

Natural History of the Saint John River Valley Hardwood Forest of Western New Brunswick and Northeastern Maine

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Abstract

Saint John River Valley Hardwood Forest (SJRHF) is a species-rich forest assemblage of western New Brunswick and northeastern Maine that is highly threatened by habitat loss. Over two centuries of land clearance have reduced this once-continuous forest type into a series of small, often highly isolated patches averaging just over 10 ha in size. Despite this fragmentation, some remnant patches still maintain large numbers of tree, vascular plant, and bryophyte species, including many that are rare or threatened within New Brunswick or the Gulf of St. Lawrence region in general. This report describes the natural history of SJRHF, focusing on the general characteristics of the assemblage, the physiography of the central St. John River Valley and its role in maintaining SJRHF species, and the rare vascular flora found within. SJRHF is characterized by over 187 vascular plant and bryophyte species, of which 43 are listed as rare. It is associated with the rich calcareous soils and relatively moderate climate of the central St. John River Valley. A number of its constituent species are disjunct from the next nearest populations in southern Maine and south-central Quebec. The cause of this disjunct distribution lies in the migrational ability of each species and numerous vegetative and environmental changes that have occurred since glacial retreat over 10,000 years ago. Most SJRHF ground flora and bryophyte species are confined to the shady and cool understoreys of mature tolerant hardwood stands, with the ground plants preferring seepy areas. SJRHF ground flora tend to begin leafing and flowering before canopy closure in the early spring, reproduce more often vegetatively than by seed, and are generally unable to migrate long distances. Persistent habitat loss and forest fragmentation threatens the long-term occurrence of SJRHF in the central St. John River Valley region. Without direct intervention through a combination of conservation measures that includes protection, specialized forest management programs, and re-introduction, the future of this assemblage type may be in doubt in New Brunswick.

Résumé

Située dans l'ouest du Nouveau-Brunswick et le nord-est du Maine, la forêt de feuillus de la vallée du Saint-Jean (FFVSJ) est une communauté forestière d'une grande diversité qui est extrêmement menacée par la perte d'habitat. Plus de deux siècles de déboisement ont réduit ce type forestier, qui présentait autrefois une distribution continue, en une série de petites parcelles souvent très isolées d'une dimension moyenne à peine supérieure à 10 ha. En dépit de cette fragmentation, certains boisés restants conservent un nombre important d'essences et d'espèces de plantes vasculaires et de bryophytes, y compris de nombreuses espèces rares ou menacées au Nouveau-Brunswick ou dans l'ensemble de la région du golfe du Saint-Laurent. Dans le présent rapport, on décrit l'histoire naturelle de la FFVSJ en mettant l'accent sur les caractéristiques générales de la communauté biotique, la géographie physique de la vallée centrale du Saint-Jean et son rôle dans le maintien des espèces ainsi que la flore vasculaire rare de cette forêt. La FFVSJ est en effet caractérisée par plus de 187 espèces de plantes vasculaires et de bryophytes, dont 43 sont considérées rares. Elle est associée aux sols calcaires riches et au climat relativement modéré de la vallée centrale du Saint-Jean. Un certain nombre de ses populations constitutives sont isolées des populations affines les plus proches, qui se trouvent dans le sud du Maine et le centre-sud du Québec. Cet isolement est lié aux capacités migratoires de chaque espèce et aux nombreux changements végétatifs et environnementaux qui se sont produits depuis le retrait glaciaire d'il y a 10 000 ans. La plupart des espèces de végétaux de petite taille et de bryophytes sont confinées aux sous-étages ombragés et frais des peuplements mûrs de feuillus tolérants, les plantes de petite taille préférant les sols suintants. Dans les plantes de petite taille de la FFVSJ, la foliation et la floraison commencent généralement avant la fermeture du couvert, au début du printemps, et la multiplication végétative est plus courante que la reproduction par graine. Par ailleurs, ces plantes ne sont ordinairement pas capables de migrations à grande distance. La perte continue de l'habitat et la fragmentation des forêts réduisent les chances de survie à long terme de la FFVSJ dans la région de la vallée centrale du Saint-Jean. À moins qu'on intervienne directement en mettant en oeuvre une combinaison de mesures de conservation - y compris des mesures de protection, des programmes spécialisés d'aménagement forestier et des activités de renouvellement - ce type forestier risque de disparaître du Nouveau-Brunswick.

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Introduction

St. John River Valley Hardwood Forest (SJRHF) is a species-rich forest assemblage that is one of the most threatened ecosystems in New Brunswick. Once spread over much of the central St. John River Valley and harboring a number of species occurring nowhere else in Atlantic Canada, the distribution of this assemblage has been severely reduced by clearing for farming and settlement, and by logging. SJRHF now covers less than 1% of the land base within this region and only occurs in small-sized and usually highly isolated patches. On-going clearing and cutting jeopardize the remaining stands, as well as the many rare plant species associated with this forest type.

This report profiles the natural history of the rich hardwood forests of the middle St. John River Valley in New Brunswick and in the eastern section of Aroostook County, Maine. Section I will define what is meant by SJRHF, provide a general description of the assemblage type, and outline how it differs from hardwood forest assemblages found in other regions of the Maritime provinces. Section II will describe the physical characteristics of the central St. John River Valley. It will also present the vegetation history of the area, starting near the beginning of the post-glacial period and extending to the present day following the onset of European colonization. Knowledge of the history of the region helps explain the current distribution pattern of SJRHF and why it is threatened. Section III will profile the life history characteristics of ground flora associated with temperate deciduous forest. Section IV will give detailed descriptions of the rare vascular plant species associated with SJRHF. Finally, Section V will outline the conservation prospects for SJRHF in New Brunswick based on current land use trends and make management recommendations for its protection.

Section I: Definition, General Description, and Distribution of St. John River Valley Hardwood Forest

Definition

St. John River Valley Hardwood Forest refers to a distinct assemblage of tree, understory vascular plant, and bryophyte species found in the central St. John River Valley and connecting tributary

valleys of western New Brunswick and eastern Aroostook County, Maine. This assemblage type is associated with the moderate climate and well-drained calcareous upland and alluvial bottomland soils of this region. SJRHF is part of a transition forest between southern hardwood forests of central Appalachia and northern hardwood forests of northern New England, the Maritimes, and Quebec. While lacking some of the species of the southern hardwood forests (*e.g.*, white trillium (*Trillium grandiflorum*), large-flowered bellwort (*Uvalaria grandiflora*), and broad beech fern (*Thelypteris hexagonoptera*)), it is the last major concentration in the northeast for many other species with southern affinities (Figure 1). A number of its constituent species are disjunct by several hundred kilometers from the next nearest populations in southern Maine and the St. Lawrence River valley of south-central Quebec. Some SJRHF species, such as basswood and butternut, approach their northern distributional limit within this region of New Brunswick.

