning s.n. (DAO), 5 July 1971, Manning s.n. (DAO), 7 September 1971 (DAO); Hudson Bay, Gilmore Island, 59°50'W, 80°05'W, 20 August 1971, Manning s.n. (DAO); Hudson Bay Post, Spence Bay, near Franklin boundary, 15 August 1958, Savile 3836 (DAO, GH); 10 mi. se. Inuvik, Campbell Lake, 68°14'N, 133°28'W, 14 July 1963, Cody & Kehoe 12651 (DAO); Inuvik airfield, Krajina 65071905 (NY), 19 July 1965, 65061905 (DAO); Inglis River, 68°35'N, 92°57'W, 21 August 1975, Gubbe, Maddison & Burr 984B (SASK); Ikaktalik, Havilland Bay, Melville Pen., 66°35'N, 85°25'W, 14 August 1950, Bruggeman 168 (DAO); Ile Castel, 55°27', 77°31', Lemeiux 21,776 (MT); James Bay, North Twin Island, 53°18'N, 80°00'W, 27 June 1973, Manning s.n. (ALTA, DAO); James Bay, Wood Island, 53°30'N, 6 September 1947, Oldenburg 47-85 (MIN); James Bay, Solomons, Temple Island, 14 July 1949, Baldwin 1657a, (MAINE), 1691 (MAINE, MICH); Jean-Marie River on Mackenzie Highway, 15 June 1973, Skogland 793 (SASK); Kelly Lake, 65°29'N, 126°21'w, 19 July 1974, Rigby 117 (CAN); Kinga Lake, 61°53'N, 96°47'W, 9 July 1975, Gubbe, Maddison, & Burr 213, 288, 155, 157, (SASK); King William Island, Gjoa Haven, 6 August 1954, Cooper 7 (CAN); Liard River on mile post 270, 61°33'N, 121°23'W, 14 June 1973, Skoglund 787 (SASK); Lake on the Mountain, 62°08'N, 118°07'W, 30 July 1959, Thieret & Reich 5817 (F); Spence Bay, 69°32'N, 93°32'W, 8 August 1975, Gubbe, Maddison & Burr 661, 667, 671 (SASK); Southhampton Island: Coral Harbour, 2 September 1955, Beckett 386 (MIN), 64°08'N, 83°10'W, 2 September 1955, Beckett 20 (CAN), 64°08'N, 83°17'W, 9 August 1948, Cody 1950 (DAO), 64°09'N, 83°18'W, 3 August 1948, Cody 1948 (DAO), 3 August 1950, Brown 468 (CAN), 9 August 1952, Brown, Irvine & Oakes 1609 (CAN), 24 July 1954, Ritchie s.n. (MT); Coral Harbour, Munn Bay, 9 August 1948, Cody 1959 (MT); Coral Harbour, 64°08'N, 83°17'W, 9 August 1948, Cody 1950; Bear's Cove Point, 27 July 1951, Brown 974 (CAN, DAO, SASK); Duke of York, 65°02'N, 84°40'W, 30 August 1971, Parker Cr-71-23, 24, 30, 69, 73, 84, 86, 96, 100, 113, 118, 131 ((DAO), 6 August 1971, Parker s.n. (DAO); 64°o15'N, 82°50'W, 15 August 1928, Malte 120573, 120622, 120667 (CAN, GH); Munn Bay, 9 August 1948, Cody 1950 (NA); Murchison River, 67°46'N, 93°52'W, 20 August 1975, Gubbe, Maddison & Burr 862 (SASK); Salmon Pond, 64°12'N, 85°00'W, 1970, Parker sp-70-160D (CAN); Tehek Lake, 2 August 1952, Oldenburg 52-80 (MIN); Thelon River, 64°45'N, 96°25'W, 27 August 1975, Gubbe, Maddison, & Burr 1042 (SASK); Thelon River, 64°45'N, 96°52'W, 27 August 1975, Rossbach 6852 (CAN); 64°19'N, 102°55'W, 4 July 1965, Rossbach 6512 (CAN); Thelon River, 64°10'N, 102°35W, 15 July 1961, Kuyt 66 (CAN); Thelon River, 20 mi. below Hornby's Bend, 2 August 1952, Tener 167 (CAN); Trout River at highway 77, 18 June 1973, Skogland 836, 837 (SASK), 838 (DAO). Mackenzie Valley: Gibson Ridge, 65°49'N, 128°08'W, 22 August 1972, Reid 638 (ALTA, SASK); CNT line south of river and Two Mountains. 21 July 1973, Reid 716 (ALTA, SASK); Caracjou River, 12 June 1972, Reid 366 (ALTA, SASK); Mackenzie Basin, Great Slave Lake, Fairchild Point, 22 July 1927, Raup s.n. (SASK); Mackenzie River, n. peak of Nahanni Mt., 9 July 1944, Wynne-Edwards 8431 (CAN); Lone Mt., 7 July 1944, Wynne-Edwards 8432 (CAN); Mackenzie River Delta, Richards Island, 22-24 July 1927, Porsild & Porsild 2165 (CAN, MT, US), 18 July 1927, Porsild & Porsild 2063 (GH); Richards Island, Reindeer Grazing Preserve, 63°30'N, 133°47'W, 24 July 1966, Scotter 10201 (DAO), Richards Island, Kidluit Bay, 69°31'N, 133°48'W, 23 July 1957, Cody & Ferguson 10173 (DAO); Inuvik, 68°16N, 133°37'W, 29 June 1966, Lambert s.n. (DAO); Inuvik, 68°20N, 133°42'W, 8 June 1966, Lambert s.n. (DAO); Kittigazuit Island, 69°22"N, 133°40'W, 19-20 August 1927, Porsild & Porsild 2328b (CAN). Mackenzie-Yellowknife River Highway, 27 June 1961, Thieret & Reich 7095 (F), 12 July 1961, 7622 (F) 6924 (F); near Tuktoyaktuk, 20 June 1974, Freeman 27 (TRTE); Taki Lake, 17 August 1954, Oldenburg 528 (MIN). Mackenzie Mountains: Banana Lake, 63°49'N, 127°28'W, 5 August 1967, Cody

17476 (DAO). Carcajou Lake, 64°41'N, 127°55'W, 4 July 1972, Cody & Brigham 20446 (DAO); Carcajou Lake, 64°42'N, 127°55'W, 16 July 1965, Youngman & Tessier 717 (CAN); Coral Peaks, 65°05'W, 129°11'W, 10 July 1972, Cody & Brigham 20715 (DAO); Canol Road, Mile 32E, Hell's Gate in Dodo Canyon, 1 August 1953, Cody & Gutteridge 7693 (DAO); Canol Road, Mile 44E, 1 August 1953, Cody & Gutteridge 7711 (ALTA, DAO, GH); Canol Road, Mile 22E, 18 August 1953, Cody & Gutteridge 7690 (DAO); Canol Road, Mile 64 from Mackenzie River, 64°40'N, 127°22'W, 16 July 1978, Kershaw & Kershaw 6578 (DAO); Canol Road, Mile 82 from Mackenzie River, 64°34'N, 127°47'W, 4 August 1978, Kershaw & Kershaw 5681 (DAO); Canol Road, Mile 93 from Mackenzie River, 64°29'N, 127°54'W, 8 August 1978, Kershaw & Kershaw 5279 (DAO); Canol Road, Mile 174E, Sekwi River, 6 September 1944, Porsild & Breitung 11853 (CAN); Canol Road, Mile 200 from Mackenzie River, 63°29'N, 129°18'W, 16 July 1977, Kershaw & Kershaw 392 (DAO); w. Dahl Lake, 63°08'N, 126°50'W, 9 July 1971, Cody 19889 (DAO); 63°08'N, 126°38'W, 9 July 1971, Cody 19850 (DAO); 63°37'N, 128°01'W, 8 July 1971, Cody & Scoggan 19826 (DAO); 63°07'N, 126°30'W, 6 August 1967, Cody 17585 (DAO); Grizzley Bear Lake, 62°41'N, 127°50'W, 10 August 1967, Cody & Spicer 17982 (DAO); Hayhook Lake, 63°30'N, 126°47'W, 6 August 1967, Cody 17543 (DAO); 10 mi. n. June Lake, 63°38'N, 128°37'W, 31 July 1967, Cody 17044 (DAO); June Lake, 63°31'N, 128°40'W, 31 July 1967, Cody 17128 (DAO); Keele River at Canadian Wildlife Service Camp, 64°12'N, 127°25'W, 17 July 1970, Cody 18904; Keele River Region in canyon, 64°47'N, 129°37'W, 25 July 1963, Kvale & Haggard 241m (DAO); Keele River Region, 64°25'N, 129°00'W, 8 July 1963, Kvale & Haggard 251. (DAO); Little Divide Lake, 63°05'N, 128°35'W, 26 July 1967, Cody 16595 (DAO); Mirrow Lake, east side Caracjou Range, 64°52'N, 126°55'W, 3 July 1972, Cody & Brigham 20410 (DAO); O'Grady Lake, 63°05'N, 128°50'W, 29 July 1967, Cody 16928 (DAO); Plains of Abraham, 64°31'N, 127°31'W, 19 July 1970, Cody 19038 (DAO); Redstone River Region, 62°55'N, 126°38'W, 21 June 1963, Kvale & Haggard 43 (DAO); Rouge Mtn. River, 62°32'N, 126°42'W, 24 June 1967, Simmons 155 (DAO); Sekwi Mt., 63°30'N, 128°40'W, 3 August 1967, Cody 17363 (DAO). South Nahanni River, 61°20'N, 124°28'W, 2 July 1970, Scotter 12577 (DAO); South Nahanni River, Hell Roaring Creek, 62°52'N, 126°36'W, Meulman 5005-12 (DAO); South Nahanni River Valley, Rabbitkettle Hot Spring, 61°57'N, 127°11'W, 12 July 1972, Cody & Brigham 20896a&b (DAO); Nahanni Butte, 61°03'N, 123°23'W, 6 August 1961, Cody & Spicer 12047 (DAO), 22 August 1959, Jeffrey 658 (CAN); Sterile Lake, 61°33'N, 126°40'W, 1 July 1967, Simmons 59, 60, 61 (DAO); Sterile Lake, 64°33'N, 126°40'W, 28 June 1967, Simmons 26 (DAO); Matthew Lake, Salmita, 64°05'N, 111°15'W, 16 August 1953, Chillcott 65 (DAO); Mount Flett, 32 mi. n Fort Liard, 62°42'N, 123°37'W, 1 August 1961, Cody & Spicer 11884 (DAO); Nahanni National Park, 61°29'N, 109°28'W, 24 July 1976, Talbot 6110 (CAN); Nahanni National Park, 61°43'N, 125°53'W, 5 July 1976, Talbot 6001-13 (CAN); Nahanni National Park, confluence Caribou and Flat River, 61°29', 125°51, 22 July 1975, Talbot T5035, T5037-18 (CAN, DAO); Deadmen Valley, Prairie Creek, 61°15'N, 124°27'W, 6 July 1976, Kershaw 538 (ALTA); Nahanni National Park, Flat River, 125°43', 61°28', 22 July 1975, Talbot t5038-18 (DAO); Nahanni National Park, Flat River, 10 mi. w. Caribou R., 61°31'N, 126°05'W, Meuleman m6025-14 (DAO); Nahanni National Park, 125°24'W, 61°33'N, 25 July 1976, Meuleman m6069-7 (DAO); Nahanni National Park, Liard Range, 61°07', 123°47', 15 July 1975, Talbot t-5027-5 (CAN, DAO); Nahanni National Park, Marengo Creek, 61°36', 125°58', 8 August 1975, Talbot 5014-2 (CAN); Nahanni National Park, Rabbitkettle Hot Springs, 61°56'15"N, 127°10'40"W, 3 August 1975, Scotter & Marsh 23256