The name "St. John River Valley Hardwood Forest" is derived from the location of this assemblage type within Atlantic Canada. It has also been referred to by other names. MacDougall (1997) labelled this assemblage as "Appalachian Hardwood Forest" due to the southern affinity of many of its member species. Similarly, "Alleghanian Forest" has sometimes been used, adapting the term used in Quebec (Marie-Victorin 1964) and Nova Scotia (Roland and Smith 1969) to describe rich hardwood forests with southern elements. SJRHF has also been called the Sugar Maple-Ash Zone within the St. John River Ecoregion (Loucks 1962) and the St. John River Forest (Stirrett 1980). The Natural Landscapes of Maine (McMahon 1990, 1991) classifies SJRHF as "cove forest" within the Aroostook Lowlands Biophysical Region. In New Brunswick's provincial land classification system (New Brunswick Department of Natural Resources and Energy 1996, 1997), SJRHF corresponds with Ecosites 7L, 7C, and 8C within the St. John River Valley Ecodistrict.

General Description

The flora of SJRHF is more diverse than the flora of most other forest types occurring in New Brunswick. There are 71 vascular plant taxa that characterize SJRHF (Table 1), as well as 116 moss and liverwort species (Table 2). Most typical

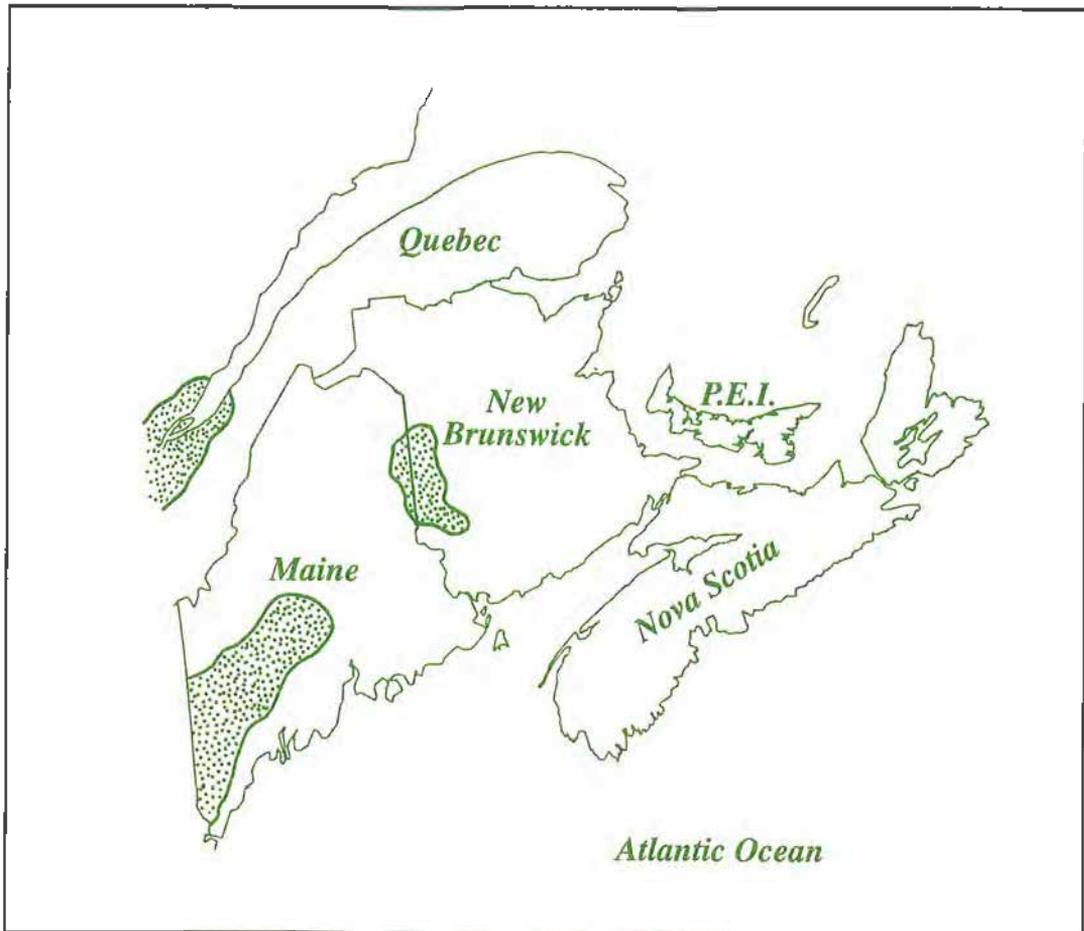


Figure 1. Estimated distribution of areas with the highest concentrations of rich tolerant hardwood flora in the Maritime provinces, Maine and southwestern Quebec.

are vascular plant species such as trout lily, red trillium, yellow violet (Figure 2), dutchman's-breeches, silvery glade-fern, toothwort, hooked buttercup, and spring beauty (Figure 3). Mosses such as *Brachythecium reflexum* and *Plagiomnium ciliare* are also common (Figure 4) (B. Bagnell, pers. comm.). In some SJRHF patches, Christmas fern, bloodroot (Figure 5), sweet cicely, rattlesnake fern, or large populations of Canada yew occur. *Raiiella scita* and *Anomodon rugelii*, two moss species considered rare within the Maritime provinces and the Gulf of St. Lawrence region, are frequently observed in SJRHF stands (B. Bagnell, pers. comm.).

SJRHF assemblages are usually associated with mature forest conditions. Younger forested areas that were once pasture, heavily and selectively cut or clearcut, rarely support species-rich SJRHF communities. Similar trends in species richness in mature versus second-growth deciduous forest have been recorded in the eastern United States and in the central Appalachians (Whitney and Foster 1988, Duffy and Meier 1992, Matlack 1994,

Meier *et al.* 1995). Mature SJRHF canopies are typically dominated by sugar maple, beech, white ash, yellow birch, and ironwood. Basswood, butternut, American elm, and hemlock are also observed in many stands, and the first two species in this latter group are usually good indicators of the presence of species-rich understorey assemblages.

Many SJRHF understorey vascular plant species are not randomly distributed within forest patches. Instead, many species, especially those provincially rare, tend to be clustered in moist seepy microsites (Figure 6). Seepy areas occur near brooks or streams, in topographical depressions, or on hillside plateaus that drain slowly relative to surrounding areas. The ecological importance of these areas lies in their higher and more persistent moisture availability. They may also act as nutrient sinks, accumulating dissolved nutrients from ground water flow from the surrounding areas. If seepage areas remain after heavy site disturbance, the chances of SJRHF ground flora persisting until the mature overstorey once again re-establishes may increase.

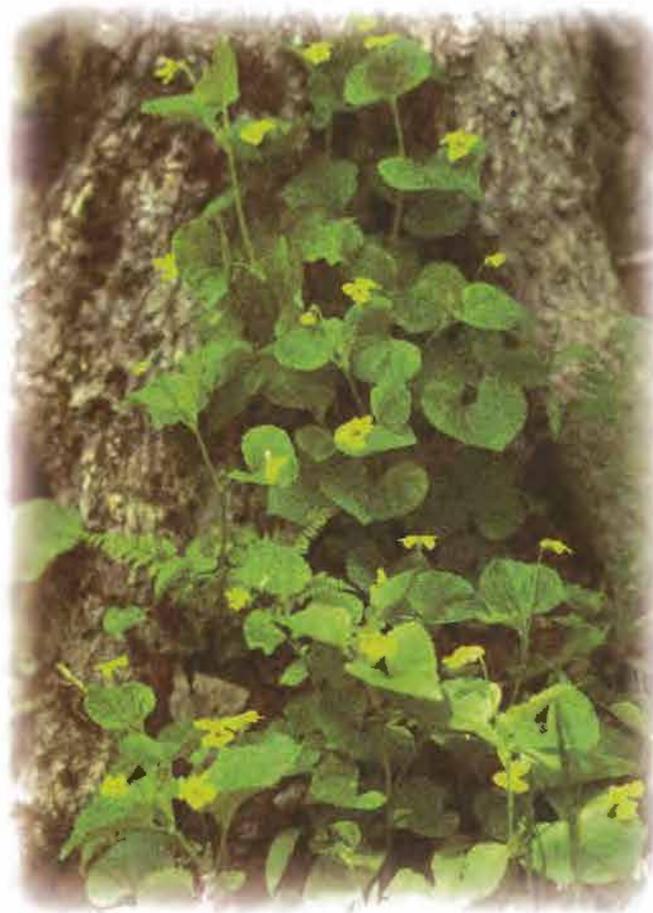


Figure 2: Yellow violet
on alluvial flood plain
- Knoxville, Carleton County.

Table 1: Vascular plant taxa that characterize St. John River Valley Hardwood Forest. Bold indicates taxa listed, but not formally protected, by the New Brunswick Committee on Endangered Species (NBCOES 1995); ** indicates taxa listed as uncommon, rare, or very rare in New Brunswick by Hinds (1983, 1986); * indicates provincially very rare taxa discovered after the publication of Hinds (1986); and ++ indicates provincially extirpated taxa.

Agrimony (<i>Agrimony gryposepela</i>)	Maidenhair fern (<i>Adiantum pedatum</i>)**
American Elm (<i>Ulmus americana</i>)	Nodding Fescue (<i>Festuca subverticillata</i>)**
Basswood (<i>Tilia americana</i>)	Northern Wild Comfrey (<i>Cynoglossum boreale</i>)**
Beech (<i>Fagus grandifolia</i>)	Pale Touch-Me-Not (<i>Impatiens pallida</i>)**
Black Ash (<i>Fraxinus nigra</i>)	Plantain-leaved Sedge (<i>Carex plantaginea</i>)**
Black Raspberry (<i>Rubus occidentalis</i>)**	Pointed-leaved Tick-trefoil (<i>Desmodium glutinosum</i>)**
Bloodroot (<i>Sanguinaria canadensis</i>)	Pubescent Sedge (<i>Carex hirtifolia</i>)**
Blue Cohosh (<i>Caulophyllum thalictroides</i>)**	Rattlesnake Fern (<i>Botrychium virginianum</i>)
Bottle-brush Grass (<i>Elymus hystrix</i>)**	Red Trillium (<i>Trillium erectum</i>)
Braun's Holly-fern (<i>Polystichum braunii</i>)**	Round-leaved Hepatica (<i>Hepatica nobilis</i>)**
Butternut (<i>Juglans cinerea</i>)	Seneca-Snakeroot (<i>Polygala senega</i>)**
Canada Yew (<i>Taxus canadensis</i>)	Sessile-leaved Bellwort (<i>Uvularia sessilifolia</i>)
Canada Violet (<i>Viola canadensis</i>)**	Showy Orchis (<i>Galearis spectabilis</i>)**
Christmas Fern (<i>Polystichum acrostichoides</i>)	Silvery Gladefern (<i>Deparia acrosticoides</i>)
Clinton's Shield-fern (<i>Dryopteris clintoniana</i>)**	Simulated Log Fern (<i>Dryopteris clintoniana</i> <i>X goldiana</i>)*
Cut-leaved Toothwort (<i>Cardamine concatenata</i>)**	Solomon's-seal (<i>Polygonatum pubescens</i>)
Daisyleaf Grape Fern (<i>Botrychium matricariifolium</i>)	Spikenard (<i>Aralia racemosa</i>)
Dissected Grape Fern (<i>Botrychium dissectum</i>)	Sprengel's Sedge (<i>Carex sprengelii</i>)**
Dowell's Wood Fern (<i>Dryopteris X dowellii</i>)*	Spring Beauty (<i>Claytonia caroliniana</i>)
Dutchman's-breeches (<i>Dicentra cucullaria</i>)	Sugar Maple (<i>Acer saccharum</i>)
Enchanter's Nightshade (<i>Circaea lutetiana</i>)	Sweet Cicely (<i>Ozmorhiza claytonii</i>)
False Solomon's-Seal (<i>Smilacina racemosa</i>)	Thin-leaved Sedge (<i>Carex cephaloidea</i>)**
Fragrant Snakeroot (<i>Sanicula odorata</i>)**	Toothwort (<i>Cardamine diphylla</i>)
Goldie's Fern (<i>Dryopteris goldiana</i>)**	Trout Lily (<i>Erythronium americanum</i>)
Great-spurred Violet (<i>Viola selkirkii</i>)	White Ash (<i>Fraxinus americana</i>)
Grove Meadow-grass (<i>Poa alsodes</i>)	White Baneberry (<i>Actaea pachypoda</i>)
Honewort (<i>Cryptotaenia canadensis</i>)**++	White Snakeroot (<i>Eupatorium rugosum</i>)
Hooked Buttercup (<i>Ranunculus recurvatus</i>)	Wild Coffee (<i>Triosteum aurantiacum</i>)**
Ironwood (<i>Ostrya virginiana</i>)	Wild Ginger (<i>Asarum canadense</i>)
Jack-in-the-pulpit (<i>Arisaema triphyllum</i>)	Wild Leek (<i>Allium tricoccum</i>)**
Kidney-leaved Buttercup (<i>Ranunculus abortivus</i>)	Wood Anemone (<i>Anemone quinquefolia</i>)
Lance-leaved Grape Fern (<i>Botrychium lanceolatum</i>)**	Yellow Birch (<i>Betula alleghaniensis</i>)
Large-Fruited Snakeroot (<i>Sanicula trifoliata</i>)**	Yellow Lady's-slipper (<i>Cypripedium pubescens</i>)
Large Toothwort (<i>Cardamine X maxima</i>)	Yellow Violet (<i>Viola pubescens</i>)
Leatherwood (<i>Dirca palustris</i>)**	Zig-zag Goldenrod (<i>Solidago flexicaulis</i>)
Lopseed (<i>Phryma leptostachya</i>)**	

Table 2: List of bryophyte (moss and liverwort) taxa recorded within St. John River Valley Hardwood Forest in western New Brunswick. Bold indicates taxa considered significant within New Brunswick, the Maritime provinces, or the Gulf of St. Lawrence region in general, based in part on Bagnell (1995). Compiled by Bruce Bagnell (B & B Botanical, Sussex, New Brunswick).