(SASK); Nahanni National Park, Prairie Creek, 61°15', 124°25', Talbot t5016-2 (CAN, DAO); Nahanni National Park, Sunblood Mtn., 61°38', 125°15', 27 July 1975, Talbot t5059-3 (CAN, DAO); South Nahanni River, Virginia Falls, 28 August 1974, Marsh 5198 (SASK); South Nahanni River, 61°20'N, 124°28'W, 3 July 1970, Scotter 12594 (DAO); Nahanni National Park, 61°37', 125°44', 29 June 1970, Scotter 12516 (DAO); Nahanni National Park, Dry Canyon, 61°15', 124°23'W, 3 July 1970, Scotter 12820, 12818b (DAO); Nahanni National Park, Mineral Springs, Flat River area, 61°25', 126°36', 3 July 1970, Scotter 12718, 12723, 12725 (DAO); Nahanni Range w. Little Doctor Lake, 61°52'N, 123°20'W, 8 August 1961, Cody & Spicer 12123 (DAO); Mission, 68°53'N, 89°51'W, 11 August 1964, Campbell s.n. (CAN); Mistake Bay, 62°05'N, 93°06'W, 20-29 July 1930, Porsild 5638 (CAN); Mt. Sidney, Dobson, 26 August 1975, Scotter & Marsh 5665 (SASK); Nauyuk Bay, Kent Peninsula, 68°22'N, 107°40'W, 25 August 1977, Taube s.n. (ALTA); North Sleeper Island, 59°17'N, 80°40'W, 2 September 1939, Dutilly, O'Neill, Duman 87568 (MO); Norman Wells, 19 July 1953, Cody & Gutteridge 7355 (NY), 7660 (US); Norman Wells, Bosworth Creek, 29 July 1953, Cody & Gutteridge 7660 (DAO, F, GH), 7355, 7391 (DAO); Nueltin Lake, Josie's Bay, 11 July 1947, Harper 2286 (CAN, MIN); Nueltin Lake, Windy River, 15 August 1947, Harper 2428 (CAN, MIN), 2 July 1947, Harper & Porsild 2250 (PH); Old Man Lake, 75 km. ne. Inuvik, 68°20'N, 132°15'W, 25 July 1980, Sims 6138 (UBC); Ranklin Inlet, Nipissak Lake, 62°52'W, 92°09'W, 31 August 1970, Rowe 1615, 1638, 1638, 1644 (DAO, SASK), 26 August 1970, Rowe 1608 (DAO, SASK), Rowe 1615, 1616 (SASK), 7 July 1968, Rowe 67-68 (DAO, SASK), 7 September 1968, Rowe 82-68 (SASK); Rankin Inlet, 63°00'N, 92°30'W, 20 July 1968, Cochran s.n. (SASK), 17 July 1968, Cochran s.n. (SASK), 17 July 1973, Gillett 16066 (CAN, WAT), 12 July 1975, Svoboda, Martin & Morochove 754327 (TRTE), 5 August 1975, Svododa, Martin, Morochove 753280 (TRTE); Rankin Inlet, 62°49'N, 92°05'W, 17 July 1973, Gillett 16067 (CAN); Repulse Bay, Churchill, Beckett s.n. (MIN); 66°33', 86°40'W, Duman 2070a (MIN), 19 August 1938, 2064 (CAN, NA, USAS); Repulse Bay, 19 August 1938, 66°33'N, 86°40'W, Duman 2064 (GH, UC); Rufus Lake, 120 km. e. Tuktoyaktuk, 69°20'N, 129°58'W, 22 July 1980, Sims 6121 (UBC); Silumiuit, 11 August 1969 McCartney s.n. (WIS); Sugluk Inlet, 13 September 1938, Duman 2424 (MO); Summit Lake, Richardson Mts., 136°28'W, 67°42'N, 28 July 1961, Packer 1289 (DAO); 3 mi. ne. Tununuk Point, 6-8 year old seismic line, 27 July 1971, Hernandez 230 (ALTA); Tuktoyaktuk Peninsula 131°07', 69°40', 9 July 1974, Owen & Larsen TUK-74-4088 (DAO); 50 km. Tuktjoyaktuk, 69°35"N, 132°30"W, 27 July 1981, Sims 6319 (UBC); Victoria Island, Cambridge Bay, 12 August 1959, Calder, Savile, Kukkonen 24152 (DAO); Thompson s.n. (WIS), 14 August 1944, Oldenburg 44-915 (GH); Washburn Lake, 18-19 August 1946, Oldenburg 46-2222 (GH), 6 July 1962, Stephens 959, 998, 1190 (CAN); Victoria Island, 70°30'N, 117°38'W, 24 July 1974, Bliss s.n. (ALTA); Victoria Island, near Holman Island trading post, 8 August 1949, Porsild 17255 (CAN); White Island, 65°40', 84°38', 11 July 1960, Smith s.n. (CU); Ya Ya Lake, 69°10'N, 134°38'W, 20 July 1966, Scotter 10200 (DAO); 67°22'N, 134°59'W, 20 August 1972, Wein et al. 1601 (DAO); 67°56'N, 116°38'W, 16 August 1947, Stock s.n. (DAO). **NOVA SCOTIA: Inverness Co.:** Big Intervale, 13 July 1954, Smith et al. 11287 (CAN, DAO, MT); Corney Brook, 29 August 1956, Webster 633 (CAN, DAO, MT); LeBlanc Brook, Cheticamp River, 6 July 1953, Smith et al. 7754 (MT), 28 August 1956, Webster 630 (CAN, DAO, MAINE). **Victoria Co.:** Salmon River, Lockhart Brook, 8 July 1952, Smith et al. 6385 (DAO); 3 mi. from mouth Indian Brook, 17 July 1953, Smith et al. 8135 (DAO). **Cape Brenton Co.:** North Sydney, Cape Breton, 13 July 1883, Macoun 31-835 (CAN). **ONTARIO: Cochane District:** Albany River, 51°13'N, 84°22'W, 7 August 1960, Dutilly & Lepage 38558 (DAO), 7 August 1960, Dutilly & Lepage 38578 (CAN); 28 mi. n. Mattice Scovil Tp., Missinaibi River, Thunderhouse Falls, 4 July 1974, Reznicek & Carleton s.n. (TRTE); Attawagami River, 50°38'30"N, 79°42'W, 24 August 1979, Riley 11180 (CAN); Mammammatawa, 50°16'N, 84°47'W, 2 August 1960, Lepage 38340 (DAO); North French River, 50°26'30", 81°03', 20 July 1979, Riley 11026 (CAN). **Kenora District:** Aquatuk Lake, Particia Portion, 54°21'30"N, 84°36'W, 11 August 1980, Riley 11763 (MICH); Barnard Point, 48°40N, 87°04'W, Mortimer Island, 30 June 1973, Given 73166 (CAN); Black Duck River, 19 July 1953, Moir 1939 (CAN, MIN), 2177 (CAN, GH, MIN); Brant River, 22 May 1973, Maycock 19226 (TRTE), 23 July 1973, 20844 (TRTE); Goose Creek, Hudson Bay, 18-20 August 1952, Moir 1556 (MIN), Goose Creek, 18-20 August 1952, Moir 1556 (CAN); Fawn & Severin River, 3-7 August 1952, Moir 1212 (MIN); Fawn & Poplar River, 26-28 July 1952, Moir 866 (CAN, MIN); Fawn & Otter River, 17-20 July 1952, Moir 605 (MIN, UBC); Fawn & Mink Creek, 23-25 July 1952, Moir 745 (MIN); James Bay, River Opinaga, 54°12'N, 26 August 1953, Lepage 31622 (DAO); Jigsaw Islands, 13 July 1958, Baldwin 7631 (CAN); Henrietta-Maria, Hudson Bay, 54°48'N, 82°20'W, July 1979, Sims 2649b (MICH); Niskibi River, 4-5 August 1953, Moir 2320 (MIN); Winisk, 53°16'N, 83°12'W, 17 August 1958, Baldwin 8037 (CAN); James Bay, Winisk River, 55°05'N, 85°20'W, 10 August 1962, Dutilly & Fernette 40003 (MT); James Bay, 22 July 1935, Doutt 2274 (MICH); confluences of Winisk River, Dutilly & Fernette 40069 (MT); James Bay, Albany River, 7 August 1960, Duman 38.578 (MY). **Thunder Bay District:** Lake Nipigon, Flat Rock Portage, e. side South Bay, 26 July 1960, Garton 7797 (MSC, MT, NHA), 10 August 1960, 8148 (DAO); Columbus Point, se. South Bay, 8 August 1960, Garton 8096 (DAO); Thunder Cape, 48°20'N, 88°50'W, 31 July 1936, Taylor, Losee & Bannan 1473 (CAN, GH); Terrace Bay, 48°46'N, 87°07'W, 13 July 1966, Parmellee & Savile 3646 (DAO); Peninsula, 5 July 1939, Harrison 237 (DAO); Peninsula, 5 July 1939, Taylor, Bannan & Harrison 648 (CAN, UBC), 17 July 1939, Taylor, Bannan & Harrison 649 (UBC); Mortimer Island, Bernard Point, 48°40'N, 87°04'W, 30 June 1973, Given & Soper 73166 (MICH), 73167 (CAN); Mortimer Island, n. shore Lake Superior, 28 July 1937, Hosie, Losee & Bannan 893 (MT); 26 July 1937, Hosie, Losee & Bannan 893 (CAN, GH), 27 July 1937, Hosie, Losee & Bannan 894 (CAN, GH). **County or District unknown:** Attawapiskat River, junct. Muketei River, 53°08', 83°18'W, 23 July 1957, Porsild & Baldwin 20302 (CAN); Baptist Harbour, 45°12'N, 81°42'W, 9 July 1975, Cuddy & Emslie 1685 (CAN); Baptist Harbour, 45°13'N, 81°43'W, 10 July 1975, Cuddy & Emslie 1711 (CAN); Cape Henrietta Maria, 18 July 1948, Watson 102 (CAN), Cape Henrietta Maria, 12 mi. s. Cape, 27 June 1957, Porsild & Baldwin 19834 (CAN); Cape Henrietta Maria, 54°47'N, 82°23'W, 8 July 1969, Courtin & Bisset 4120 (CAN); Fort Severn near H.B.C. post, 14 July 1956, Hustich 1302 (CAN); Golden Valley shore Lake Huron, 1 June 1911, Klugh s.n. (DAO, WAT); Hawley Lake, 28-30 June 1957, Porsild & Baldwin 21041 (CAN); Little Eagle Harbour, 23 August 1901, Macoun 33.729 (CAN, GH); Severn River, between Limestone and White Seal Rapids, 3-7 August 1952, Moir 1212 (CAN); Shamattawa River, 55°01'N, 85°23'W, 7 August 1958, Baldwin 7899a (CAN).**QUEBEC:** Black Lake, Caribou Hill, 16 July 1951, Raymond et al. 1457, 1626 (DAO, MT), Black Lake, 26 August 1915, Fernald & Jackson 12044 (CAN, GH, MT, NY, RM, US); Black Lake, 21 August 1926, Rousseau 25 834 (GH, MT, PH, WIS, US); Black Lake, 15 July 1944, Marie-Victorin et al. 520 (CU, DAO, GH, MT), Black Lake, 11 August 1933, Marie-Victorin et al. 43 839, 45 724 (GH, MT), 431 (UC), 11 August 1933, Marie-Victorin, Rolland-Germain & Meilleur s.n. (CAN); Black

Whale Harbour, 28-29 July 1947, Baldwin et al. 335 (CAN, MICH); Black Lake, Silver Mtn., 9 June 1976, Morton s.n. (WAT); Brompton, near Richmond, 3 May 1970, Forest s.n. (CAN); Caribou Lake, 20 May 1965, Blais et al. s.n. (CAN, SASK); Chicoutimi, Monts Otish, 52°15' 70°48', Lemieux 18932 (CAN); Coleraine, 3 August 1977, Beach 43 (TRTE), 26 July 1965, Blais, Deschaises & Forest s.n. (DAO); Coleraine, 15 July 1954, Pease & Wells 37516 (GH); Diana Bay, 10 August 1936, Ney & Courtright 2404 (CAN); Fort Chimo, 22 July 1963, Legault 6770 (DAO, MT, SASK); Fort Chimo, 58°07'N, 68°23'w, 2 August 2 1948, Calder 2309 (CAS, MT, NA, WIS), 2320 (DAO), 8 August 1948, Calder 2463 (DAO, RM, WIS); Fort Chimo, Ungava Bay, 23 August 1896, Spreadborough 13608 (CAN, GH, MT); Gerin Mountain, 55°04'N, 67°14'W, 21 July 1955, Viereck 666 (MT); Great Whale River, 2 mi. n. Hudson Bay Post, 55°17'N, 77° 47'W, 1 August 1949, Savile 562 (MT, NA), 521 (BH, DAO, NY), 663 (DAO), 760 (DAO), 637 (DAO), 652 (DAO), Great Whale River, 1.5 mi. e. Hudson Bay Post, 10 August 1949, Savile 637 (MT, NA), Great Whale River, 1.25 mi. ne. Hudson Bay Post, 31 August 1949, Calder 760 (US), Great Whale River, 6.5 mi. n. of the Post, 55°17'N, 77°46'W, 24 June 1969, Brisson & Forest 21154 (UC); Gulf Hazard, 12 August 1939, Abbe & Abbe s.n. (MIN); Labrador Peninsula, Anse des Dunes, Brest, 31 July 1915, St. John 90248 (CAN); Long Island, 54°50'N, 79°40'W, 24-28 July 1949, Baldwin 1739 (MAINE); Long Island Sound, 54-45°N, 25-27 July 1947, Baldwin et al. 337 (CAN); Long Island, 25-27 July 1949, Baldwin 1737 (CAN); Ilot Des Tofieldies (Dauphin Bay) 51°11'12"N, 72°45'W, 1-7 August 1944, Rousseau & Rouleau 1282 (CAN, MT); Penin. Du Dauphin, 72°49'W, 51°15'07"W, 29 July 1944, Rousseau 1067 (US); 72°51'33"W, 51°10'39"N, 1-7 August 1944, Rousseau & Rouleau 1256 (GH); Marble Mountain, N. Canton, 19 May 1970, Hamel, Forest & Brisson 70048 (DAO); Mont Caribou, 7 June 1981, Blondeau s.n. (CAN); Mont Logan, 20 June 1948, Levesque 48400 (DAO); Mont Logan, 6 July 1937, Terrill 1715 (CAN); Riviere aux feuilles, 59°48'N, 70°05'W, 31 July 1965, Legualt 6960 (DAO); Schefferville, Sonny Mts., 0.6 mi. s. Geren Mt., 55°03'N, 67°14'W, Mäkinen 67-675 (CAN); Sunday Lake, Gorthby, Morton 3626 (WAT), 20 July 1966, Blais et al. 11433 (CAN, VT, UBC); Shickshock Mts., 27 August 1882, Macoun 31-836 (CAN); Riviere George, 57° 39, 6 August 1947, Rousseau 882, 884 (DAO, MT); Riviere Payne, 71° 23', 11 August 1948, Rousseau 1146 (DAO, MT), 11 August 1948, 1121 (DAO, GH); 56°52'N, 2 August 1947, Rousseau 675 (DAO). Mistassini Territory: Lake Albanel, Presqu'ile Sylvie, 73°43W, 51°5'44"N, 1-7 August 1944, Rousseau & Rouleau 1227 (MT); Lake Mistassini, 74°30'W, 50°26'N, Tambegwilnou Passage,20 July 1945, Rousseau 1782 (MT), Lake Mistassini, Ile Manitounouk, 12 July 1944, Rousseau & Rouleau 90 (GH, MT); Portage du Vieux-Coom, 72°49'W, 51°15'N, 29 July 1944, Rousseau & Rouleau 1063, 1065, 1066 (GH, MT), 1067 (CAN); 72°49'W, 51°15'N, 1067 (GH, MT); Pointe Raphael, 72°51'33"W, 51°10'39"N, 1-7 August 1944, Rousseau & Rouleau 1256, 1265 (MT); Pointe des Apocyn, 73°15'20"W, 50°55'30"N, 1-7 August 1944, Rousseau & Rouleau 1483 (MT). **Gaspé: Bonaventure Co.:** Bonaventure River, 2-9 August 1904, Collins, Fernald, & Pease 6738 (MT), 6740 (MICH), 6743 (F),5795, 5934 , 5935, (GH), 5793 (GH), S. N. (UC), s.n. (GH), Bonaventure River, 31 July 1931, Marie-Victorin et al. 44 601, 44 602 (GH, DAO, MT), s.n. (CAN), Bonaventure River, 24 July 1905, Churchill 92 (CU, MO), 2 August 1961, Kowal 45 & 46 (WIS), 1 July 1941, Scoggan 1804 (CAN), 2 August 1939, Scoggan 35 (CAN). **Gaspé-Est Co.:** Isle Bonaventure, 28 July 1950, Fabius & Allyne 3029 (DAO); Bonaventure Island, 9 July 1946, Proctor 2094 (MT); Bonaventure Island, Percé, 29 June 1939, Terrill 2511 (CAN); 3 mi. w. Cap-Des-Rosiers-Est, 18 August 1971, Morisset 71-581 (CAN); Cape Rosier, 9 July 1931, Stebbins 837 (DS); Grand River, June-July 1904, Fernald s.n. (GH, MT), 22 July 1951, Fr. Samuel 63. 2501 (MT), 12 August 1960, Dansereau et al. 60-1013 (MT), 21 July 1975, Churchill 722104 (MSC), 10 August 1972, Cinq-Mars et al. (DAO, PH), 3 July 1941, Scoggan 1803 (CAN); Mt. Percé, 25 July 1905, Williams. Collins & Fernald (GH, MIN); Mt. Percé, 13 August 1935, Adams s.n. (DAO); Petit Pabos River, 2 July 1941, Scoggan 1802 (CAN); Percé, Grande Coupe, 10 July 1946, Proctor 2139 (MT, PH); Percé, Grande Coupe, 24 July 1923, Marie-Victorin et al. 17 086. 087 (GH, MO, NY, US) & 088 (MT), 088 (GH, MO); Percé, Grande Coupe, 18-23 August 1940, Marie-Victorin. Boivin. Raymond & Kucyniak 3996 (MT). **Gaspé-Ouset Co.:** Mont Albert, 24 July 1953, Sylvio 4329 (MT, NY), 8 August 1940, Louis-Marie 40104 (US), 27 August 1922, Anderson 114061 (CAN), 27 August 1882; Macoun 31-837 (CAN), 27 August 1958, Brisson. Cayouette & Brassard 6035 (CAN), 24 July 1933, Fernald & et al. (GH, NY), 6 August 1923, Marie Victorin et al. 17 090 & 091 (GH, MO, MT, NY, US), 2 September 1936, Gosselin 3613 (MT, OSU, UC, UBC, US), 3617 (PH), 7 August 1923, Marie-Victorin et al. 17 089 (MT, NY), 7 July 1951, Fr. Samuel 2503 (MT), 9 July 1951, Fr. Samuel 64 (MT), 1 October 1955, Desmarais 1670 (DAO, MT), 21 July 1906, Fernald & Collins s.n. (CAN, GH, MSC, MT, VT, US), 28 August 1937, Clausen & Trapido s.n. (CU), 4 August 1965, Sherh & Cinq-Mars s.n. (DAO), 4 August 1965, Cinq-Mars et al. 65-242 (DAO), 27 July 1949, Sargent s.n. (MIN), 16 July 1964, Cinq-Mars et al. (DAO), 7 July 1946, Proctor 2061 (PH), 26 August 1947, Cody. Senn. Pore & Savile s.n. (DAO), 10 July 1963, Lepage 4937 (DAO), 10 July 1940, Scoggan 884 (CAN), 18 July 1940, Scoggan 1646 (CAN); Riviere de la Madeleine, 19 July 1935, Brûle 35 337 (MT); Saint Ann River, Parc de la Gaspésie, 31 July 1956, Raymond 68192 (MT), Saint Ann River, 18-23 August 1940, Marie-Victorin et al. 3860 (MT); Saint Ann River, 25 July 1962, Fr. Rolland-Germain 8172. 8163. 8167 (MT); Saint Ann River, 19 June 1973, Cayouette & Ouattara 73-249. 250 (CAN). **L'I sle d'Anticosti:** Cirque a la Chaloupe, 7 mi. from the ocean, 14 July 1942, Rousseau 52282. 52283 (MT); Riviere Du Brick, 23 July 1927, Marie-Victorin & Rolland-Germain 27 510. 511 (CAN, CAS, F, MO, MT, NY, PH, WS); Riviere Chicotte, 24 July 1927, Marie-Victorin & Rolland-Germain 27 512 (CAS, MT, MO, NY, UC, WIS); Riviere Jupiter, 10 August 1926, Marie-Victorin & Rolland-Germain 25233 (MT); Riviere Jupiter, 27 August 1940, Rousseau 51460 (MT), 2 July 1942, Rousseau 52069 (MT, UC), 52078 (MICH), 12 June 1961, Bernier et al. s.n. (DAO), 27 June 1974, Lemieux 15394 (CAN); Riviere à la Patate, 25 July 1925, Marie-Victorin et al. 20 100 (MT, NY, WIS, US); Patate River, 2 August 1936, Adams s.n. (DAO); Riviere au Saumon, 11 August 1927, Marie-Victroin & Rolland-Germain 27 509 (MO, MT, US); Riviere au Saumon, Ruiseau Poulin, 13 July 1942, Rousseau 52247 (MT); Riviere au Saumon, 15 mi. from the ocean, 11 July 1942, Rousseau 52209 (MT); Riviere La Loutre, 3 August 1925, Marie-Victorin & Rolland-Germain 25 197 (MO, MT, US); Riviere Pavillon, 17 July 1942, Rousseau 52313 (MT); Riviere Vaureal, 27 July 1925, Marie-Victorin & Rolland-Germain 20495. 20496. 20497 (MT, US, NY); Riviere Vaureal, 10 July 1942, Rousseau 52153 (MT); Riviere Vaureal, 8 July 1942, Rousseau 52087. 52114 (DAO, MT). **Matane Co.:** Mt. Collins, Nettle Gully, 9 July 1923, Fernald et al. 25509 (CAN, CAS, F, GH, MO, MT, NY, UC, US); Mt. Pembroke, Kowal 78 (WIS); Hudson Bay, Cairn Island, 6 July 1939, Abbe 3180 (GH, MICH, MIN, PH, RM), 3153 (CAN, DS, US, UC); Cairn Island, Hudson Bay Narrows, 28 July 1939, Abbe & Abbe 4227 (MIN); south Carin Island, 5 July 1939, Abbe & Abbe 3153 (DAO); Cape Jones, n. of portage, 24-25 June 1947, Baldwin. Hustich. Kucyniak & Tuomikosky 333 (CAN, WS); Cape Jones, 31 August 1920, Johansen s.n. (CAN); Churchill, 19