(a) Mosses

Amblystegium serpens var. *serpens*
Andreaea rupestris
Anomodon attenuatus
Anomodon minor
Anomodon rostratus
Anomodon rugelii
Atrichum altecristatum
Atrichum oerstedianum
Brachythecium populeum
Brachythecium reflexum
Brachythecium rivulale
Brachythecium rutabulum
Brachythecium salebrosum
Brachythecium velutinum
Brotherella recurvans
Bryhnia novae-angliae
Bryohaplocladium microphyllum
Bryum pseudotriquetrum
Callicladium haldanianum
Campylium chrysophyllum
Ceratodon purpureus
Cirriphyllum piliferum
Cratoneuron filicinum
Dicranella heteromalla
Dicranella rufescens
Dicranella schreberiana* var. *robusta
Dicranum fuscescens
Dicranum fulvum
Dicranum flagellare
Dicranum montanum
Dicranum polysetum
Dicranum scoparium
Dicranum viride
Ditrichum lineare
Ditrichum pusillum
Ditrichum pallidum
Drummondia prorepens
Entodon brevisetus
Eurhynchium pulchellum
Fissidens bushii
Fissidens dubius
Fissidens taxifolius
Funaria hygrometrica
Hedwigia ciliata
Herzogiella turfacea
Homalia trichomanoides
Hylocomiastrum umbratum
Hylocomium splendens
Hypnum imponens
Hypnum lindbergii
Hypnum pallescens var. *pallescens*
Leskea polycarpa
Leskeella nervosa
Leucodon brachypus var. *andrewsianus*
Mnium ambiguum
Mnium stellare
Neckera pennata
Oncophorus wahlenbergii
Orthotrichum obtusifolium

Orthotrichum ohioense
Orthotrichum sordidum
Orthotrichum speciosum var. *elgans*
Orthotrichum stellatum
Oxystegus tenuirostris
Paraleucobryum longifolium
Physcomitrium pyriforme
Plagiomnium ciliare
Plagiomnium cuspidatum
Plagothecium cavifolium
Plagiothecium laetum
Platydictya subtile
Platygyrium repens
Pleurozium schreberi
Pogonatum pensilvanicum
Pogonatum urnigerum
Pohlia lescuriana
Pohlia nutans
Polytrichum commune var. *commune*
Polytrichum formosum
Polytrichum juniperinum
Polytrichum ohioense
Ptilium crista-castrensis
Pylaisiella intricata
Pylaisiella polyantha
Pylaisiella selwynii
Rauvella scita
Rhizomnium appalachianum
Rhizomnium punctatum
Rhodobryum ontariense
Rhytidiadelphus triquetrum
Sanionia uncinata
Schistidium apocarpum
Taxiphyllum deplanatum
Tetraphis pellucida
Thuidium delicatulum
Thuidium recognitum
Tortella tortuosa
Trematodon ambiguus
Ulotia coarctata
Ulotia crispa

(b) Liverworts

Anastrophyllum minutum
Bazzania trilobata var. *trilobata*
Barbilophozia barbata
Cephalozia lunulifolia
Conocephalum conicum
Frullania eboracensis
Jamesoniella autumnalis var. *autumnalis*
Lepidozia reptans
Lophocolea heterophylla
Nowellia curvifolia
Plagiochila porelloides
Porella platyphylla
Porella platyphylloidea
Ptilidium ciliare
Ptilidium pulcherrimum
Radula complanata



Figure 3: Spring beauty on upland hardwood site near Centerville, Carleton County.



Figure 4: Moss-covered trunk in shaded understorey near Jackson Falls, Carleton County. The bark of tolerant hardwood trees such as sugar maple and ironwood is a preferred substrate for the establishment of many bryophyte species.



Figure 5: Bloodroot in flower near Woodstock, Carleton County.



Figure 6: Seepage area covered with spring ephemerals in mid-May - Woodstock, Carleton County.

The diversity and abundance of SJRHF flora is greater than other "rich tolerant hardwood forest" known to occur in Nova Scotia, Prince Edward Island, and other New Brunswick locations. These other rich hardwood forests, usually associated with narrow alluvial bottomlands, contain some of the ground flora species found in the central St. John River Valley (Erskine 1960, Keddy 1979, Simmons *et al.* 1984). However, SJRHF generally harbours the greatest concentration and the largest populations of these species in the Maritimes. To the east, SJRHF species such as dutchman's-breeches, spring beauty, common toothwort, and hooked buttercup are considered rare on PEI (Day and Catling 1991) and New Brunswick's eastern lowlands. Uncommon or rare SJRHF species such as maidenhair fern, plantain-leaved sedge, blue cohosh, wild leek, and yellow lady's slipper are extremely rare or threatened with extirpation in Nova Scotia (Maher *et al.* 1978, Keddy 1979) and are absent on PEI. SJRHF also contains a subset of species that are unique to the Maritime provinces. These species include showy orchis, Clinton's fern, simulated log fern, large-fruited snakeroot, thin-leaved sedge, Dowell's wood fern, cut-leaved toothwort, and lopseed.

Distribution

SJRHF species are most abundant in the stretch of the St. John River Valley extending from Meductic to Beechwood, and including tributary valleys of the Eel River, Meduxnekeag River, Big Presque-Isle Stream, Monquart Stream, and Guisiquit Stream. The greatest concentration of species-rich SJRHF sites, and of rare SJRHF species, is in the watershed of the Meduxnekeag River. Other areas hosting species-rich sites occur on alluvial bottomlands of the Eel River, and near the communities of Florenceville, Upper Knoxford, Summerfield, and Mineral. Concentrations of some SJRHF sites occur elsewhere in New Brunswick. For example, sites are known from the Restigouche River, Keswick Ridge, Perth-Andover, near the mouth of the Salmon River (Undine), along Belleisle Bay, Havelock, and in several locations in the Sussex area. (Note: some of these occurrences are known only from old herbarium records from sites that have since been destroyed. For example, large-fruited snakeroot, a very rare SJRHF species, has not been observed in Sussex since 1889 (MacDougall *et al.*, in press). Populations of maidenhair fern and round-leaved hepatica re-

corded at Belleisle Bay earlier this century have not been found since that time (MacDougall and Loo 1996).) However, none of the areas have hardwood assemblages that are as rich in species, or as numerous, as they are within the central St. John River Valley.

The distribution of SJRHF sites in eastern Aroostook County, Maine is less well known than in New Brunswick. Only a few scattered locations have been discovered by botanists, reflecting higher and more intensive levels of disturbance of hardwood forest in Maine, as well as less systematic and intensive survey efforts (Sally Rooney, *pers. comm.*). It is also possible that SJRHF were originally less extensive in Maine. Much of the discussion of SJRHF in this text will refer to New Brunswick sites based on information obtained during an extensive survey of the region conducted in 1997 (MacDougall 1997). However, it is assumed that the discussion is pertinent to SJRHF sites in north-eastern Maine.

Section II: Physical Description and Vegetation History of the Central St. John River Valley

Why does the central St. John River Valley harbor the greatest concentration of temperate deciduous forest species in northern Maine and the Maritime provinces? And what factors have shaped the present-day distributions of these species within the region? The explanations probably lie in a combination of environmental and historical factors (Clayden 1994). The environmental factors include the particular edaphic, climatic, and topographic features found within this central St. John River Valley compared with adjacent areas in western New Brunswick and northern Maine. The historical factors include the likely pathways and times of arrival of SJRHF species following glacial retreat, and the settlement of the area by European colonists beginning two centuries ago.

Environmental features of the central St. John River Valley

The central St. John River Valley, as referenced in this report, lies between latitudes 45.95° and 46.65° and longitudes 67.50° and 68.00°. The region consists of gently rolling terrain bordered on the east and north by higher rugged hills (Figure 7). Its western boundary is in Maine and coincides with the westward extent of the enriched, well-drained

soils that characterize the region (McMahon 1990). The elevation ranges from 150 - 200 m a.s.l., with the surrounding hills exceeding 300 m in some areas. The hills to the north, known as the Kintore Hills, cut across the valley between Rivière de Chute and Perth-Andover. The Kintore Hills rise steeply from the edges of the river, limiting interval formation on the valley bottom. Downriver from the Kintore Hills, extensive stretches of alluvial bottomlands likely occurred along the St. John River and on riverine islands. However, many of these bottomland areas disappeared following flooding by hydroelectric dams at Mactaquac and Beechwood. Today, only a short section of river below the Beechwood dam and above Woodstock, the upper limit of the Mactaquac headpond, is free from the influence of this flooding.

The most notable environmental feature of the region is the soil. Here, overlying a bedrock of Ordovician argillaceous limestone or Silurian calcareous sandstone rocks, occur well-drained, nu-

trient-rich, and deep loamy soils that are the most fertile, and heavily farmed, in New Brunswick (New Brunswick Department of Natural Resources and Energy (NBDNRE) 1996). These soils are represented mostly by two soil groups. The Caribou Soil Unit is associated with the limestone parent material, and consists of fine-textured, well-drained glacial tills. It is the richer of the two soil units and occurs almost entirely on the western half of the St. John River Valley, except for the Monquart Stream watershed near Mineral. The Carleton Soil Unit overlies the sandstone bedrock and is a fine-textured compact glacial till. It occurs on the western side of the valley between the Eel and Meduxnekeag Rivers, and on the eastern side between Hartland and Florenceville (Colpitts *et al.* 1995). The remaining areas of the valley, mostly the uplands plus the eastern side of the valley bottom from Meductic to Hartland, consist of non-calcareous glacial till soils derived from metasedimentary parent materials.



Figure 7: Rolling terrain of central St. John River Valley near Upper Knoxford, Carleton County.

The climate of the central St. John River Valley is generally warmer and drier than that of neighboring regions in west-central New Brunswick and northern Maine. It has a higher average summer temperature, by as much as 6°F (Millette and Langmaid 1964), with slightly less annual precipitation (1050 mm per year - NBDNRE 1996) and a longer frost-free period (80-120 days - Hinds 1980, McMahon 1990) than these other adjacent regions. The relatively moderate climate of the central St. John region likely results in part from the influence of the river, which ameliorates local temperatures, plus the sheltering effect of the valley.

The soils and climate of the central St. John River Valley are not unique to New Brunswick. The calcareous soils extend north along the St. John River Valley between Grand Falls and St. Leonard, and along the Restigouche River Valley to the Baie des Chaleurs. The moderate climate of the area is comparable to other regions in eastern and southeastern sections of the province (Dzikowski *et al.* 1984). However, it is only in the central St. John River Valley that the combination of calcareous soils and relatively moderate climate co-occur. This combination is likely largely responsible for the presence of SJRHF species that are more typical of latitudes to the south.

Post-glacial colonization of the central St. John River Valley by SJRHF species

The disjunct distribution of some SJRHF species within northeastern North America (Figure 1) begs the question: how did they arrive in New Brunswick? Some SJRHF species are separated by several hundred kilometers from the next closest population to the south or west, thus there is no obvious corridor for their arrival. Similarly, there is a large distance between populations of some SJRHF species in New Brunswick and Nova Scotia.

The answer likely lies in the distant past, several thousand years ago or more, when large numbers of plant and animal species were colonizing northern Maine and the Maritimes following the end of the last glacial period. Because many SJRHF ground flora species have limited capacity for long distance dispersal (e.g., Matlack 1994), it is plausible to assume that disjunct populations were at one time continuously distributed. Furthermore, the strong association between the occurrence of SJRHF vascular plant species and the presence of tolerant hardwood forest suggests that broadleaf

deciduous forest was also more widespread. Without deciduous forest continuously extending from southern Maine or western Quebec to the central St. John River, and from New Brunswick to Nova Scotia, it seems unlikely that many SJRHF flora could have jumped across such large distances.

Evidence from palynological studies in New Brunswick confirm that tolerant hardwood forest, and particularly the SJRHF assemblage, was more abundant than it is today (Mott 1975). It also documents considerable changes in the region's forests since the glaciers finally receded approximately 13,000 years ago. The primary cause of these changes has been fluctuating climate, though other related factors such as fire frequency, interspecies competition, and soil development have also played a role (Green 1987, Miller 1989). Rich hardwood tree species (ironwood, ash, and elm) first begin appearing in the pollen records 11,000 to 9,500 years BP (Before Present), followed soon thereafter by maple and beech. Tolerant hardwood species continued to increase in abundance over the next several thousand years, finally peaking in a period between 5100 and 3000 BP. Mott (1975) speculates that the hardwood-dominated forests of this period may have been similar to those found today in the central St. John River Valley. It is likely no coincidence that the rise in deciduous forests occurred at the warmest time interval in the current interglacial period. Called the hypsithermal interval, it came immediately after the rapid warming that led to the retreat of the glaciers, and is believed to have peaked around 6000 BP (Pielou 1991). After 3000 BP, tolerant hardwoods once again began to decrease. Since that time, this pattern has been maintained; spruce has increased in abundance and hardwoods, though still common, have decreased relative to their earlier peak (Livingstone 1968, Mott 1975, Green 1987).