July 1938, Duman 1038 (MT), 1144 (PAC), 1246 (UC), 1466 (BH); Black Whale Harbour, 28-29 July 1947, Baldwin, et al. 335 (CAN, MICH, MT). James Bay, Opinaca River, 54°12'N, 26 August 1953, Dutilly 31622 (MT); South Twin Island, 53°8'N, 80°0'W, 15 July 1929, Porsild 4213 (CAN); Solomons Temple Island, 14-17 July 1949, Baldwin 1657, 1693 (CAN); Bear Island, 17 August 1947, Coates s.n. (CAN); Pte. au Huard, Pint Hills, 11 July 1947, Baldwin et al. 334 (CAN); Long Island Sound, 54-45N. Baldwin et al. 337 (MT); Port Burwell, 60°22'N, 64°50'W, 25-28 July 1928, Malte 120061 (CAN, GH, US), 120134 (CAN, WS), 121049 (MICH), 120166 (CAN); 3 September 1928, Malte 121-49 (SASK); Port Harrison, Malte 120837 (CAN, UC); Port Harrison, 58°17'N, 78°10W, 18-20 August 1928, Malte 120819 (CAN); Richmond Gulf, 14 August 1944, Lepage & Dutilly 13103 (GH); Smith Island, east coast of Hudson Bay, 60°47'N, 78°36'W, 24 August 1928, Malte 120899 (CAN, GH, MT). **Ungava District**: Knob Lake near Lake Gillard, 16 August 1948, Hustich 540 (GH, MT); Manitounok Islands, 55°40', Dutilly 14229 (US); North Sleeper Island, 59°17'N, 80°40'W, Dutilly, O'Neill & Duman 875668 (CAN, UC, US); Pattee Island, 59° 42'N, 80° 9'W, Dutilly, O'Neill & Duman 87524 (US); Payne Bay Post, 13 August 1948, 1250 Rousseau (MT); Payne River, near 60° N, 71°25', 11 August 1948, Rousseau 1121, 1143 (MT); Portland Island, 55°20'N, 78°50'W, 13 September 1939, Dutilly, O'Neill & Duman 87948 (BH, DAO, GH, MIN, MT, PAC); Porpoise Cove, Hopewell Sound, 10 September 1039, Dutilly, O'Neill & Duman 87799 (USAS, US); Port Manvers, 56°58'N, 61°23'W, 9 August 1939, Dutilly, O'Neill & Duman 7726 (DAO), 14 July 1937, Potter s.n. (US), 14 July 1937, Walker 488 (PH, US); Mont Reed, 52°1', 68°05', 20 July 1961, Landry 762 (MT), 13 August 1951, Landry 734 (DAO, MT); Ungava Bay, near Korok Bay, 21 July 1951, Rousseau 416 (MT); Ungava Bay, sw. coast near Tasiujag, 59°00'N, 70°00'W, 6 August 1977, MacInnes 5158; Ungava Bay, Erik Cove, 14 August 1965, Bartley 172 (CAN), 13 August 1965, Bartley s.n. (CAN); Windly Tickle, 55°46'N, 60°20'W, Dutilly, O'Neill & Duman 7459 (US); Walrus Point, 53-42°N, 13 July 1947, Baldwin et al. 336 (CAN); Wakeham Bay, 61°40'N, 72°5'W, 30 July 1928, Malte 120262 (CAN); Wakeham Bay, 20 July 1938, Dutilly, O'Neill & Duman 6004 (US).**County unknown**: Little Eclipse Lake, 55°25'30", 67°44'30", summer 1953, Grayson 234, 261, 277, 370 (MT); Mont Blanc, 9 July 1961, Cinq-Mars et al. s.n. (DAO, MT), 2 July 1945, Terrill 4142 (CAN), 27 July 1940, Terrill 3189 (CAN), 29 June 1941, Terrill 3946 (CAN), 12 July 1950, Le Gallo 1133 (DAO, RM); Tabletop Mt., 27 July 1940, Scoggan 1237 (CAN); York River, Copper Mines, 21 August 1947, Dansereau et al. 126 (MT). **SASKATCHEWAN**: Churchbridge, e. Yorktown, Grand Trunk Pacific Railway, 4 July 1908, Macoun & Herriot 72763 (GH, US); Dry Lake, 12 mi. s. Indian Lake, 16 June 1964, Ledingham et al. 3736 (DAO); Dry Lake, s. Indian Head, 16 June 1964, Jones & Ledingham 28 (USAS); Hasbala Lake, 59°55'N, 102°05'W, 13 July 1963, Argus 173-63 (CAN, DAO, GH, SASK), 18 July 1963, Argus 327 (DAO, SASK), 339-63 (CAN, SASK), 28 July 1962, Argus 842-62 (SASK); Humboldt, 8 July 1960, Russell & Russell s60059 (DAO); Insinger, 5 mile north, 15 June 1952, Boivin & Alex 9313 (DAO, SASK); Kisbey, 13 July 1951, Boivin & Dore 7821 (DAO); 40 mi. south of Lake Athabasca, w. side Carswell Lake, 58°35'N, 109°25'W, Argus 561-62 (DAO, SASK); Lake Athabaska, Cornwall Bay, 59°27'30"N, 108°27'30"W, 12 July 1935, Raup 6522 (CAN, DAO, F, GH, NY), 8 July 1935, Raup 6448 (CAN, CAS, GH, NY); Lipton, Clokey 294 (UC, US); Lake Louise, 10 July 1927, Fraser s.n. (SASK); McIntyre Creek, 1 mi. e. Quantock, 7 August 1980, Ledingham 6840 (USAS); Meunster, 11 July 1928, Ledingham s.n. (SASK); Muenster, 26 July 1936, Russell s.n. (DAO); Mortlach, 12 June 1950, Ledingham 791 (USAS); Paterson Lake, 59°55'N, 102°20'W, 27

July 1963, Argus 443-63 (SASK); Patience Lake, 3 June 1940, Ledingham s.n. (SASK), 16 June 1940, Fraser & Ledingham s.n. (RM); Pipestone Valley, 10 mi. s. Broadview, Ledingham, Roney & Zacharioas 3777 (DAO, USAS); Prince Albert, 19 June 1949, Ledingham 49-251 (MT, SASK, USAS), 24 May 1952, Ledingham & Hudson s.n. (DAO), 25 August 1933, Fraser s.n. (SASK, USAS), 23 July 1936, Ledingham s.n. (SASK, USAS), 13 July 1934, Fraser s.n. (SASK), 30 June 1935, Fraser 37 (DAO), 23 June 1933, Fraser s.n. (SASK), 8 June 1937, 6 June 1935, Fraser s.n. (USAS, WIS), 24 June 1940, Fraser & Ledingham s.n. (PAC, USAS, WIS), 19 June 1949, Ledingham 49-251 (DAO), 12 July 1933, Fraser 11 (ALTA), 8 June 1937, Ledingham 126 (ALTA), 4 July 1896, Macoun 13609 (CAN); Quill Lake, 26 July 1936, Breitung s.n. (SASK, USAS); Quillwort Lake, s. Hasbala Lake, 59°54'N, 102°05'W, 28 July 1962, Argus 843-62 (SASK), 842-62 (DAO, US); Raymore, 12 mi. n. Tower, 4 July 1976, Hudson 3166 (DAO, SASK, USAS); Richard, 13 June 1952, Jenkins 1234 (DAO); Saskatchewan Plains, 4 August 1872, Macoun s.n. (NA), 22 August 1872, Macoun s.n. (GH); Scott, 24 July 1916, Malte s.n. (CAN); Sutherland, 25 June 1940, Fraser s.n. (CAN, SASK); Watson, 19 July 1952, Russell 521 87 (DAO); Wood Mountain Post, 24 July 1966, Hudson s.n. (SASK), 2327 (DAO); Wiseton, 27 May 1978, Hudson 3513 (DAO, SASK, USAS); Wadena, Ledingham s.n. (SASK); e. Yorkton on Grand Trunk Pacific Railway, 4 July 1906, Macoun & Herriot 72763, 72764 (F); 5.5 mi. n. and 2 mi. e. junction Hwy. 5 & 11, 26 July 1971, Skoglund 589. **YUKON TERRITORY**: Atlin Lake, 60°22'N, 133°51'W, 19 August 1943, Raup & Correll 11438 (MICH); Alsek River Valley, near mi. 1021, 60°47'N, 137°38'W, 26 June 1944, Raup & Raup 11933 (AA, CAN); Blackstone Valley, along Demster Hwy. Mile 83, 4 July 1968, Porsild 1513 (CAN); Boulder Creek, 68°27'N, 138°13'W, 22 June 1974, Nagy & Goski 74-159 (DAO); Bridge Creek, 61°35'N, 138°50'W, 6 July 1948, Raup, Drury & Raup 13420 (AA) 13433, (AA) 13345 (AA, CAN, GH), 13378 (CAN, GH), 13379 (AA) British Mountains, 69°13N', 139°37'W, 21 July 1972, Wein et al. 264 (DAO); Chappie Lake, 65°46'N, 134°42'W, 10 July 1972, Harrington cr-72-19-6-7 (CAN); 90 mi. nw. Dawson City, se. Mt. Klotz, 62°21'N 140°06'W, 6 July 1973, Greene 386, 389 (ALTA, DAO); 65°22'N, 140°06'W, 5 July 1973, Greene 311 (ALTA), 4 July 1973, Greene 281 (ALTA); Dawson, May 1898, Maclean s.n. (UC); Donjek River, 11 August 1927, Müller s.n. (NY); Firth River, 69°22'N, 139°25'W, 18 July 1972, Wein et al. 269c (DAO), 21 July 1972, Wein et al. 279c (DAO); 68°50'N, 140°33'W, 15 mi. s. Joe Creek, 28 July 1962, Youngman & Tessier 161 (CAN); 69°30'N, 139°20'W, 6 August 1953, McEwen 149 (CAN); Kaskawulsh nunatak, jct. n. and central arms Kashawulsh Glacier, w. Kuluane Lake, July-August 1965, Murray & Murray s.n. (DAO), 77 (CAN, CAS); Kaskawulsh Glacier, 60°49'N, 138°44'W, 23 July 1966, Murray & Murray 610 (CAN); Keno Hill, 63°58'N, 135°42'W, 25 July 1967, Porsild 959 (CAN); Kuluane River, 20 June 1962, Spetzman 99 (CAN); Kluane Lake, Burwash Landing, 3 July 1943, Clarke 211 (CAN); Kluane Lake, 61°03'N, 138°31'W, 2 July 1944, Raup & Raup 12100 (AA, CAN, MICH); Kluane Lake, Slim's River 60°57'N, 138°25'W, 15 July 1944, Raup & Raup 12483 (AA); Lake Kluane, 1920, Müller s.n. (NY); Lake Kluane, 61°03'N, 138°30'W, 22 July 1967, Leena, Häet and Ahti 728 (WIS); Kuluane National Park, Bullion Creek-Sheep Creek Plateau, ca. 7 km. nw. Slims River, 3 July 1975, Douglas 8471 (DAO); Kuluane National Park, Dezadeash Lake, (Mile 132, Haines Highway), 16 July 1973, Douglas 5985 (DAO); Kuluane National Park, Fisher Glacier, 60°03'N, 137°53'W, 29 July 1975, Weaver 436 (DAO); Kuluane National Park, Onion Lake, ca. 46 mi. s. Haines Junction, 12 August 1973, Douglas 7052 (DAO); Onion Lake, 18 July 1975, Weaver 212 (DAO); Kuluane National Park, Sheep Mountain near Kuluane Lake, 18 July

1970, Krajina & Hoefs s.n. (DAO, UBC); Lapie Lake, near Mile 105, Rose-Lapie R. Pass, 10 June 1944, Porsild & Breitung 9290 (GH); McQuesten area, 63-64°N and 136-138°W, 12 August 1948, Campbell 809 (CAN); Mile 123 Haines Highway, (ca. 6.5 km W of), 11 July 1975, Weaver 137, 138 (DAO); 24 Mile Cabin on 60 Mile Road from West Dawson to Alaskan border, 64°13'N, 140°06'W, 15 August 1949, Calder 4517 (CAS, RM, MT, NA, WS), Calder & Bellard s.n. (CS); 60 Mile road, 57 mi. from Dawson to Alaskan border, 64°05'N, 140°53'W, 9-10 July 1949, Calder & Billard 3590 (DAO); 60 Mile road, on 60 mile road from Dawson to Alaskan border, 64°13'N, 140°06'W, 15 August 1949, Calder & Billard 4517 (DAO); Mile 85 Haines Road, 17 July 1944, Clarke 554 (CAN); Mt. Caribou, n. of Carcross, 60°14N 134°42'W, Calder 4528 (MT), 17 August 1949, Gillett & Mitchell 4528 (BH, DAO, NA); Mt. Sedgwick, British Mts. 68°53'N 139°06W, 19 July 1962, Calder 34460 (DAO); Mt. Schaeffer, 67°43'N, 139°48'W, 10 August 1971, Wein et al. 142d (DAO), 12 August 1971, Wein et al. 146k (DAO); Mt. White 7 mi. e. Little Atlin Lake, 19 August 1943, Raup & Soper 11438 (SASK), 13 August 1943, Raup & Corell 11298 (SASK); Old Crow Flats, 68°15'N, 138°50'W, 11 July 1970, Welsh & Rigby (NY); Ogilvie Mts. 65°37'N, 138°56'W, 26 July 1960, Calder & Gillett 26004 (DAO); Ogilvie Mts., along Dempster Rd. Mile 51-52, 17 July 1966, Porsild 211 (ALTA, CAN, UBC); Mile 57, 19 July 1966, Porsild 232 (CAN), 31 July 1966, 396 (GH); Mile 61, Dempster Hwy, 15 June 1969, Packer 186 (ALTA); 52 mi. ne. Dawson, 15 July 1963, Youngman & Tessier 342, 343 (CAN); Ptarmigan Heart, 61°49'N, 138°35'W, 16 July 1948, Raup, Drury & Raup 13701 (AA, CAN, MICH), 13741 (AA); 61°44'N, 138°32'W, 13 July 1948, Raup, Drury & Raup 13596 (AA, CAN, UBC); 2 mi. w. Sam Lake, 16 June 1974, Nagy & Goski 74-89, 74-87, 74-290 (DAO); Rampart House on the Yukon-Alaska border, 21 July 1951, Loan 624 (DAO, MT); Red Tail Lake, 61°50'N, 138°52'W, 9 July 1948, Raup, Drury & Raup 13469 (AA, CAN); Ruby Range, Gladstone Creek, 61°17'N, 138°36'30"W, 12 July 1966, Neilson 816 (CAN); St. Elias Mts. Steele Glacier, 5-10 August 1967, Murray & Murray 1339 (CAN); St. Elias Mts., Dezadeash River Valley, 3 June 1967, Pearson 67-22 (CAN); Sam Lake, 13 July 1974, Nagy & Pearson 74-304 (DAO); Spruce Creek, 19 July 1974, Nagy & Pearson 74-477 (DAO); Upper Bonnet Plume River, Pinguicula Lake, 64°13'N, 133°27'W, 11 August 1964, Hultén s.n.; Yeiken River, Rink Rapids, 9 July 1902, Macoun 53898 (CAN, NY); White River on Alaska Hwy., 21 July 1944, Anderson 9308 (CAN, GH); 68°33'N, 138°31'W, 10 August 1972, Wein et al. 161 (DAO); 67°39'N, 139°12'W, 29 June 1972, Wein et al. 166d (DAO); 68°12'N, 139°49'W, 20 July 1974, Nagy et al. 74-526 (DAO); 60°22'N, 133°51'W, 13 August 1943, Raup & Correll 11298 (MSC).

FRANCE: Miquleon, Cape Miquleon, 27 July 1937, Hors 50 (MT); 22 July 1942, Le Gallo 187 (MT); Voiles Blanches, 17 August 1939, Hors 50-a (MT).

GREENLAND: Arfersiorfih Fjord, 19 July 1924, Porsild s.n. (CAN, GH, MO, NY, US); Arsuk Fjord, 24 June 1888, Kolderup Rosenvinge (BH); Amitsuarssuk, 60°08'N, 44°45'W, 7 August 1967, Hansen, Kliim-Nielsen & Øllgaard 67-1920 (DAO); Angmagssalik Dist, Gingertivag, 14 July 1969, Hamann & Kliim-Nielsen 69-1368 (NY),69-1367 (MO); 65°59'N, 37°26'W, Astrup & Kliim-Nielsen 25 (NY); Angmagssalik Fjord, 65°50'N, 37°07'W, 8 July 1967, Elsley 26/67 (MO); Augpilagto, 22 July 1966, Gravesen & Hansen 66-2034 (CAN, NY); Battle Harbour, 29 June 1883, Waghorne s.n. (MO); Cape York, 23 July 1894, Peary Auxilliary Expedition, Wetherill 51 (GH); Disko, Arktiske Station, ca. Neria, 61°33'N, 4 August 1931, Eugenius s.n. (MT), 12 August 1930 (MO, US), 16 August 1936, (UC), 7 June 1931, Eugenius s.n. (UC, US), 5 May 1928, Eugenius s.n. (F), 15 July 1965, Johansen 65-2452 (UC), 7 June 1933, Porsild 131256 (CAN, UC), 1 September 1925, Eugenius s.n. (CAN, MO); Disko Island, Mudderbugtsdalen, 69°40'N, 4-5 August 1937, Porsild 377 (CAN); Egalugialik, Itivdleg, 64°21N, 50°27W, 5 August 1973, Feilberg s.n. (NY); Egalungmiut, August 1970, Neilsen (NY); Egalungmiut, 63°28'N, 41°55'W, 15 August 1970, Astrup & Kliim-Nielsen 698 (MO); Disko Island, Skansen, 21 June 1928, Erlanson 2932 (DAO, MICH); Disko Island, Godhaven, 8-10 August 1937, Porsild 337 (CAN, NY, US), 10-20 September 1922, Porsild s.n. (CAN, GH, MIN, NY, US), 27 July 1923, Ekman (NY), Grontved s.n. (CU), 25 September 1927, Erlanson 2631 (DAO), 27 September 1927, Erlanson 2631 (MICH), 2709 (DAO), Nygand s.n. (MO, UC), July 1934, Lagerkranz s.n. (DAO); Ella Island, Cape Oswald, Ulvedalen, 72°52', 25°10', 24 July 1932, Sørensen 3120 (CAN); Fiskenaesset, 63°13'N, 50°14W, 16 July 1972, Andersen & Feilberg 4301 (MO); Gâoseland, Faxe Sø, 70°15', 29°, 21 July 1958, Holmen & Laegaard s.n (DAO); Godthoats, 64°12'N, 27 June 1927, Erlanson 2355 (MICH); Godhaab Gulf, Jordan Hill, 74°07', 27 July 1930, Seidenfaden 825 (NY) 828 (US); Heath, Pâut, 26 July 1928, Erlanson 3367 (MICH) Higerdleg, 62°04'N, 49°20'W, Johansen 65-2188 (UC); Hurry Fjord, 70°52'N, 22°30'W, Liverpool Land, 14 July 1963, Taggart s.n. (CAN); Igdlorssuit, 17 July 1966, Gravesen & Hansen 66-1848 (MO); Igdlorssuit, 23 July 1925, Porsild (US) Ilua Fjord, Porsild s.n. (NY); Ikâsaulaq, 65°59°N, 37°26'W, Astrup & Kliim-Nielsen 25 (MO); Ikertog, 66°56', 52°20', 31 July 1978, Moller s.n. (COLO); Ikerasak Umanaq Distrikt, 70°29'N, 9 July 1929, Porsild s.n. (CAN, MT); Inigssuamdn, Seidenfaden 388 (NY); Itivdlerssuaq, 60°10'N, 44°29'W, 28 July 1967, Hansen. Kliim-Nielsen & Øllgaard 67-535 (CAN); Julianehaab, near Søen, 30 August 1937, Grøntved 2114 (DAO); Kanaluk, 69°74', Kruse (NY); Kangerdlugsuak, Knud Rasmussen Land, Skaergaerd Peninsula, 17 August 1936, Wager & Wager s.n. (DAO), 3 July 1936 Wager & Wager (DAO); Kangerdlugsuak, Irminger Fjord, 23 August 1935, Wager & Wager (DAO, PH); Kangerdluk, 60°13'N, 44°19'W, 11 July 1966, Gravesen & Hansen 66-1253 (DAO); Kangerssuneq, Igdlorssuit, 20 July 1967, Hansen et al. 67-1336 (PH); Kangerssuneq Quigordleq, Anivia, 60°19'N, 44°07'W, 4 July 1966, Hansen 66-1047 (MO); Kiagtut Sermia Glacier, Narssarssuaq, 61°12'N, 45°20'W, Ray 205/69; Kjerulf Fjord, 8 August 1937, Oosting 1014 (CAS); Kong Oscars Fjord, 72°14'N, 23°55'W, 1 July 1956, Raup. Raup & Washborn 25 (CAN), 13 July 1956, 63. 64 (GH); Kûngmiut, 60° 00'N, 44°28'W, 2 July 1967, Hansen. Kliim-Nielsen & Øllgarrd 67-924. 969 (NY), s.n. (RM), 67-1032 (MO); Lake Hullet, 61°28'N, 45°15'W, Ray 123/69 (MO); Lakesfjord, Kingna, 72°30', Porsild s.n. (MO); Lukketopyn, 15 July 1895, collector unknown (UC); Musk-ox Fjord, 9 August 1929, Seidenfaden 271 (MT, NY), 13 August 1930, Seidenfaden s. n. (NY); Nanortalik, 60°09', 45°15', Hansen. Petersen. Smitinand (UC); Neria, 61°33'N, Eugenisus s.n. (US); Nigerdleq, 21 June 1966, Jørgensen & Larsson 66-119 (CAN, NY), 25 June 1966, 66-128 (CAN, MO), 66-129 (DAO), s.n. (CAN); Nigerdleq, 62°04', 49°20', 4 July 1966, Jørgensen & Larsson s.n. (DAO); Pamiagdluk, Sagsivik, Hansen. Kliim-Nielsen. & Øllgaard 67-807 (DAO), 67-808 (PH); Pamiagdulk, Kûngmiut, 60°00'N, 44°28'W, 2 July 1967, Hansen. Kliim-Nielsen & Øllgaard (CAN); Praestefjeld, 66°55', 53°35', 5 July 1949, Gelting s.n. (COLO); Quinqua, 60°21'N, 23 July 1925, Porsild & Prosild s.n. (US); Scoresbysund, 71°20', 24°40W, 13 August 1937, Sørensen 259 (MT), Sørensen s.n. (DAO); Skeldal, 72°15'N, 24°W, 16 July 1963, Spearing et al. 171 (MICH); Söudre Strömfjord, 7 August 1927, Erlanson 2584 (MICH, NY), 13 July 1927, Erlanson 2441 (DAO, MICH), 20 July 1927, Erlanson 2478 (DAO, MICH), 22 July 1927, Erlanson 2497 (DAO, MICH), 23 July 1927, Erlanson 2529 (MICH); Sydkepoen, 71°20', 24° 40', SØrensen 257, 259 (US); Tasiussakasik, 61°38'N, 49°'W, Johnsen 65-54 (UC); Tasissårssik Fjord, 66°05'N, 37°00'W, 14 July 1963, Gribbon 28 (CAN); Tasiusak, 61°45', 25 July 1889, Hartz s.n. (MO); Tasersuak, 69°31', 7 July 1888, Hansen s.n. (MO); Tasersiaq, Cache Point, 14 August 1962, McCormick 201 (PH); Thafjorden, 11 August 1935, Lagerkranz s.n. (UC); Tornarssuk, Nûa, 59°54'W, 44°21'W, 1 August 1967, Hansen et al. 67-1794 (PH); Trail Island, Holm's Bay, 11 August 1929, Vaage s.n. (DAO); Tunugdlairfick, MÂjût, 61°04'W, 45°35'W, 31 August 1962, Hansen, Hansen & Petersen 2235 (DAO); Tunah, 65°54', 28 June 1902, Kruse (UC), 62°04', 49°20', 4 July 1966, Jorgensen, Larsson s.n. (VT), 71°15',24°40'W, Sørensen s.n. (DAO), Umiarfik Fjord, Vestside, Niaqornaq, 7 September 1934, Porsild s.n. (MO); Ymer Island, Botanikerbugten, 73°08', 25°10', 18 August 1932, Sørensen 3116 (CAN).

NORWAY: Norland Province, Junkerdalen, Salten, Mt. Solvagtind, 66°48'N, 15°35'E, 9 August 1859, Behm s.n. (UC), 8 August 1859, Schlyter & Behm s.n. (F, NY), 12 August 1869, Schlegel & Arnell s.n. (F, NY, UC, US), 18 August 1883, Nessen 805 (F), 18 August 1883, Mörner s.n. (NY, RSA, RM, US), August 1883, Torsell s.n. (MT), 9 July 1948, Jordal 1202 (F, MICH), 1 August 1952, Rune s.n. (MT), 15 July 1918, Landmark s.n. (SASK), 5 August 1923, Jorgensen s.n. (MT), 1926, Johnsson s.n. (NY, UC, US), July 1907, Holgersen s.n. (CU), 19 August 1904, Greldberg s.n. (UC), 1 August 1894, Dyring s.n. (MT), 22 July 1897, Dyring s.n. (MT, NY, RM), 7 August 1899, Dyring s.n. (MO, MT, UC, WS), August 1904, Peters & Pettersson s.n. (DAO), August 1883, Forssell s.n. (MO)

SOVIET UNION (Russian Federation Socialist Republic): Kamchatka Oblast, Koryaksky National District, Olyutorsky region, Verkhoturova Island, 26 July 1975, Kharkevich & Kozhevnikov s.n. (ALA, DAO, UBC). Madadam Oblast, Chukotskiy Peninsula, (north-east coast) near the mouth of the Chegitum River, 12 August 1971, Sekretareka, Sitin & Yurtsev (ALA); Middle branch of the Erguveem River (left bank) near the mouth of the Vatamkaivan River, Pepenveem River, 1 August 1970, Nechaeva (ALA); middle branch of the Utaveem River, 25 August 1970, Kozhevnikov, Nechaev & Yurtsev (ALA); coast of the Bering Strait, Puoten Bay, 21 August 1972, Gorbukova, Makarova & Plieva (ALA); Amguenii River Valley, middle branch, 87 km. Evgekinot-Iultin Road, 5 August 1970, Kozlova (ALA); Amguemi River Valley, middle branch, 115 km. on the Evgekinot-Iul'tin Road, 25 August 1970, Kozlova (ALA); North part of the Gulf of Laurentiya, 13 August 1969, Afonina & Korobsov (ALA); Iul'tinsk Region, near the Egvekinot-Iul'tin Road, 16 July 1978, Razhivin (ALA); Anadirskii Region, southern extremity of the Pekul'nay Mountains, middle branch of the southern Pekul'nayevem River, 8 August 1979, Korobkov & Sekretareva (NY); Anyuiskoye Upland, 15 August 1973, Petrovsky (ALA); southern spur of the Teniah Mts., at the source of the Loran River, 14 August 1972, Gorbukova, Makarova & Plieva (ALA); south-western coast of the Chukotskiy Peninsula, near Nunligran settlement, 28 August 1970, Afonina, Korobkov, Plieva & Khrenov (ALA); Anyuiskoye Upland, Pogingen River, 8 August 1976, Petrovsky & Korobkov (ALA); eastern Chukotka, Iskaten Mountain pass, near km. 32 Egrekinot-Iul'tin Road, 2 August 1971, Katenin, Kostina, Sakhorukova, Kozhevnikov, Pileva & Efros (ALA, DAO); Tschukotsky, Iultinsky, 14 August 1967, Derviz-Sokolova (MICH, NY).

UNITED STATES: ALASKA: Alaktak, Half Moon, 70°45'N, 155°00'W, 1 August

1949, Spetzman 2439 (CAN, US); Anaktuvuk Pass, 12-15 August 1960, Hultén s.n. (GH); Arakamtchetchene Island, Bering Strait, U.S. N. Pacific Explor. Exp. 1853-56, Wright (NY); north slope of Alaktak, Half Moon, Spetzman s.n. (MIN); Alaska Yukon Boundry, 10 August 1961, Hultén (NY); Alaktak, 155°, 70°45', Scholander s.n. (DAO); ca. 15-16 km. Atkasuk, Meade River, ca. 100 km. ssw. Barrow, 70°28'N, 157°25'W, 7 August 1966, DeBenedictis 534 (CAN, DAO); Meade River, 35 mi. s. Atkasuk, 70°03', 157°15'W, 23 August 1956, Wiggins 13939 (DS, GH, US); Meade River, 45 mi. s. Pt. Barrow, 70°42', 156°38', 10 July 1951, Wiggins 12697 (DS); Meade River, 50 mi. s. Pt. Barrow, 70°40', 156°55'W, 18 July 1952, Ward 1214 (DS, GH, US); Azimuth Peak, 2 mi. Tanis Lake, 59°15'N, 138°30'W, 20 June 1967, Argus & Chunys 6260 (CAN, SASK); Barrow Base, Meade River, 10 July 1951, Wiggins 12697 (US); Benites, Cantlon 4553 (MSC); Bering Strait, Seward Peninsula, Cape Prince of Wales, Village Creek Valley, June-August 1978-80, Kelso, Flock & Colson 287 (CAN, COLO, MICH, NY); Bonanza Creek, Eagle Summit, 16 July 1949, Scammon 5270 (GH); Brooks Range, airstrip at 'Nolan', 19 June 1949, Jordal 1839 (BH, MICH); Brooks Range, Umiat, 23-29 July 1960, Hultén s.n. (US); Brooks Range, Anaktuvuk, 12-13 August 1960, Hultén (NY, US); between Cantwell & McKinley Peak, 30 July 1964, Viereck 7413 (RM); 12 km se. Cape Sabine, w. Pitmegea River, 13 July 1959, Shetler & Stone 3249 (CAN, MICH); 40 mi. e. Cape Lisburne, w. bank Pitmegea River, 26 June 1957, Cantlon & Gillis 57-275 (MSC); 2 July 1957, 57-504 (MSC); Cameron Creek, 7 September 1939, Moss 634 (GH); Camp Columbus, 49°04'N, 113°53'W, 16 June 1969, Nagy & Blais 1071 (DS); Cane Creek, 35 mi. n. Arctic Village, 68°41'N, 145°00'E, 27 August 1973, Hettinger 981 (ALTA), 976 (ALTA); 38 mi. nne. Arctic Village, 27 August 1973, Hettinger 585a (CAN), 5764b (CAN); 46 mi. nnw. Arctic Village, 68°40'N, 146°30'W, 18 August 1973, Hettinger 814 (CAN); Cane Creek, 68°35'N, 144°50'E, 8 August 1972, Hettinger 159 (ALTA); Cape Beaufort, 3-7 August 1961, Hultén s.n. (DAO, GH); Cape Nome, 1900, Blaisdell s.n. (US); Chip River, 70°26'N, 154°50'W, 17 July 1956, Wiggins 13674 (DS, US); Chitina River head, 16 June 1925, Laing 20 (CAN); Chugach Mts., Anchorage, 29 June 1948, LePage 23355 (US); Chugach Mt., Worthington, 8 July 1961, Hultén (GH, NY, US); Circle Hot Springs, 138 mi. n. Fairbanks, 17-22 July 1936, Scamman 69 (GH); Colville River, 150°45'W, 69°45'N, 10 August 1953, Cantlon et al. 649 (MSC); Colville River, 150°45'W, 69°45', 12 August 1953, Borman, Rebuck & Cantlon 670 (MSC); Colville River, 3 mi. n. junction of Chandler River, 69°30'N, 151°30'W, 25 July 1951, Chambers 251 (DS); Deering, 13 August 1938, Anderson 4797 (CAS); Delta River, s. of Donnely Inn, 10 August 1966, Foote 8075 (RM); Daipaious Creek, 21 July 1958, Packer s.n. (ALTA); Donnely Dome, Mile 250 Richardson Hwy., 63°47'N, 145°45'W, 2 August 1951, Cody 6284, 6286 (DAO); Donnely Dome, Mile 242.6, 2.5 miles n. Donnely, 15 July 1951, Cody & Webster (CAS); Donnely Dome, Richardson Hwy., 63°47', 145°45'W, 30 June 1957, Argus 1075 (DS, DAO, RM, SASK); Dry Creek, 63°53-59'N, 147°20-35'W, 2 July 1962, Viereck & Jones 5775 (CAN); Eureka, Glen road, 16 July 1947, Dutilly, LePage and O'Neill 21305 (US); Farwell Lake, 62°33'N, 153°36'W, 3-4 August 1949, Drury 2463 (GH); Falls Creek, Mile 229 Richardson Hwy., 63°32'N, 145°52'W, Cody 6323 (DAO); Fairbanks, Miller House on Steese Hwy., 12-28 July 1940, Scamman 2009 (GH); Firth River, 2 mi. s. junction Firth & Mancha Creek, 11 August 1961, Stone (RM); Firth River, Mancha Creek, 10-15 August 1961, Hultén s.n. (AA, NY); Fish Creek, 70°19'N, 151°58'W, 26 July 1977, Murray & Johnson 6532 (CAN); Grayling Lake, 65 mi. ese. Arctic Village, 67°57'N, 143°10'E, 27 June 1973, Janz & Boyce 81 (ALTA); Hettinger 81 (CAN); Healy, 1922, Anderson 1509 (NY); Healy, 23