Glaciation also had a pronounced effect on global sea levels, which in turn affected the distribution of tolerant hardwood forest within the Maritimes. Glaciers can affect sea level in two ways. They can raise or lower the volume of water in the world's oceans depending on whether glaciation is contracting or expanding (called "eustatic change"). Glaciers can also affect sea levels by lowering the earth's crust due to the weight of the ice, causing sea levels to rise relative to the position of the coast (called "isostatic change"). In the Maritimes, both eustatic and isostatic changes are believed to

have influenced sea levels (Pielou 1991). At the peak of the last ice age, much of the Maritime provinces was covered in ice; yet at the same time, the continental shelf off New England and Nova Scotia was an exposed coastal plain (Pielou 1991). As the glaciers finally began leaving the region, around 13,000 years BP, the pace of isostatic rebound was faster than the rising sea levels caused by melting ice, leaving considerable expanses of previously glaciated land free from both ice and the rising oceans. The Maine and New Brunswick coastlines extended farther into the Bay of Fundy, the isthmus connecting New Brunswick and Nova Scotia was wider, and Prince Edward Island (PEI) was linked to mainland Nova Scotia, Cape Breton, and northeastern New Brunswick by a wide land bridge (Simmons *et al.* 1984). Much of this landmass was still partially exposed as recently as 5,000 years BP and, combined with the warmer climate at this time, may have served as the conduit for the arrival of deciduous forest flora into Nova Scotia and PEI. Some hardwood species may also have reached Nova Scotia via the exposed continental shelf, though these coastal lowlands are believed to have disappeared by 8000 BP (Green 1987). By 3000 BP, ocean levels resembling those of today isolated Prince Edward Island and Cape Breton, and narrowed the connection between New Brunswick and Nova Scotia (Simmons *et al.* 1984). The rising waters, combined with the decrease in abundance of tolerant hardwood forest, would have isolated tolerant hardwood species established in Nova Scotia and PEI, and halted further arrivals by more slowly migrating species. This may explain in part why tree species such as butternut and basswood, both capable of growing in Nova Scotia and Prince Edward Island, do not naturally occur in these provinces today.

The pollen records clearly demonstrate an expansion and subsequent contraction of tolerant hardwood forest within northeastern North America. Did many of the SJRHF ground flora species follow the same pattern? Were many SJRHF plant species more widely distributed at one time, and did their ranges subsequently contract? Or does the present-day distribution of many vascular plant species match the distribution at the peak of the hypsithermal period? There is no available palynological evidence to indicate when these species arrived or how extensively they were distributed. However, by examining their current distribution and our knowledge of their migrational abilities, we

can speculate on two possible scenarios. The first suggests that the distribution of SJRHF flora has significantly contracted in northeastern North America within the past several thousand years. The second suggests that SJRHF species arrived at different times, depending largely on their dispersal ability, and that many species are concentrated in the central St. John River region due to an inability or insufficient time to reach suitable habitat in other places.

The first scenario, the “contraction” hypothesis, is largely supported by the trends observed for the deciduous trees in the pollen record. It assumes that the understory flora migrated widely across the Maritimes in concert with the deciduous tree species, and similarly contracted as the hardwood forests receded. Examining the present-day distribution of very rare SJRHF flora indicates that species with inefficient long-range dispersal nonetheless have isolated populations in Nova Scotia. This includes Canada violet, wild coffee, fragrant snakeroot, nodding fescue, northern wild comfrey, and pubescent sedge. These species may have arrived via a formerly more continuous tolerant hardwood forest from areas to the west. The fact that most are only represented by one or a few very small populations, and are considered threatened, suggests that current environmental conditions may not be entirely suitable for their persistence. Intense human disturbance over the past several centuries would have exacerbated this effect. If the “contraction” hypothesis is indeed valid - if SJRHF species in other regions of the Maritimes were once more abundant and have either disappeared or are in the process of disappearing - then the richness and abundance of SJRHF species in the central St. John River Valley is explained by its specialized environmental features. That is to say, the conditions found in the region are sufficient to offset the effects of the shifting environmental conditions, and associated habitat change, elsewhere, thus allowing species with a southern affinity to persist.

The second scenario is a “limited expansion” hypothesis. It assumes that each SJRHF ground flora species arrived at different times during the post-glacial colonization, with the time of arrival and the distributional extent within the Maritimes being determined by dispersal ability. The strongest supporting argument for this scenario is the known limited range of migration of many SJRHF ground flora species (see Section III). The rapid

northern expansion of tree species in this post-glacial period is well documented, with some species such as white pine, hemlock, and red oak “migrating” at an average of up to 35 km every century (Davis 1983). Ground flora species, on the other hand, have average annual dispersal distances as little as a few centimeters (Hughes and Fahey 1991). As a result, certain SJRHF species may never have reached Nova Scotia, PEI, or even eastern New Brunswick, even though these regions may have contained suitable habitat in the past and still do. Limited dispersal ability may also explain in part why some rich tolerant hardwood plant species, such as wild ginseng (*Panax quinquefolius*) and squirrel-corn (*Dicentra canadensis*), occur in south-central Maine and southeastern Quebec but have not yet been observed in the central St. John River Valley even though habitat conditions appear similar.

To test the “limited expansion” hypothesis, Holland (1980) conducted extensive transplant experiments using trout lily, placing this species in areas within the Maritimes where it did not previously occur. It was found that trout lily was able to establish in these other locations, leading the author to conclude that the species is distributionally limited by its slow rate of dispersal, rather than the unsuitability of the habitat. These findings suggest that present-day SJRHF distribution may be more a function of migration than of past environmental change. If the “limited expansion” hypothesis is valid, it implies that the central St. John River Valley was the original point of arrival for SJRHF species from the south, and that many species have yet to expand elsewhere. The elimination of hardwood forest in much of the St. John River Valley following European colonization has further reduced the ability of SJRHF species to migrate outside of the region; the original bottomland forests of the valley would have served as an effective and continuous dispersal corridor.

There is insufficient evidence to confirm which scenario most accurately describes historical events. However, it is likely that both have some validity. Some species likely did expand in conjunction with the deciduous tree species, but have since contracted and no longer occur outside of the central St. John River Valley due to environmental limitations. Dispersal ability determined to some degree which species were wide-ranging and which remained restricted to western New Brunswick. It is likely no coincidence that those species most

common within SJRHF stands, such as trout lily and yellow violet, are also those most widely scattered across the Maritime provinces in general. The common occurrence of some species probably also reflects an ability to tolerate a wider range of habitat conditions compared with other species, or a higher success rate at successfully germinating and establishing at new sites. For example, of the three species of black snakeroot (*Sanicula*) that occur in New Brunswick, one is common and two are very rare, even though there is no appreciable difference in the size, shape, or formation of seed-coat bristles among the three species. Chance may also play a role in explaining current patterns of occurrence. A combination of long-distance dispersal, propagule deposition in suitable habitat, and then successful germination may occur at random for any one species, leading to the establishment of a new population. Only through detailed demographic investigations can insight be gained into why and how existing SJRHF distributional patterns developed.