July 1939, Anderson 5766 (CAN); Independent Ridge, 20 June 1957, Spetzman s.n. (US); Index Mountain 40 mi. ene. Arctic Village, 68°15'N, 144°10'E, 11 July 1973, Hettinger 235, 246 (CAN, ALTA); Itkillik River, 150°33'W, 12 August 1953, Cantlow s.n. (MSC); Jago Lake, 143°47'W, 69°26'N, 23 July 1957, Cantlon & Gillis 57-1295 (MSC); Jago River, 143°39'W, 69°23'N, 13 July 1957, Cantlon & Gillis 57-8023, 57-980 (MSC); Jago Lake, 143°47'W, 69°26'N, 2 August 1957, Cantlon & Gillis 57-1728 (MSC), 143°47'W, 69°26'N, 24 August 1957, Cantlon & Gillis 57-1402, 1406, 1407 (MSC), 143°42'W, 69°26'N, 15 July 1957, Cantlon & Gillis 57-1036 (MSC), 143°47'W, 69°26'N, 27 July 1957, Cantlon & Gillis 57-1537 (MSC); Juneau Ice Field, Death Valley, 58°30'N, 134°15'W, Argus 178 & 196 (SASK); Juneau, Coville 549 (US); Juneau, 6 June 1896, Kearney s.n. (US); Kanayut Lake, 68°20'N, 151°00'W, 17 July 1949, Spetzman s.n. 1966 (CAN, MT); Kaolak River, 69°57'N, 160°W, 23 August 1956, Wiggins 13974 (DS, US); Karluk, July 1901, Horne n. s. (NY); Katzebue, 12 August 1938, Anderson 4678 & 4679 (CAS); e. bank Kaolak R, 69°57'N, 160°, 23 August 1956, Wiggins 13974 (DS); Kiigluaik Mt., 49 mi. on Noew Taylor Hwy., 65°00'N, 164°38'W, 14 July 1981, Harris 1368 (ALTA); King Lodge, Border, Dawson Road, (e. of Chicken), 12 July 1963, Spetzman 4883 (CAN); Kodiak, 28 July 1904, Piper 4776 (US); Kodiak Island, trail over Mt. to Sturgeon River near Karluk, Rutter s.n. (DS); Kogosuknuk River, 151°45'W, 69°45'N, 16 July 1953, Borman, Rebuck & Cantlon 351 (MSC), 441 (MSC); 151°40'W, 69°46'N, 16 July 1953, Borman Rebuck & Cantlon 398, 403 (MSC), 19 July 1953, 470 (MSC); Kongakut River Hill, 138 mi. nne. Arctic Village, 69°34'N, 141°50'E, 19 July 1973, Hettinger 347 (CAN, ALTA); Kongakut River, 152 mi. nne. Arctic Village, 69°35'N, 141°40'E, 16 July 1973, Hettinger 306 (ALTA, CAN) 307, 320 (ALTA); Kaness River, 15 mi. sse. Arctic Village, 67°46'N, 143°45'E, 3 July 1973, Hettinger & Boyce 175 & 176 (ALTA); Kaness River, 55 mi. sse. Arctic Village, 3 July 1973, Hettinger 171 (CAN); Kotzebue Sound, 9-16 August 1945, Scamman 3967 (GH); Kotzebue, 12 August 1938, Anderson 4679 (CAS); Kuskokwim River, Farewell Mt., 62°33'N, 153°36'W, 8 August 1949, Drury 2691 (GH-3), 8 August 1949, 2734 (CAN), 14 August 1949, 2935 (GH); Big River, 61°55'N, 154°25'W, 10 July 1950, Drury 4211 (GH), 415 (GH); Big Wash, 61°52'N, 154°33'W, 3 July 1950, Drury 3824, 3884 (GH); Kuskokwim River, Swift River, 62°40'N, 152°30'W, 19 July 1961, Viereck 5067 (CAN); Kenai Peninsula, Steton Creek Valley, 3 August 1951, Calder 6444 (CAS, DAO); Moose Pass, 60°32'N, 149°32'W, 31 July 1951, Calder 6388 (DAO); 5 mi. on Portage Rd., from Hope-Seward-Anchorage Rd. junct. 60°44'N, 149°21'W, 16 July 1951, Calder 5960 (DAO); Ptarmigan Lake, 5 mi. e. Lawing on Kenai Lake, 2 August 1952, Klein 48 (DAO); Knife Ridge, 2 mi. n. of Knifeblade, 2 August 1951, Jones 717 (WS); Kokrines Mts., 65°17'N, 154°30'W, 6 July 1926, Porsild 659-60 (CAN, MT, US); Lake Noluk, 2 August 1950, Thompson 1337 (DS, US); Lake Peters, 69°20'N, 145°00'W, Spetzman s.n. (MIN), 688 (US), 8 July 1961, Holmen 61-1027 (CAN, DAO, US); Lake Peters, 69°18'30"N, 145°04'W, 3 July 1973, Batten 327 (DAO), July 1948, Scholander & Flagg 146 (US); Lake Schrader, 69°25'N, 145°00'W, 8 July 1948, Spetzman 529 (DS, US); Lazy Mt., e. Palmer, 29 July 1965, Mitchell 729b6 (DAO); Livengood, 80 mi. nnw. Fairbanks, 19-20 June 1940, Scamman s.n. (MIN), 1703 (GH, US); Livengood, 9 July 1944, Anderson 9019 (CAN, MSC); Lodiack, 21 July 1904, Piper 4776 (POM); Mancha Creek, 68°40'N, 141°W, 4 August 1958, Shanks & Sharpe 24237 (NY); Mancha Creek, Firth River, 26 June 1959, Shanks (NY); McKinley River, 1-2 mi. s. Wonder Lake, 63°25'N, 150°45-50'W. 5 August 1956, Viereck 1729 (DS, MT, UC); Mt. McKinley National Park, 2 mi. n. of n. entrance, 29 July 1967, Hermann 21517 (MICH, NY); Mt. McKinley, 22

June 1943, York 199 (MO), 13 August 1943, York 23 (US); Trail from Wonder Lake to McKinley River, 26 July 1956, Argus (RM); Mt. Eielson, Coppers Mt., 11 July 1956, Viereck 1250A (MIN, RSA), 27 July 1956, Langenheim 4204 (UC); Highway Pass, 14 August 1939, Nelson 4138 (CAS); Hines Creek, 6 August 1950, Bailey 5017 (UC); Savage River, 31 July 1932, Henderson 14790 (ORE); Toklat Cabin, 11 July 1939, Murie 35 (RM), 22 June 1943, York 199 (F); Polychrome Pass, Mile 43, 1-10 July 1964, Hultén s.n. (AA), 63°43'N, 149°15'W, 13-22 June 1937, Scamman 585 (GH); Meade River, ca. 15 km. from Atkasuk, 70°28'N, 157°25'W, 30 June 1966 DeBenedictis 92 & 534 (MICH); Meade River, 10 mi. n. Athabaska Village, 16 July 1953, Cantlon 4759 (MSC); Mile 40, Globe Creek, Smith 2366 (UC); Mile 242 Richardson Highway, 15 July 1951, Cody 5990 (CAS, DAO); Mile 246 Richardson Hwy., 63°45'N, 145°47'W, 15 July 1951, Cody & Webster 5991 (DAO); Mile Post 50, along Pipeline Haul Road, 6 August 1981, Allred, Welsh & White 1214 (RSA); Mt. Dustin, 21 mi. from Nome, 4 July 1938, Anderson 3768 (CAS); Mt. Fairplay, Mile 43 Taylor Hwy. between Tetlin Junction & Chicken, 63°41'N, 142°15'W, Calder & Gillett 26456 (DAO); Nabesna River, 7 August 1902, Schrader & Hartman 67 (US); Nebesna River, Nebesna Rd., mile 91, 21 July 1947, Schrader & Hartman (US); Nelchina Caribou Range, Tyone Creek, (100-200 miles n.e. Anchorage), 28 June 1957, Hanson 57-60, 62A, 119 (US); Nome Quad, meadow below radio tower, Anvil Mt., 64°31'N, 165°30'W, 11 July 1982, Kelso 82-39 (COLO); Nome, 1900, Blaisdell 139 (UC); Ogotoruk Creek, Cape Thompson, 27 July 1966, DeBenedictis 421 (MICH); Ogotoruk Creek, Crowbill Ridge, 68°06'N, 165°46'W, 4 July 1962, Packer 1985 (ALTA, DAO); Ogotoruk Creek, 30-31 July 1960, Hultén (GH); Okpilak Valley, 69°25'N, 144°02'W, 30 June 1958, Cantlon & Malcom 58-0117, 0120 (MSC); Okpilak Valley, 69°22'N, 144°04'W, 9 August 1957, Cantlon & Gillis 57-2011 (MSC); Old John Lake, 27 July 1950, Jordal 3751 (BH, MICH, MT); Pastolik, 5 July 1928, Miller 88c (US); Mile 91 nw. Paxson, Denali Hwy., Mitchell 720b32 (DAO); 20 mi. w. Paxson, Smith 2032 (UC); Paxon's, 28-30 July 1943, Went s.n. (MT); Port San Juan, Evans Island, 10 August 1948, Eyerdam 7031 (MIN, OSC, RM, WS); Prince Wales Island, Virginia Mt, 7 mi. s. of Pt. Baker, 19 July 1972, Jaques 1476 (OSU); Point Barrow, Canning River, 17 July 1947, no collector (MICH); Rapids Lodge, 138 miles south Fairbanks on Richardson Hwy., 25-28 August 1937, Scamman 1046 (GH); Sadlerochit River, 69°N, 149°10'W, 26 July 1948, Spetzman (US); Sadlerochit River, 69°30'N, 145°00'W, Spetzman s.n. (MIN); 69°25'N, 149°10'W Spetzman s.n. (MIN); Seward Peninsula, 64°33'N, 163°45'W, 5-6 August 1926, Porsild & Porsild 1193-94 (CAN, GH); Sheenjek River, 68°22'N, 143°55'W, 19 June 1956, Schaller 54 (MT); Sheep Camp on Canning River, 51 mi. nnw. Arctic Village 68°49'N, 146°05'E, Hettinger 891 (ALTA); Sheenjek River, 68°36'N, 143°45'W, 11 June 1956, Schaller 163 (MT); Snow Camp, Sagavanirkton River, 1958, Korando & Shanks s.n. (NY); Sunset Pass, 69°40'N, 144°45'W, 13 August 1948, Spetzman 1154 (CAN, MIN); Talkeetna Mts., 62°50'N, 147°54'W, 2 September 1978 Talbot T8001-19 (DAO), 62°47'N, 148°03'W, 4 September 1978, Talbot T8011-21 (DAO), 62°44'N, 148°08'W, 8 September 1978, Talbot T8021-28b (DAO), Talkeentna Mts., Litle Susitna Valley, n. Palmer, rd. between Palmer & Willow, Kornada s.n. (DAO); Tanacross Quad, Sheep Creek, 63°23'N, 143°53'W, 24 May 1977, Winters 121 (DAO); Taylor Hwy., 64°50'N, 141°15'W, 9 August 1965, Harms 4062 (SASK); Teller, Port Clarence, 6-20 August 1949, Scamman 5433 (GH); Teller Reindeer Station, 13 July 1901, Walpole 1418 (US), 26 July 1901, Walpole 1572 (US); Thorofare River and Glacier Creek, 63°24'N, 150°20'W, Viereck 1491 (GH, MT); Umiat Mt., 2 July 1953, Bormann 3394 (MT); Umiat, Borman et al. 178 (MSC), 118 (MSC); Umiat, Colville River, 23 July 1951, Churchill 652 (ALTA); Umiat, Colville River, 27 July 1949, Spetzman 2328 (CAN, US); 10 mi. ssw. of Umiat, July 1953, Cantlon s.n. (MSC); 40 mi. nw. of Umiat, 29 July 1951, Jones 723 (WS); Umiat, 23-29 July 1960, Hultén s.n. (GH); Umiat, 69°30'N, 152°00'W, Spetzman s.n. (MIN), 2328 (US); Umiat, 69°25'N, 152°10'W, 25 June 1953, Bormann, Rebuck & Cantlon 118 (MSC); Upper Marshfork River, 46 mi. nnw. Arctic Village, 68°40'N, 146°30'W, 18 August 1973, Hettinger 814 (ALTA); se. Wrangell Mt., outwash plains of Federicka Glacier, 8 July 1968, Scott 2672, 2674 & 2862 (MICH); se. Wrangell Mt., Skolai River, 9 July 1968, Scott 2708 (MICH); White River Valley, 61°42'N, 141°39'W, 17 August 1968, Murray 2279 (CAN); White River Valley near the boundary, Easton s.n. (US); Wiseman, 2-12 August 1937, Scamman 991 (GH); Wiseman, 11 August 1950, Lutz 101589 (RM,) 866 & 867 (MT); Wiseman, 19 June 1949, Jordal 1839 (CAN, US); Wiseman, 1 August 1939, Anderson 5866 (CAN); Lake Schrader, 69°25'N, 145°00'W, Spetzman s.n. (MIN); Anaktuvuk Pass, 68°17'N, 151°25'W, Spetzman s.n. (MIN); Lake Noluk, 68°47'N, 160°00'W, Spetzman s.n. (MIN); Noatak River, 67°58'N, 161°55'W, Spetzman s.n. (MIN); Sagavanirktok River, 69°22'N, 148°40'W, 18 July 1951, (RM); Knob Ridge, 12 August 1957, Spetzman s.n. 1053 (US); Nimiuktuk River, 68°20'N, 159°55'W, Spetzman s.n. (MIN); Kanayut Lake, 68°20'N, 151°00'W, Spetzman s.n. (MIN); Canning River, 69°17'N, 145°52'W, Spetzman s.n. (MIN); Nuka, 69°45'N, 159°45'W, Spetzman s.n. (MIN); Nuka, 68°47'N, 160°00'W, Spetzman s.n. (MIN); Colville River, 68°47'N, 160°07'W, Spetzman s.n. (MIN); Noluk, 68°47'N, 160°00'W, Spetzman s.n. (MIN); 69° 35', 146°15'W, 15 July 1951, Spetzman s.n. (MIN); Alaska-Yukon Boundary, Firth River and Mancha Creek, 11 August 1961, Stone 1176, 1217 (DS). **COLORADO: Park Co.:** Sheridan Mt., above Hilltop Mine, 12 July 1967, Weber 13299 (COLO); Pike National Forest, Fairplay, Beaver Creek at Beaver Creek Campground, 5 July 1978, Colson, Weber & Wingate 78-1a (COLO); Horseshoe Cirque, 23 July 1984, Weber & Randolph 17396 (COLO); Fairplay, Horseshoe Cirque, T10 R79W S12, 21 July 1985, Dunlop & Orlando 2025 (NHA); South Park, 1873, Wolfe 1002 (COLO, F, MICH, NY, US), South Park, Wolfe 242 s.n. (RM), South Park, Hall & Harbour 1862 (F), South Park, 15 June 1893, Hughes s.n. (GH). **IDAHO: County unknown:** Soda Springs, 25 May 1934, Davis 83-34 (NY); Upper Priest River, 20 July 1925, Epling 7513 (UC). **MAINE: Aroostook Co.:** Aroostook River Basin, 15 June 1940, Chamberlain 1579 (MAINE, UC); Aroostook River, Fort Fairfield, 5 June 1901, Fernald s.n. (GH, MAINE). **Piscataquis Co.:** Mt. Katadin, 4 July 1856, Blake (MAINE, NHA), August 1861 Tuckerman s.n. (MASS), August 1874, Scribner 36 (MO), 12 August 1873, Scribner s.n. (MAINE), 13 July 1900, Churchill s.n. (NHA), August 1892, Briggs 1207 (BH, MAINE), August 1902, Davis s.n. (MICH); N. Basin headwall below Hamlin Peak, 1 August 1929, Ewer 226 (Mass); west end of North Basin, 26 July 1929, Ewer 152 (Mass); Chimney Brook, 9 August 1926 Norton, Farring and Rich 17169 (NHA), Chimney Pond, 8 July 1900, Fernald s. n. (GH, PH); Chimney Pond shores, 16 June 1936, Norton et al. (CU); Chimney Pond, 2 September 1929, Pease s.n. (MASS); Between Chimney Pond and Pamola Peaks, 19 September 1926, Stebbins 132 (DAV); Chimney Pond, 9 July 1900, Kennedy s.n. (PH); Hawlin Ridge and North Basin, 31 July 1923, Norton, Farring and Rich s.n. (NHA, USAS, WIS), Porter s.n. (PAC, WS), 4 September 1930, Steyermark 180 (MO); Trout Brook Mt., T6 R9, 29 July 1946, Odgen, Chamberlain & Norton 2749 (US). **MICHIGAN: Delta Co.:** Escanaba River, ca. 1 mi. ne Cornell, ca. 10 mi. nw Gladstone, 23 August 1982, Voss 15553 (MICH); Escanaba River, 23 August 1982, Henson 1448 (WIS); Lake Superior, August 1871, Macoun s.n. (MICH). **MINNESOTA: Clay Co.:** 3 mi. N Downer, 2 June 1964, Stevens 2697 (MIN, UC,

US); Audubon Prairie near Moorhead, T139N R45W S32, 23 June 1980, Cross-Leila 167 (MIN); Bluestem prairie near Moorhead, T139N R46W S22, 23 June 1980, Petron 116 (MIN). **Polk Co.**: Pankratz Prairie near Crookston, 18 July 1979, Farrell 117 (MIN); Pembina Trail, 17 June 1979, Sperling 4797 (MIN); **Wilkin Co.**: Barnesville, 17 July 1962, Stevens 2596 (MIN, UC, US); Zimmernam Prairie near Ogema, 26 June 1980, Severson 401 (MIN). **MONTANA**: **Beaverhead Co.**: Red Rock Pass, 23 August 1952, Booth s.n. (DAO); Wisdom, 10 August 1946, Booth 1490 (WTU, US). **Glacier and Flathead Cos.**:: 11 July 1914, Hitchcock 11893, 30 June 1979, Blair s. n. (UT); Cut Bank Pass, 3 August 1931, Cox 643 (US); Hidden Lake, 17 July 1933, Abrams 22 (POM); Hidden Lake Trail, 26 August 1962, Hermann 18300 (MICH, MONTU, US); Hidden Lake, 24 August 1934, Maguire & Piranian 5476 (CU); Logan Pass, 27 July 1936, Peirson s. n. (CAS), 9 August 1949, Harvey 3959 (MONTU), 9 August 1957, Harvey 6678 (MONTU, US), 7 August 1951, Harvey 4661 (MONTU), 11 August 1949, 4026 & 4027 (MONTU), 8 July 1934, Maguire et al. 5475 (CAS, CU, RM), 5478 (CU), 31 July 1978, Wheeler 2731 (MIN), 18 September 1937, Barkley 1827 (MONTU), 30 July 1949, Berkhelmer 11801 (PH); Siyeh Creek, 20 August 1985, Dunlop & Orlando 2256, 2259 (NHA), Hidden Lake Trail, 21 August 1985, Dunlop & Orlando 2266 (NHA); Siyeh Creek, 31 July 1957, Harvey 6656 (MONTU), Siyeh Creek, 5 August 1931, Cox 644 (US); Lunch Creek, 20 August 1985, Dunlop & Orlando 2264 (NHA); Gunsight Pass, 25 August 1919, Standley 18139 (NY, US); Gunsight Lake, 24 July 1984, DeBolt & Lesica 3208 (MONTU); Grinnell Glacier, 28 July 1936, Peirson 11976 (CAS), 26 July 1932, Maguire 606 (CU); Pigeon Pass, 22 July 1958, Bamberg 92 (COLO); Reynolds Mt., 2 August 1960, Schofield s.n. (MONTU); St. Mary Lake, 6 August 1919, Standley 17150 (US); Highland Trail, 31 July 1977, Wheeler 2770 8 (MIN); MacDonald Lake, 3 August 1895, Williams s. n. (NY, US); Altyn Peak, 13 July 1919, Standley 15596 (NY, US); Divide Mountain, 9 August 1964, Harvey & Pemble 7175 (MONTU, WTU). **Teton Co.**: Pine Butte Preserve, 23 June 1982, Lesica 2055 (MONTU); Pine Butte Preserve, 10 July 1982, Lesica 2192 (MONTU); Pine Butte Preserve, Willow Creek, 14 August 1982, Lesica 2388 (MONTU, NY); Antelope Butte, Lackschewitz & Ramsden (NY); Antelope Butte, 22 July 1982, Lackschewitz & Ramsden 10049 (COLO, MONTU); Duhr Fen, 16 August 1982, Lesica 2408 (MONTU, WTU); Mt. Patrick Gass, 30 July 1983, Lackschewitz 10609 (MONTU, NY). **NEVADA**: **Elko Co.**: Ruby Valley, Point Hot Springs, T27N R58E S15, 20 June 1984, Tiehm, Atwood & Williams 8748 (NY, ORE); Ruby Mts., Seitz Canyon, T32N R58E S28, 16 September 1983, Goodrich, Tuhy & Smith 20130 (BRY); Ruby Mts., Seitz Lake, T32N R58E S20, 16 September 1983, Goodrich, Smith & Tuhy 20183 (BRY); Ruby Mts., T29N, R57E, nw. Harrison Pass, 15 August 1980, Atwood 7713 (BRY); Lamoille Canyon, Thomas Canyon Camp, 15 June 1941, Holmgren 1130 (NY, UC); Lamoille Canyon, 15 July 1969, Lewis 1843 (RM), Lamoille Canyon, slope above Terrace G.S., 14 July 1969, Lewis 1796 (RM); w. of Ruby Mts., along Rt. 229, T32N R60E S19, 4 August 1985, Dunlop & Orlando 2140 (NHA); Humbolt National Forest, Lamoille Canyon Creek Road, T32N R59E S31, 5 August 1985, Dunlop & Orlando 2155 (NHA); East Humboldt Range, s.w. Wells, Angle Lake & Greys Peak, T36N, R61E, S4, Tiehm & Nachlinger 10924 (RM). **White Pine Co.**: Monte Neva Hot Springs, 15 June 1944, Ripley & Barneby 6284 (CAS), Monte Neva Hot Springs, 18 air mi. n. McGill, T21N R63E S24, 6 June 1970, Holmgren & Holmgren 4172 (BRY, NY), Monte Neva Hot Spring, 17 mi. n. McGill, 4 August 1985, Dunlop & Orlando 2130 (NHA). **Unknown Co.**: East Humboldt Mt., 27 July 1900, Jones (POM); Humboldt Mts., September 1865, Watson 1219 (GH). **NEW HAMPSHIRE**: **Carroll Co.**: Albany, Mt. Chocorua, 4 July 1978, Storks 385 (NHA); Mt. Willard, Butterwort Flume, 21 June 1953, Hodgdon, Steel & Linclon 7392 (NHA); Butterwort Flume, 4 July 1979, Storks & Evans (NHA); Mt. Willard, 8 June 1980, Hellquist, Crow, Storks & Smith 14317 (NASC), 13 August 1891, Kennedy (PH), June - July 1878, Faxon (F, GH, NY, ORE, US), 15 August 1926, Ferguson (NY), 8 July 1891, Collins s.n. (MT, US), 20 August 1929, Pease 21095 (MASS), 1 July 1898, Greenman 1141 (GH, MO), 9 September 1930, Steyermark 145 (MO); Hart's Location, Mt. Willard, Butterwort Flume, 23 September 1984, Dunlop & Orlando 1965-1968 (NHA); Hart's Location, grave by railroad, 21 June 1953, Pease (NHA). **Coos Co.**: Mt. Washington, 9 July 1910, Long & Bartram 120A (PH), 23 July 1913, Curtis (MAINE), August 1921, Standley, Ellsworth & Killip 7787 (US), Sargent (MIN), 11 July 1983, Fairbanks (F), 15-20 August 1898, Eggleston (MICH), 17-24 August 1901, Eggleston 2392 (DS, MIN, MICH, MO), July 1910, Williamson (PH), 10 July 1895, Williams (NY); alpine garden, 31 July 1977, Storks 147 (NHA), alpine garden, head of Huntington's Ravine, 8 August 1977, Storks (NHA), 9 August 1902, Forbes (RM, NY, UC, WIS), 19 August 1907, Pease 10588 (MICH), 28 August 1909, Pease 12,530 (CAS), 31 July 1926, Pease 44565 (MASS), 10 July 1895, Kennedy (CU, GH, PH, RM, WIS), June-August 1878, Flint & Huntington (GH, MASS), June-August 1876, Flint & Huntington 8809 (CAN, MASS, MO, NHA), 30 June 1950, Hodgdon (NHA), 10 August 1929, Carpenter (VT), 27 July 1958, Beaudry & Löve 58 169 (MT), 5 July 1895, Churchill 235 (MO), 15 August 1901, Robinson 997 (GH). **Grafton Co.**: Franconia, Cannon Mt., 4 August 1960, Hodgdon 11670 (NHA), Cannon Mt., cliffs, 4 July 1977, Storks 29 (NHA), Cannon Cliffs, 7 June 1984, Dunlop, Brackley & Rawinski 1578 (NHA), Cannon Cliffs, 14 June 1984, Dunlop & Orlando 1950-1964 (NHA); alpine areas of Franconia Mt., Oakes 3045 (MASS); Mt. Lincoln, summit, 18 July 1915, Fernald & Smiley 11607 (CU, GH, NY, US); Mt. Lafayette, 23 August 1865, Blake (GH, NHA), 10 August 1882, Bailey (MT), 27 June 1889, Blanchard s. n. (MIN), Oakes (PH), 15 July 1891, White s. n. (NY), 6 July 1938, Churchill s.n. (MSC); above Eagle Lake, Mt. Lafayette, 9 July 1891, Collins s.n. (MT). **Grafton Co.**: Lyme, Winslow Ledge, 3 June 1964, Nelson 1034 (NHA), Lyme, on Winslow Ledge, 25 June 1984, Dunlop, Korpi & Hency 2394 (NHA). **County unknown**: Great Haystack Mt. Tuckerman (GH, NY, US); White Mountains, Sartwell (CAS, MO), White Mountains, 10 August 1900, Forbes 1784 (MIN), White Mountains, 30 June 1849, Tuckerman (MSC, NY), White Mountains, 1827, Oakes (BH, CAS, GH, MASS, NY, UC, US, WIS); 1829, (MO), White Mountains, Tuckerman 48801 (CAN), White Mountains, Booth s.n. (US). **NEW YORK**: **Essex Co.**: n. end Indian Pass, 5 August 1948, Smith 4602 (NA); Whiteface Mt., Peck (NY, RM), 6 July 1899, Rowlee, Wiegand, & Hastings (CU, GH, UC); Wilmington, Whiteface Mt., 7 July 1986, Dunlop & Orlando 2414 (NHA); Avalanche Lake, cliff on w. side, 15 July 1884, collector unknown (DS); Avalanche Lake, 26 June 1917, Killip 1500 (CU, US); Avalanche Pass, Mt. Marcy, 20 August 1924, Killip 12713 (US); Mt. Marcy, 18 August 1888, collector unknown (GH); Mt. Marcy, Lesquereux (MICH, NY); Wallface Mt., June, Peck s.n. (NY, US). **NORTH DAKOTA**: **Dunn Co.** Killdeer Mts., east slope, 11 August 1951, Stevens 1293 (CAN, UC, US). **Rolette Co.** between Rolette & Thorne, 3 June 1913, Lunell 767 & 236 (MIN, US), Thorne, 3 July 1913, Lunell (UC). **OREGON**: **Wallowa Co.**: e. side Lostine Canyon, 18 mi. above Lostine, 22 July 1933, Peck 17861 (DS, NY, WILLU); Hurricane Creek, 23 July 1944, Peck 22549 (UC, WILLU); Hurricane Creek Canyon, 7 mi. s. of Enterprise, 13 July 1971, Mason 8888 (ORE, RM, WTU); w. side of Ice Lake, near creek off the Matterhorn, 30 August 1965, Mason 7511 (OSU); Ice Lake meadows, T4S R44E S12, 11 August 1961, Mason 1902 (OSC), Ice Lake, foot of Matterhorn, T4S R44E S12, 11 August 1962, Mason 5619 (ORE), Ice Lake, sec 11, 28 August 1975, Cole 211b-c (ORE), 31

August 1974, Cole 84A (ORE). **UTAH: Duchesne Co.:** Ashley National Forest, Four Lakes Basin, 22 August 1974, Goodrich 3736 (BRY). **Emery Co.:** Scad Valley, T15S R6E S27, 5 August 1984, Lewis & Lewis 7758 (BRY, UT); Scad Valley Meadow, 24 July 1980, Lewis 6613 (NY). **Garfield Co.:** Dixie National Forest, Pine Lake Campground, 31 July 1985, Dunlop & Orlando 2100 (NHA); Upper Henderson Canyon, T35S R1W S32, ca. 11 NE Tropic, 4 July 1983 Tuhy 863 (RSA). **Iron Co.:** Cedar Breaks, T36S R9W S24, ca. 13 mi. s. of Parowan, near Brian Head, 20 July 1977, Welsh & Clark 15512 (BRY, NY); Cedar Breaks, 25 September 1938, Eastwood & Howell 7283 (CAS, POM, UC, US). **VERMONT: Bennington Co.:** Mt. Equinox, 22 May 1932, Steyermark 7006 (MO), woody mountain slope, Manchester, 29 June 1898, Day 194 (GH, US), Mt. Equinox, Deer Knoll, 5 May 1985, Dunlop, Brackley & Thompson 2003 (NHA). **Lamoille Co.:** Smugglers Notch, Mt. Mansfield, 5 July 1906, Burnham s.n. (CU), 1895, Bates 3031 (CU), 10-11 July 1917, Dobbin (CU, MO), 30 May 1878, Horsford (BH), 10 August 1893, Eggelston 2463 (DS, MIN, NY-2, VT, WIS), 17 June 1878, Brainerd (MICH, MIN, MO, MSC, RM, VT, WIS), 1877/1878, Pringle (CAS, F-2, GH, MICH, MO, MSC, NHA, NY-3, PH, POM, UC, VT-2), 1885, Steele (NY, RM), 31 July 1878, Morong (MO, NY), July 1878, Morong s.n. (US), July 1884, Knight (NY), 1877/1878, Pelton (MSC), 18 August 1899, Eggleston & Balch 1700 (UC), 24 June 1936, Torrey, Mehlquist & Hill (NA, PH), 18 July 1902, Saunders (PH), 18 June 1976, Walker SC-2-1 (VT), 16 June 1926, Pease 19746 (MASS), 21-24 June 1922, Dutton (MICH, VT), 7 July 1910, Bissell (NHA), 3 July 1896, Balch (VT), 16 June 1895, Grant (CAS, VT), 4 July 1897, Greenman (MO), 6 July 1895, Grout (F, GH, VT-2), 4 July 1904, Murdoch 1770 (F), 16 June 1895, Grout & Jones (NHA), Seymour 29743 (BRY), July 1885, Marcus s.n. (POM); Cambridge, in Pringle's Ravine in Smugglers Notch, 4 August 1956, Charette 2288 (VT). **Orleans Co.:** Willoughby Cliffs, Mann (BH, CU), 19 July 1885, Deane (BH, GH, NY), 7 July 1885, Deane (F, PH), 5 June 1895, Deane 611 (MO), August 1820, Jesup (MASS), 1 July 1894, Grout (F, NY, UC), 7 July 1915, Woodward (PAC, UC), 2 July 1894, Grout (VT), 1 August 1894, Grout & Eggleston (POM, VT), 17 August 1896, Faxon (GH), 10 August 1894, Grout and Eggleston (MSC), Flynn (UC), 4 June 1886, Foster (BH), Eggleston 2126 (UC), Smith (PH), 19 June 1871, Congdon (F), 30 June 1873, Congdon (F), 18 June 1861, Blake (F, MO, NA, US), 30 May 1875, Stanford (DS), 23 May 1878, Horsford 44583 (MICH), July 1904, Winslow (MAINE), 7 July 1915, Carpenter (VT), 25 June 1949, Hodgdon 6046 (NHA), August 1860, Tuckerman (MASS), 11-12 July 1900, Eggleston 2126 (MO, US), 17 June 1898, Floyd 2678 (MO), 22 July 1885, Churchill 235 (MO), 5 June 1895, Churchill s.n (GH); Willoughby Lake, 31 May 1909, Churchill 92 (BH, MO); Mt. Pisgah, Lake Willoughby, along Rt 5A, 16 August 1979, Ahles 78931 (MASS); Westmore, on Mt. Pisgah, Hodgdon, Countryman & Straus (NHA); Mt. Pisgah, 12 June 1919, Knowlton s.n. (MO). **WYOMING: Johnson Co.:** Big Horn Mts., 33 mi. nw. Buffalo, T53N R87W S27, 7 August 1979, Nelson 4705 (RM). **Park Co.:** Clay Butte, 15 August 1979, Dorn 3377 (RM); T56N R106W S11-14, 12 August 1984, Dorn 4142 (RM). **Sheridan Co.:** Big Horn Mt., Boyd Ridge, ca. 18 mi. w. Parkman, Hartman 9469 (RM), Big Horn Mt., T57N R90W S19, 5 August 1979, Nelson 4681 (RM); Hunt Mt., 17 August 1966, Johnson 528 (CS, RM); Tongue River, August 1953, Beetle 6297 (RM). **Uinta Co.:** 5 mi. sw. Hilliard, 25 June 1950, Beetle 11062 (RM); Spring Creek, 5 mi. w. Robertson, 25 June 1950, Beetle 11061 (DAV, RM).