Human settlement within the central St. John River Valley

Like many regions in New Brunswick, the central St. John River Valley has been subject to human influence for at least several thousand years, with the last two centuries being the period of greatest change. Given that humans have been significantly altering the landscape in this region for some time, understanding today’s forest patterns, and in particular why mature SJRHF occupies such a small percentage of the landscape, requires examination of historic land use patterns.

Significant human disturbance began in the central St. John River Valley in the early 1800s, the region being one of the last areas of the St. John River to be colonized by European and American immigrants. Prior to this period, the Malecite people had occupied the central St. John River Valley for several millennia. The Malecite people tended to be highly mobile, and the river systems of the region, particularly the St. John River and the Eel River (Ganong 1899), were their primary means of travel. They are believed to have had a minimal effect on the forests of the central St. John, with their impacts being concentrated in bottomland areas where they established permanent settlements in a few locations (e.g., Meductic) and conducted low intensity agriculture.

The European colonization of the St. John River system occurred in a series of waves as different groups of settlers arrived and became established. Large numbers of settlers began colonizing the central St. John River in the early part of the 1800s. By then, all downriver land grants along the St. John had been claimed, and large numbers of settlers were demanding land. Many of these settlers were immigrants from Europe, and were mostly Scottish and Irish. The others were discharged soldiers from the War of 1812 who were promised land at the end of their service. As well, there were colonists moving into the valley from Maine, in part due to uncertainty over the location of the Canada-US border (Bailey 1894). By this time, the central St. John region was known to have rich, highly productive soils, and it was given the nickname "the garden of Maine" by colonists from the south. Also, the extensive stands of centuries-old hardwood forests had very open, park-like understoreys that made land clearance very easy compared with other more conifer-dominated regions of New Brunswick and Maine. As a result, in a period of only 50 years, ending in the 1850s, much of this region was cleared for farming, or was heavily logged for timber (Bailey 1894).

Settlement of the central St. John River Valley continued for most of the 19th Century. Once all riverside grants were filled, settlement continued in the areas away from the river. This settlement in the 'interior' finished off the last tracts of pre-settlement forest in the central St. John River Valley and, by the 1890s, there were already reminiscences about the region's former appearance. By that time, cleared agricultural land extended almost completely from Grand Falls to Meductic, a stretch of river that was described only 90 years earlier as dark wilderness (Bailey 1894).

At the peak of settlement in the late 1800s and early 1900s, the central St. John Valley would have been dominated by cultivated fields and pasture but woodland patches were likely still abundant. Often settlers left their "back 40" forested to serve as a source of fuelwood and building material, extracting logs when needed. This persistent cutting selectively harvested the best trees, and reduced the size and quality of standing timber in the remnant stands. The long-term effects of such "high-grading" shaped the present-day appearance of many of the mature forest stands within the

study region, as well as in New Brunswick forests in general. Whether these disgenic harvesting practices resulted in genetically impoverished forests depends on the degree to which the trees had regenerated prior to their harvest. Fortunately, the probability of leaving offspring before selective harvesting is higher for tolerant tree species than for intolerants.

Despite the persistent cutting in many forest fragments, these stands would have served as the only refuge for many SJRHF plant species following the intensive land clearance over most of the landscape. Many of these forests would have maintained their overstorey canopy, and understorey impact would have been minimized by the use of horses to extract harvested timber. As a result, disturbance was likely not intensive enough to eliminate SJRHF ground flora directly, though the isolation of populations by forest fragmentation may have adversely affected some species. The absence of detailed plant surveys from this period limits our ability to comment on specific changes in plant species composition in SJRHF forests since the onset of European colonization, but it seems likely that most species would have survived.

Land use patterns in the 20th Century

Rural land use patterns in the St. John River Valley dramatically changed in and around the period of the first and second world wars, and these changes affected the appearance of the landscape. Regional economies shifted in emphasis from rural to urban, and from agricultural to industrial. Many farms were abandoned as younger generations sought their livelihoods in urban centers. These changes not only affected the St. John River Valley but also the Maritimes and northeastern North America (e.g., Dunwiddie *et al.* 1996) in general. Areas that had been cleared for the first time several decades earlier were abandoned and allowed to reforest (Figure 8). Only the richest and most economically viable lands were maintained in agricultural production. These changes likely reduced the level of harvest in forested remnants in the central St. John River Valley as human population density and economic activity diminished. Thus, the mature forest remnants that survived the period of intense land clearance in the 19th century are thought to have remained stable for most of the 20th century.

In this decade, demand for hardwood forest products, either pulp or saw logs, has increased, once again leading to relatively high levels of harvest within the central St. John River Valley region. Woodlots now often serve as a supplementary source of income for many landowners. Combined with the development of powerful and sophisticated equipment for both harvesting and extracting timber, areas that have remained forested for many decades are now being cut. Given that many second growth forests in the region are 50 years old or younger, it is the remnant mature stands, the stands supporting the richest SJRHF assemblages, that provide the highest value.

Section III: Life History Characteristics of St. John River Valley Hardwood Forest Ground Flora Species

This section describes life history characteristics of understory vascular plant species associated with temperate deciduous forest. Vascular plants are targeted for this discussion because less is known regarding the life history of bryophytes found in hardwood forests. Many understory plant species are spring-flowering herbs, also referred to as “spring ephemerals,” and share many life history traits, including phenology, longevity, modes of reproduction, and means of dispersal. However, there are also differences among some of these species, differences that explain to some degree why certain species are common and others are rare both within SJRHF stands, and within northeastern North America in general. Knowledge of life history patterns for SJRHF understory flora also helps to assess the potential effects of intensive human disturbance on these species, which will be discussed in more detail in Section V.



Figure 8: Old stone fence in SJRHF site near Woodstock. Spring ephemerals occur mostly to the right of the fence. The forest on the left is regenerating on abandoned pasture and contains few SJRHF species.

Phenology

Most of the vascular plant species associated with SJRHF die back some time between early and late summer. Exceptions are plantain-leaved sedge and round-leaved hepatica, both of which maintain foliage throughout the winter. The leaves of many SJRHF species generally begin emerging in early to mid-May, long before the canopy begins to close. Light availability at this time is high, around 50% of total incident radiation; once the canopy forms, light levels drop below 10% (Schemske *et al.* 1978). New leaves of evergreen species usually appear just after flowering, which also occurs in early spring. Fern species are generally more delayed in the appearance of their leaves. The foliage of species such as Goldie's fern, silvery glade fern, and maidenhair fern usually begins to emerge from the ground in late May but can take several weeks to fully expand.