REPRESENTATIVE SPECIMENS OF CAREX SCIRPOIDEA SSP. PSEUDOSCIRPOIDEA

CANADA: BRITISH COLUMBIA: Cathedral Ridge, ca. 4 1/2 mi. n. Monument 95, 28 August 1972, Douglas & Douglas 4629 (ALA); Cathedral Park, Lake Lady Slipper, 12 July 1975, Hainault 7728 (DAO), 14 July 1975, Hainault 7526 (DAO); Lakeview ridge, 28 July 1976, Hainault 7962 (DAO); Mt. Apex, 11 August 1964, Mclean & Haupt 65-64 (DAO), McLean & Marchand 65-63 (DAO); Mt. Bomford, Cathedral Lakes, Ashnolda District, 49°N, 120°15'W., 11 July 1951, Taylor 1359 (UBC); Ashnola Range, Mt. Bomford, 49°04'N, 120°12'W, Calder, Parmelee & Taylor 19715 (DAO).

UNITED STATES: CALIFORNIA: Alpine Co.: Carson Pass, Round Top Lake to Fourth of July Lake, 29 August 1974, Taylor 4910 (DAV). **Mono Co.:** Minarets Wilderness Area, Inyo National Forest, Dana Plateau, n. Mt. Dana, T1N R25E S28, 7 August 1985, Dunlop & Orlando 2158 (NHA), Dana Plateau, 19 September 1936, Sharsmith 2404 (CAN, CAS, CU, MICH, UC), 15 July 1937, Sharsmith 2480 (DS), 1 September 1937, Sharsmith 3516a (CAS, CU, DAO, DS, GH, MICH, MO, NY, UC, US, WTU), 25 July 1979, Taylor 7549 (COLO); Convict Creek Basin near Lake Mildred, 11 July 1962, Mayor & Bamberg 953 (DAV). **COLORADO: Chaffee Co.:** Monarch Pass, 20 mi. west of Salida, 22 June 1926, Erlanson 2020 (MICH); Manassas Creek, 24 July 1919, Clokey 3337 (BH, MO, NY, RM, UC, US), 24 July 1919, Clokey 3338 (BH, CAN, DS, MICH, MO, MONTU, MT, POM, RM, UC, US, WS, WTU), 24 July 1919, Clokey 3339 (CAN, BH, CAS, MICH, MO, MONTU, MT, NY, POM, RM, UC, US, WILLU, WS, WTU); Bulca Mine, 11 August 1919, Clokey 3340 (CAN, CAS, MO, MT, NY, UC, US). **Gunnison Co.:** North Pole Basin, 14 July 1955, Weber & Barclay 9193 (COLO, CS, DS, MT, NY, RM, RSA, UC); West of the road to Schofield Pass, 1 August 1961, Barrell 256-61 (CS). **La Plata Co.:** San Juan National Forest, Chicago Basin, Eoleus, 29 July 1962, Michener 661, 724 (COLO); summit of Eoleus, 29 July 1962, Michener 679 (COLO). **San Juan Co.:** San Juan National Forest, Eldorado Lake, T40N R6W, 19 July 1971, Instarr s.n. (COLO); Kite Lake, 13 August 1971, Instarr s.n. (COLO); Tenmile, Animas River drainage, 18 August 1962, Michener 806 (COLO), 18 August 1962, Michener 799 (COLO); San Juan National Forest, NoName Basin on Middle Ridge, 6 August 1962, Michener 750a (COLO). **IDAHO: Blaine Co.:** Sawtooth Range, Devils Bedstead, 28 July 1936, J. W. Thompson 13,562 (CAS, CU, PH, MO, NY, WS, WTU); Sawtooth National Forest, head Boulder Creek, 4 August 1937, J. W. Thompson 14,114 1/2 (CAS, WTU). **MONTANA: Beaverhead Co.:** Oreamnos Lake, 25 July 1945, Hitchcock & Muhlick 12793 (BH, CAS, PH, NY, WS, WTU), 12 August 1976, Lackschewitz 6870 (MONTU, RM); wet meadow, T4S R11W S24, 10 August 1920, Pasushta 102 (RM); Pioneer Range, Black Lion Mountain, 30 July 1945, Hitchcock & Muhlick 12977 (BH, CAS, NY, WS, WTU); Torrey Lake, 27 July 1946, Hitchcock & Muhlick 15050 (CAS). **Carbon Co.:** Moon Lake, 15 August 1979, Lackschewitz 9154 (MONTU); Beartooth Mountain near Glacier Lake, 15 September 1976, Lackschewitz 7041 (MONTU, RM); Beartooth Mountains near Wyoming state line, 25 mi. sw. Red Lodge, T9S R19E S32, 22 July 1955, Cronquist 7998 (CAN, CAS, CU, DAO, DS, GH, MICH, MONTU, MT, NY, OSC, RM, RSA, UC, WTU); Hell Roaring Plateau, 25 July 1921, Simms & Zeh 640 (RM); Hell Roaring Lake, 11 August 1980, Dorn 3577 (COLO, NY, RM); Hell Roaring Plateau, 27 June 1966, Stolze s.n. (GH, WIS); Beartooth Plateau, 14 September 1976, Lackschewitz 7002 (MONTU, RM, WTU); Silver Run Plateau, 12 August 1913, Jordini 7 (RM). **Deerlodge Co.:** Mt. Tiny above Goat Flats, 10 September 1972, Lackschewitz 4123 (MONTU), 4 September 1974, Lackschewitz 5753 (MONTU), 4 September 1974, 5771, 6 August 1980, Soreng & Spellenberg 1184, (NY); Goat Flats, 28 July 1971, Lackschewitz 3063 (MONTU, RM), 25 August 1972, Lackschewitz 3993 (MONTU), 2 August 1976, Lackschewitz & Weber 6767, 25 August 1972, Lackschewitz 3987 (MONTU, NY); east of Goat Pass, 10 September 1972, Lackschewitz 4097 (MONTU); Storm Lake, 18 August 1975, Webber & Johnston 15164 (COLO), 22 July 1946, Hitchcock & Muhlick 14798 (CAS, MO, NY, RSA, WTU, WS); Deerlodge National Forest, meadow below Storm Lake Pass, T4N, R13W, S30 & 31, 24 August 1985, Dunlop & Orlando 2280 (NHA); Anaconda Pintlar Wilderness, T3N R14W S36, sw. Mt. Tiny on Strom Lake trail to Goat Flats, 24 August 1985, Dunlop & Orlando 2285 (NHA); basin below w. Goat Peak, 23 August 1974, Lackschewitz 5670 (MONTU, RM, WTU). **Madison Co.:** Gravelly Range, Black Butte, 26 July 1947, Hitchcock 16869 (CAS, NY, RSA, WS); Tobacco Root Mts., Spuhler Peak, T3S R4W S15, 29 August 1981, Lesica 1827 (MONTU); Tobacco Root Mts., Mt. Bradley, 26 August 1959, Bamberg 431 (COLO); Tobacco Root Mts., Lily Lake, 6 August 1982, Lackschewitz 10154 (MONTU); Tobacco Root Mts., Belle Point, T4S R3W S15, 9 August 1982, Lackschewitz 10214 (MONTU); Taylor Mts., Koch Peak, 2 August 1946, Hitchcock & Muhlick 15194 (CAS, MO, NY, WS, WTU). **Missoula Co.:** Bitterroot Mts., Lolo Peak, 8 September 1968, Lackschewitz & Fageraas 1081 a&b (MONTU), 5 September 1971, Lackschewitz 3480 (MONTU).**County unknown:** Spanish Basin, July 1896, Rydberg 3064 (NY). **OREGON: Harney Co.:** Steen Mts., above Alberson, 5 July 1925, Peck 14272 (CAS, F, PH, WILLU), se. rim of Little Blitzer Gorge, T33S R33E S13 NW1/4, 27 August 1980, Wright 1459 (OSC), W. rim of Kiger Gorge near viewpoint, T32S R33E S36, July 6 1979, Wright 1115, (OSC), head Big Indian Gorge, T33S R33E, 3 August 1979, Wright 1191 (OSC), Big Indian Gorge, T33S R33E S35, 28 August 1980, Wright 1468 (OSC), meadow overlooking Big Indian Creek near pass to Little Wildhorse Creek, 28 July 1959, Cronquist 8797 (DAO, MICH, NY, RSA, UC, WTU), 19.5 mi. ese. of Frenchglen, T35S R33E S1, 27 August 1953, Hansen 474 (CAS). **UTAH: Daggett Co.:** Leidy Peak, 31 July 1929, Dremolski D-7 (RM). **Duchesne Co.:** Atwood Lake, 28 July 1945, Hayward 39 & 40 (BRY); Bald Mountain Pass near Rt. 150 scenic overlook, 6 August 1964, Bennett 8444 (CAS); Mt. Emmons, Chain Lakes, Kregs Basin, 18 July 1933, Hermann 4935 (CAS, DS, MICH, MO, NY), 8 July 1946, Haywood 142 (BRY, DAO), 1 July 1946, Haywood 117 (BRY), 24 July 1948, Harrison 11284 (BRY), 11310 (BRY), 17 July 1950, Murdock 32 (BRY), 22 July 1950, Murdock 41, (BRY NA), 26 July 1950, Murdock 60 (BRY), 14 August 1965, Murdock 597 (BRY), 14 August 1965, Bjerregaard 84 (BRY); Fourth Chain Lake, 28 July 1940, Harrison, Liechty & Allen 10028 (BRY, US, UT); Fishhatchery Lake, Granddaddy Lake basin, 7 August 1952, Lewis 134 (BRY, MT); Garfield Basin, Bluebell Lake, T4N R5W S31 & 32, 30 July 1980, Neese & Welsh 214016 (NY), 9427 (BRY); Uinta Mts. n. slope 1 mi. se. Island Lake, 25 September 1983, Neely & Carpenter 1892 (COLO); Uinta River, face of gap above Fox Lake, 14 August 1953, Lewis 230 (BRY, CAS); Pole Canyon near Lake Chepeta, 29 June 1977, Ostler 460 (BRY); Squaw Basin, T3N R7W S25, 28 August 1981, Goodrich & Atwood 16192 (BRY, UT); West Granddaddy Mtn. T2N R8W S7, 5 September 1984, Tuhy 2226 (BRY); Yellowstone Canyon, Milk Lake, T4N R5W S25, 2 August 1980, Welsh & Neese 213930 (NY), 19945 (BRY). **San Juan Co.:** La Sal Mts., e. flank Mt. Tukuhnikivatz, T27S R24E S22, 1 September 1988 Franklin & Chadler 2527 (BRY), basin below Mt. Tukuhnikivatz, T27S R24E S22, 27 August 1985, Franklin 2432 (BRY); La Sal Mountains, w. end Dark Canyon, Mt Peale, T27S R24E S13, 26 July 1985, Dunlop, Orlando & Franklin 2075 (NHA), w. end of Dark Canyon, 7 August 1982, Siplivinsky & Beck 4700 (COLO, WTU), Dark

Canyon, T27S R24E S13, 26 July 1985, Franklin 2053 & 2052 (BRY); ridge between Mt. Mellenthin and Mt. Peale, T27S R24E S14, 26 July 1985, Franklin 2042 (BRY), Mt. Peale, T27S R24E S24, 1 August 1982, Siplivinsky & Beck 4576 (COLO), Mt. Mellenthin, T27S R24E S12, 26 July 1984, Tuhy 1746 (BRY), Mt. Mellenthin, 19 August 1954, Lewis 371 (BRY), between Mt. Waas & Mt. Peale, T27S R24E S14, S15, S22, S23, 26 July 1983, Tuhy & Warner 989 (RSA), Noan Mt. 28 August 1954, Lewis 386 (BRY), w. Mt. Peale, 10 July 1911, Rydberg & Garrett 8973 & 8806 (NY). **Summit Co.**: Bald Mt., between e. fork Black Fork and Smith's Fork drainage, 29 July 1977, Ostler 641 (BRY), 27 July 1978, Ostler & McKnight 1624 (BRY), south shoulder of Bald Mt., 3 September 1953, Lewis 267 (CAS), south base Bald Mt., 6 August 1952, Lewis 133 (BRY), Bald Mt. summit, 3 September 1953, Lewis 267 (BRY, CAS), s.w. slopes Bald Mt., 14 August 1933, Maguire, Richards & Maguire 4032 (CU, RM, UC); head of Bear River, in meadow of Stillwater Basin, 18 August 1933, Maguire, Richards & Maguire 4031 (CAS, CU, MO); e. fork of Blacks Forks, T2N R21E, 23 June 1978, Ostler & Freeman 1866 (BRY); near divide west of Fish Lake on n. slopes of Uinta Mts., T2N R11E S2, 3 September 1945, Harrison & Harrison 10971 (BRY, US); rocky washes above Dollar Lake, Henry's Forks Basin, 12 August 1936, Maguire, Hobson & Maguire 14580 (CAS, DAO, RM, US, WS, WTU); margins of Henry's Forks Lake, 11 August 1936, Maguire, Hobson & Maguire 14562 (CAN, CAS, PH, WTU); w. rim Henry's Forks Basin, 19 August 1936, Maguire, Hobson & Maguire 14715 (CAN, CU, DAO, PH, WTU); Lamotte Peak, streamlet below lake, 15 August 1933, Hermann 5971 (RM, MICH, MO); Murdock Mt., T3N R9W S3, 7 August 1983, Franklin 370 (BRY); upstream from Hessie Lake on East Fork of Smiths Fork Creek Trail, T2N R13E S26, 28 September 1981, Tuhy 481 (BRY); ridgetop e. of East Fork Blacks Fork, T2N R13E S30, ca. 28 mi. wsw. Mt. View, Wyo, 28 August 1984, Tuhy 2109 (BRY); Red Castle Bench, T1N R13E S28, 28 August 1983, Tuhy 1340, (BRY); Uinta Mt., Mirror Lake, 3 September 1953, Lewis (BRY). **Uintah Co.**: Uinta Mt., Ashley National Forest, 22 mi. nw. of Vernal, T1S R19E S27, 2 mi. e. Marsh Peak, 19 August 1982, Goodrich 17689 (BRY, UT); 2 mi. nw. of Paradise Park Res., T3N R1W S2, 5 July 1980, Goodrich 14253 (BRY); e. side Leidy Peak, T1N R19E S31, 24 July 1986, Goodrich 22074 (BRY), Leidy Peak, 9 July 1971, Waite 278 & 292 (BRY), Leidy Peak, T1S R19E S6, 30 July 1978, Neese & Peterson 6384 (BRY); East Fox Lake, Uinta River, 14 August 1953, Lewis 230 (BRY). **WASHINGTON**: **Okanogan Co.**: Chopaka Mt. ca. 11.5 mi. nw. Loomis, 16 July 1972, Douglas & Douglas 3858 (DAO), 17 July 1972, 3887 (DAO), 3891 (ALTA); Rock Mt., ca 21 mi. ne. Winthrop, 18 July 1971, Douglas & Douglas 2903 (RM); Tiffany Lake Pass, 24 July 1931, Fiker 406 (WILLU, WS); Windy Peak, ca 17 mi. nw. Loomis, 17 August 1971, Douglas 3120 (RM), 3123 (DAO, RM), 19 July 1972, Douglas 3967 (DAO). **WYOMING**: **Fremont Co.**: Shoshone National Forest, East Fork Wind River, 8 August 1962, Johnson 249 & 250 (CS, RM); Wind River, T1N R5W S13, 20 July 1960, Field & Tidd 41 (RM), 19 July 1960, Field & Tidd 30 (RM); T1N R4W S19, 29 July 1960, Field & Tidd 14 (RM); Wind River Range, Roaring Fork Mt., 1 mi. ne. Stough Creek Lakes, 4 July 1964, Scott 275 (RM); Roaring Fork Mt., 2 mi. nw. of Silas Lake, 20-26 July 1965, Scott 535 (CAN, GH, UC); Dickinson Creek, 3 mi. w. Dickinson Park, 9 July 1965, Scott 497 (RM). **Johnson Co.**: Big Horn Forest, Grasshopper Ridge, Elk Lake, 28 August 1961, Johnson 144 (RM). **Park Co.**: Beartooth Peak, 17 July 1939, Rollins 2853, 2852 (CAS), 2857 (US); Beartooth Plateau, T58N R104W S31, 10 August 1956, Gierisch 1848 (CS, RM); Beartooth Range, 28 July 1958, Johnson 65 (RM), 50 (RM), 29 July 1960, Johnson 251 (RM); Island Lake, 19 July 1948, Daubenmire 48330 (WS); Little Bear Creek, cross Hwy. 212, 17 July 1973, Taylor 1606

(RM); Shoshone, T57N R104W S3, 26 August 1938, Schwan s-4, s-6 (RM). **Sublette Co.:** Bridger National Forest, Bridger Wilderness Area, near Lake Timeco, 5 August 1976, Beetle 16673 (RM); Hay Pass, no date, Johnson 243 (RM); Mt. Osborne, Green River Lake, 8 August 1950, Beetle 11201 (RM); White Rock Mt., near Green River Lakes, 8 August 1925, Payson & Payson 4605 (MO, MSC, NY, PH, RM, WS).

REPRESENTATIVE SPECIMENS OF *CAREX SCIRPOIDEA* SSP. *CONVOLUTA*

CANADA: ONTARIO: Algoma District: Great Cloche Island, 26 July 1956, Soper & Fleischmann 6633 (CAN), Great Cloche Island, 26 July 1956, Cody et al. 9438 (DAO), 23 July 1954, Stirrett s.n. (DAO), 29 June 1934, Fernald & Pease 3188 (GH), 30 July 1932, Grassl 4145 (MICH, NY). **Bruce Co.:** Cape Croker, MacGregor Harbour, 19 May 1969, Morton 2658 (CAN, WAT); Dorcas Bay, 2 June 1979, Webber s.n. (TRTE), 23 June 1971, Masih & Keal 579 (TRTE); French Bay, 22 August 1898, Dearness 2518 (DAO), between Frenchman Bay and Sauble Beach South, 3 June 1950 Soper & Shields 4538 (CAN, DAO, MO, MT); Howdenvale, 31 July 1936, Watson 2904 (CU, NY, US); 11 August 1926, Watson 3164 (CU, CAS); 17 July 1957, Wells & Pease 38760 (GH); Lion's Head, 11 June 1932, Marie-Victorin, Rousseau & Prat 45-922 (DAO, GH, MT); Little Pine Tree Harbour, Zinker Island Cove, 30 June 1982, Webber 4552 (TRTE); Oliphant, 9 August 1971, Montgomery 3693 (WAT); Pine Tree Point, 27 July 1948, Dore 8945 (CAS, DAO); Red Bay, 18 June 1933, Stebbins et al. 49 (VT), 50 (PH), 52 (CU, GH), Red Bay, 9 July 1941, Sargent 5 (GH); Sauble Beach, 20 June 1934, Taylor & Fernald s.n. (WIS), 5 July 1954, Churchill s.n. (MSC), 31 July 1947, Dore & Senn 47-484 (DAO), 20 June 1934, Eames 34 & 67 (CU), Sauble Beach, 1 July 1935, Davis 299 (ALTA), Stokes Bay, 26 May 1934, Krotkov 8759 (NY, US), 8792 (GH); Barrie Island, May 1979, Hogg s.n. (CAN, WAT); Georgian Bay Island National Park, Cove Island, Bass Bay, 22 September 1981, Bobbette 7403 (WAT); Zinkan Island, 45°04'N, 81°29'W, 15 July 1975, Cuddy & Emalie 1815 (CAN). **Manitoulin District:** Barrie Island, Rozels Bay, 29 July 1985, Hellquist 15513 (NASC); Bourinot Island, North Channel, 24 June 1976, Morton & Venn 9006 (WAT); Creasor Bight, Briton 3275 (DAO); Green Island Harbour, 20 July 1976, Ringius & Wilson 327 (WAT); Hensly Bay, 26 May 1978, Morton & Venn 11521 (WAT); La Cloche Peninsula, 20 August 1932, Fassett 14899 (WIS, GH), 11 July 1957, Pease & Bean 26203 (GH); Whitefish River w. side Hwy. 68, 3 July 1976, Catling & McIntosh s.n. (DAO, WIS); Misery Bay, 28 July 1972, MacDonald & White 3593 (CAN); Murphy Point, 14 July 1952, Senn 5974 (DAO, MT, NY, PAC, US, WS); Tamarack Cove, 20 July 1932, Koelz 4206 (MICH, WIS); Tamarack Point, Grassl 4594 (MICH).

UNITED STATES: MICHIGAN: Alpena Co.: Thunder Bay Island, 18 August 1895, Wheeler 44584 (BH, CAN, GH, MICH, MIN, MSC, NY, POM, VT), 22 June 1907, Dodge 1088, (MICH, MSC, NY); 24 June 1970, Voss 13289 (CAN, MICH, MSC, NY, WIS), Thunder Bay Island, T31N R10E S34, 14 July 1984, Dunlop & Katz 1772-1795 (NHA). **Chippewa Co.:** Drummond Island, Meade Island, 19 June 1979, Voss 15074 (MICH), Meade Island, T41N R6E S15, 8 July 1984, Dunlop & Katz 1681 (NHA); Drummond Island, Maxton Plains, 2 July 1966, Voss 12217, (MICH, WIS), 18 June 1979, Voss 15063 (MICH, WAT), 13 June 1981, Gereau 866 (MSC, MIN); Drummond Island, T43N R6E S34, 8 July 1984, Dunlop & Katz 1644 (NHA), Drummond Island, 3 August 1839, Houghton (MICH), 3 August 1839, Wright (NY), 28 June 1948, McVaugh 9154 (MICH, MT), 9 July 1950, McVaugh and Wood 11314. (CAN, MICH), 30 May 1972, Churchill (MSC), 13 August 1979, Crispin and Herman 500 (MSC); Drummond Island, False Detour Channel, 15 June 1981, Voss 15395 (MICH).

REPRESENTATIVE SPECIMENS OF CAREX SCIRPOIDEA SSP. STENOCHLAENA

CANADA: BRITISH COLUMBIA: Bluster Mt., Marble Mts., 14 July 1938, Thompson & Thompson 455 (CAS, DAO, F, GH, MO, NY, US, WTU); Chilliwack Valley, 49°10', 121°-122°25', 12 July 1901, Macoun 33728 (CAN-2, MO, MSC, NY, US); Chilliwack Lake, 25 June 1906, Spreadbourgh 78140 (CAN, US); Katharine Lake, 57°26'N, 126°48'W, 25 July 1977, Gillett & Boudreau 17441 (CAN); Kinbasket, Big Bend Hwy., Sullivan River, 1 August 1947, Eastman 15994 (DAO, UBC); Maroon Mt., 54°47'N, 128°40'W, 18 September 1977, Foster 9 (UBC); McGillivray Creek, Cascade Range, 10 August 1916, Macoun 97965 (CAN, GH, US); Moose River, 15-17 July 1911, Hollister 43 (NY, US); Mt. Assiniboine Park, Lake Magog, 16 July 1937, Rose 37550 (CAS, UC), 37571 (CAS); Mt. Chelam, 15 August 1901, Anderson s.n. (MO); Noaxe Lake, 4 August 1957, Brink s.n. (DAO, OSU, UBC), 7 August 1957, Brink s.n. (UBC); Ellis Point & Mercer Point, w. Skidegate channel, Graham Island, Calder & Savile 22870 (DAO, DS, GH, NY, RSA, UC, WS, WTU); Vancouver Island, Marble River, n. Alice Lake, 13 July 1964, Hett & Armstrong 403 (DAO); Marble Lake, near Jeune Landing, 13 July 1964, Hett & Armstrong 399 (DAO); Mt. Klitsa, 22 July 1971, Pojar 177 (UBC).

UNITED STATES : ALASKA: Charlie River, 64°50'N, 143°40'W, 30 August 1956, Argus 872 (RM, SASK); Chugach Range, Tazalina Glacier, 61°45'N, 146°30'W, 19 July 1957, Viereck 2194 (CAN); Juneau, 10 July 1917, Anderson 365 (NY); Juneau, 26 August 1897, Canby et al. 310 & 312 (BH, US); Mt. McKinley National Park, 2 mi. n. of n. entrance, 29 July 1967, Hermann 21517 (MICH, NY); Camp Denali, MMNP, 29 July 1967, Hermann 21517 (US); Mt. McKinley, 22 June 1943, York 199 (MO); Wonder Lake, Argus 660 (SASK); Borrow pit, 24 August 1939, Nelson & Nelson 4224 (CAS, GH, RM, UC); Mt. Hayes, Palmer 606 (US); Mt. Hayes, Glacier Creek, 10 July 1941 Palmer 578 (US), 650 (DAO, US); Mt. Roberts, Juneau, 26 June 1925, Anderson 2A233 (GH); Yes Bay, 16 July 1895, Howell 1705 (CAS, MSC, NY, US). **MONTANA: Ravalli Co.:** Bitterroot National Forest, Bailey Lake, 22 August 1985, Dunlop & Orlando 2272 (NHA); Bailey Lake, 12 July 1969, Lackschewitz 1344 (MONTU); Bitterroot-Selway Divide above Baily lake, 12 July 1969, Lackschewitz 1344 (NY, RM); Blodgett Trail, 24 August 1923, Kirkwood & Severy 1586 (MONTU, NY, UC); Boulder Creek Trail, 13 June 1971, Lackschewitz 2664 (MONTU); Canyon Creek Falls, 23 August 1971, Lackschewitz 3382 (MONTU, WS); Chaffin Lake Basin, Chaffin Peak, 30 August 1971, Lackschewitz 3397 (MONTU) Chaffin Lake Basin, 18 July 1971, Lackschewitz 2863 (MONTU); Chaffin Lake Basin, Hart Lake, 18 July 1971, Lackschewitz 2931 (MONTU); Chaffin Lake Basin, Sugarloaf Massif, above Hart Lake, 31 August 1971, Lackschewitz 3460 (MONTU); Ranger Peak, 23 August 1969, Lackschewitz 1893 (MONTU), Lackschewitz & Fageraas 1859 (MONTU); Sheafman Lake, 17 August 1979, Lackschewitz 2317 (MONTU); St. Joseph's Peak, 31 July 1969, Lackschewitz & Fageraas 1631 (MONTU), St. Joseph's Peak, 24 July 1971, Lackschewitz 2965 (MONTU, WTU); Lackschewitz 2987 (MONTU); St. Mary's Creek, 6 August 1947, Hitchcock 17117 (RSA, WS, WTU), T9N R21W S28, August 1968, Arno 172 (MONTU); Tin cup Lake, 19 June 1971, Lackschewitz 2727 (MONTU); Watch Tower Trail Pass, 26 July 1969, Lackschewitz 1484 (MONTU, RM); Trappers Peak, 14 August 1946, Hitchcock & Muhlick 15381 (CAS, NY, WTU); White Mt., 11 August 1970 Lackschewitz & Smith 2277 (MONTU). **WASHINGTON: Chelan Co.:** Crown Point, Holden-Lyman Lake Trail, 20 August 1956, Raven 10176 (CAS);

3 mi. nw. Cottonwood Camp, 29 July 1971, Naas 1138 (RM); Ingalls Peak, 20 July 1925, St. John & Thayer 7239 (WS); Mt. Stuart, 23 July 1933, Thompson 9580 (DS, GH, MO, NY, RSA, UC, US, WTU), 20 August 1930, Thompson 5812 (DS, MO, NY, WTU); Skagit Pass, 24 Agust 1892, Lake & Hull 408 (WS); Stuart Pass, 21 July 1925, St. John & Thayer 7288 (US, WIS, WS), 7262 (NY, WS). **Clallam Co.**: Mt. Angles, Starvation Flats, 17 July 1931, Thompson 7419 (PH, WTU); Mt. Angles, 9 September 1933, Thompson 10068 (DS, MO, NY, POM, UC, WTU); Mt. Auburn, no date, Meyer 686 (CAS); Olympic Mt., August 1895, Piper 2243 (BH, GH, WS). **Jefferson Co.**: Mt. Anderson, 28 July 1936, Meyer 686 (MO, WS); **King Co.**: Denny Creek, 19 August 1936, Thompson 13684 (CAS, MO, NY, PH, WS, WTU); Guy Peak, Snoqualmie Pass, 7 August 1933, Thompson 9690 (NY, WTU). **Kittitas Co.**: Beverly Creek, 17 August 1932, Thompson 8899 (DS, GH, NY, WTU); Beverly Creek Trail, T22N R15E ca. S1, 17 August 1985, Dunlop & Orlando 2241 (NHA); Eldorado Creek at Forest Road to N. Fork Teanaway Creek, T22N, R15E, S10 & 11, 17 August 1985, Dunlop & Orlando 2255 (NHA); El Dorado Creek at De Roux Forest Camp, n. Fork Tenaway River, 23 June 1960, Kruckeberg 5000 (UC); Fish Lake, 17 June 1934, Thompson 10663-4 (CAS, DS, GH, NY, POM, US, WTU, UWT); Iron Mt., Mt. Stuart, 27-31 July 1931, Thompson 7805 (CAS, GH, PH, OSC, WILLU, WTU); Mt. Stuart, August 1898, Elmer 1126 (POM, MIN, US, WS), 1124 (US). **Mason Co.**: Mt. Steele, east side, 14 August 1937, Meyer 1164 (MO, WS). **Okanogan Co.**: Hart's Pass, ca. 20 mi. e. Diablo, 11 July 1971, Douglas 2866 (ALTA); ca. 3 mi. s. Hart's Pass and 29 mi. nw. Winthrop, 15 August 1972, Douglas & Douglas 4448 (DAO, RM); Horse Shoe Basin, September 1897, Elmer 684 (MIN, MO, NY, POM, US, VT, WS). **Snohomish Co.**: Mt. Pugh, 18 August 1938, Thompson 14340 (CAS, GH, WTU). **Whatcom Co.**: Big Four, 5 September 1964, Schofield s.n. (UBC); Crater Mt., 20 August 1971, Naas 1240 (RM), 1253 (RM), 19 August 1971, Douglas & Ruyle 3149 (RM); Twin Lakes, Jackson Mt., 7 September 1927, St. John 8941 (WS, RM); Twin Sister Range, headwater of South Fork of Nooksack River, 12 August 1939, Muenscher 10324 (GH, CU), 10315 (DS, WTU); Mt. Shuksan, ca. 22 mi. n. Rockport, 13 July 1969, Douglas 1417 (RM), 18 July 1970, Douglas & Ruyle 2215 (RM).

PLANTS INTERMEDIATE BETWEEN SSP. SCIRPOIDEA AND SSP. STENOCHLAENA

YUKON TERRITORY: Alsek Valley, ca. 8 mi. w. Mackintosh, 5 July 1957, Schofield & Crum 7559 (DS, UBC); Canol Road, Mile 132, Lower Lapie River, 26 June 1944, Porsild & Breitung s.n. (NY, US), 22 June 1944, Porsild & Breitung 11981 (CAN); Canol Road, Mt. Sheldon, 3 August 1944, Porsild & Breitung 11708 (CAN), 11703 (GH); Kuluane Lake, near Rusty Glacier, w. Burwash Landing 61°16'N, 140°15'W, 9 July 1968, Murray 1671 (CAN); Mackintosh, Mile 1002, Alaska Hwy., Alsek Valley Road, 4-5 July 1957, Schofield & Crum 7520, 7560, 7561 (CAN).

REPRESENTATIVE SPECIMENS OF *CAREX CURATORUM*

UNITED STATES: **ARIZONA**: **Coconino Co.**: Grand Canyon National Park, Kaibab Trail to Roaring Springs, 22 September 1938, *Eastwood & Howell 7073* (CAS, F, MICH, MT, NY, POM, UC, US, WTU), 23 June 1933, *Eastwood & Howell 1045* (CAS, DS), *Eastwood & Howell 1101* (NY), *Eastwood & Howell 1047* (MO), *Eastwood & Howell 1089* (CAS), *Eastwood & Howell 1100* (CAS), 23 June 1933, *Eastwood & Howell 1101* (CAS); Grand Canyon National Park, False President Harding Rapids, mile 43, 17 March 1974, *Karpiscak & Theroux 941* (ARIZ); Colorado River, Buck Farm Canyon, 40.75 mi. below Lees Ferry, 1/2 mi. above river, 29 April 1970, *Holmgren, Holmgren & Ross 15481* (COLO); Colorado River and Marble River, Buck Farm Canyon, 41 river mi. below Lees Ferry, 6 May 1971, *collector unknown* (NY); **Mohave Co.**: Grand Canyon National Monument, Toroweap Pt., Saddle Horse Springs, 13 June 1941, *Cottam 8652* (COLO, UT), 1 May 1949, *Cottam 9763* (ARIZ, UT), 10 May 1952, *Cottam 13256* (COLO, UT), 10 May 1952, *McClintock 52-539* (CAS). **UTAH**: **Kane Co.**: confluence of the San Juan-Colorado Rivers, on the San Juan, ca. 1/8 mi. above the second hanging garden on the west side in side canyon, 9 June 1972, *Atwood 4094* (BRY); Glen Canyon National Recreation Area, Lake Powell, vicinity of N. Escalante, ca. 3800 ft., T40S R9E S36, 28 May 1983, *Welsh 22113* (BRY, NY); Long Canyon, Waterpocket Fold, T39S R9E S1, 24 May 1984, *Welsh 22850* (BRY); Coyote Canyon, T39S R8E S15 & 16, and adjacent mesa tops, 11 April 1982, *Welsh & Neese 20998* (BRY, NY), *20993* (BRY); Coyote Creek Canyon, near Jacob Hamblin Arch, T38S R8E, 29 July 1985, *Dunlop & Orlando 2087* (NHA); Cow Canyon, GCNRA, Waterpocket Fold, T38S R9E S36, 26 July 1983, *Welsh, Welsh & Chatterley 22350* (BRY). **San Juan Co.**: Lake Powell, Double Cove Garden, 401/2S, R9E, S25, 3800 ft., 1 July 1983, *Welsh 22322* (BYU, UT); Lake Powell, Three Garden, ca. 1 mile n. of confluence with San Juan Arm, 5 May 1974, *Welsh 12425* (BRY, NY); Lake Powell, Ribbon Canyon, canyon sides and hanging gardens, T41S R10E S5, 25 April 1983, *Welsh 21730* (BRY).