Flowering generally precedes canopy closure, though some species flower during or after. Different flowering times may assist in pollination success by staggering the emergence of flowers to offset inter-specific competition for pollinators (Schemske *et al.* 1978). The earliest to flower include trout lily, wild ginger, bloodroot, red trillium, round-leaved hepatica, dutchman's-breeches, and the three toothwort species. Trout lily (Figure 9) and dutchman's-breeches (Figure 10) are the classic spring ephemerals, finishing their annual life cycle of leafing, flowering, and setting seed by early to late July, and becoming inapparent after this time. Other species develop more slowly. Yellow lady's-slipper, showy orchis, wild leek, sweet cicely, hooked buttercup, and spikenard tend to flower later in the spring during or just after canopy closure in mid or late June. Other species flower later in the summer, usually beginning at the end of June or in early July. Such species include the two rare black snakeroot species, lopseed, enchanter's nightshade, bottle-brush grass, and zig-zag goldenrod. Finally, pale touch-me-not is the last of the SJRHF species to begin to flower, doing so in mid-to late-August.



Figure 9: Trout lily - Debec, Carleton County.



Figure 10: Dutchman's-breeches near Woodstock, Carleton County.

Longevity

Almost all understorey plant species of temperate deciduous forest are perennials (Bierzychudek 1982). In SJRHF, only pale touch-me-not, an annual, and large fruited snakeroot, a biennial, are exceptions. Most species are slow growing, usually averaging 10 cm of growth per year, and may take 3 - 5 years or more to reach sexual maturity (Matlack 1994, Meier *et al.* 1995). The onset of sexual maturity may vary depending on local site conditions and nearby competition (Bierzychudek 1982). Overall life span is thought to range from 10 - 15 years, with some species approaching 25 years or more (Bierzychudek 1982). Clonal colonies of trout lily and wild ginger may apparently reach 100 years of age or more in some cases (Curtis 1959, Damman and Cain 1998).

Estimates of longevity for deciduous forest flora only apply to plants that are fully established at a particular site. The longevity of ungerminated seeds is usually one year or less, depending on the conditions where they lie. As well, there is a high level of mortality among newly germinated juveniles; only a small percentage actually survives to reach sexual maturity (Bierzychudek 1982).

Modes of reproduction

Most hardwood forest ground flora can reproduce either by vegetative propagation or by seed. Vegetative spread is thought to be more common but many species do flower and produce seed on a regular basis. Seed production does not necessarily occur every year and it is rare for all individuals within a population to set seed (Bierzychudek 1982). Vegetative spread occurs by sending up new growth from subterranean or surficial runners. Wild ginger often expands in this manner, forming large colonies of plants that are interconnected by an extensive network of prostrate stems and shallow rhizomes that spread along the ground (Cain and Damman 1997). Trout lily is believed to reproduce mostly by vegetative spread (Holland 1974), though seed production does occur and is necessary for any long-distance dispersal to new areas. Nault and Gagnon (1993) determined that less than 2% of wild leek population expansion was the result of seed production.

The flowers of most species are hermaphroditic, with both male and female parts within the same floral structure. SJRHF species known to be hermaphroditic include cut-leaved toothwort, dutchman's breeches, bloodroot, false solomon's-seal, and red trillium (Bierzzychudek 1982). At least two species, the plantain-leaved sedge and the pubescent sedge, are monoecious, with separate male and female flowers on the same plant. The separation of male and female flower parts, either within the flower or by developing separate flowers, reduces the chances of self-fertilization. However, studies on the breeding systems of temperate forest herbs reveal that self-compatibility is not uncommon, and that seed production can occur via self-fertilization (Bierzzychudek 1982).

It is believed that most ground flora species are pollinated by insects, especially honeybees (*Apis mellifera*), other bee species (halictid and anthrophorid bees), and flies, and that most species are generalists, attracting multiple pollinator

species (Schemske *et al.* 1978, Bierzzychudek 1982). Only the orchids, yellow lady's-slipper and showy orchis, have specialized floral structures that may limit visitation to one or a few pollinator species. Red trillium (Figure 11) has specialized scent production in its flowers, resembling the smell of decaying organic matter (hence the sometimes-used common name of "stinking Benjamin"), that attracts flies.

Successful insect pollination is strongly determined by early spring weather. Flowering under persistently cold conditions tends to result in very poor pollination success, especially among patchily distributed populations. Under these circumstances, seed production occurs largely by self-fertilization (Schemske *et al.* 1978). Wind-pollinated species such as the grasses and sedges are less subject to problems caused by poor weather, though wind velocity in hardwood forest understoreys is lower than in open areas (Matlack 1994).



Figure 11: Red trillium - Upper Woodstock, Carleton County.

Seed dispersal

Many species of deciduous forest understoreys have larger and heavier seeds than flora from other habitats. The comparatively heavier seed weight may be attributed to the embryo's need for a greater food supply to compensate for the lower light levels in the hardwood understoreys (Bierzuchudek 1982).

Hardwood forest herbs also tend to lack highly specialized seed dispersal mechanisms capable of consistently transporting seeds over long distances to suitable habitats. Numerous species simply disperse by gravity, either dropping off the plant, or dispersing the distance of the stem as it falls to the ground. Species such as the plantain-leaved sedge, honewort, wild leek, and hooked buttercup are known to disperse in this manner (Matlack 1994, Williams and Guries 1994). The seed capsule of cut-leaved toothwort opens explosively as it matures, releasing seeds several meters or more (Schemske *et al.* 1978). Other ground flora species have small, light-weight seeds or spores that can be carried by the wind, such as the ferns and to a lesser extent, grasses and sedges. Finally, the seeds of some species can be carried by insects, birds, or mammals. Fleshy-fruited species such as blue cohosh are likely ingested by some birds and mammals. Species with hooked or barbed seed appendages can disperse by attaching to moving animals. The two black snakeroot species, enchanter's nightshade, and sweet cicely are transported this way (Williams 1994, Williams and Guries 1994), as are northern wild comfrey and pointed-leaved tick-trefoil. Ants also are known to disperse seeds for some species, including trout lily, bloodroot, wild ginger, spring beauty, round-leaved hepatica, red trillium (Beattie and Culver 1981, Matlack 1994), and Canada violet (Hinds, *pers. comm.*). Ant-dispersed species are referred to as "myrmecochores" (Beattie and Culver 1981). The distance over which insect-, bird-, and mammal-dispersed seeds travel depends on the movement patterns of the disperser. If a disperser has a limited distance of travel (*e.g.*, ants) or does not move among habitat fragments (*e.g.*, mice), propagule dispersal will mostly be confined within stands.

Section IV: Rare Flora of St. John River Valley Hardwood Forest

SJRHF assemblages contain a number of species that are listed as uncommon, rare, very rare, threatened, or endangered within New Brunswick, Maine, the Maritime provinces, or even the Gulf of St. Lawrence region. These species include 28 vascular plants, as listed in Table 1. Given that almost all of these species are strongly associated with mature SJRHF stands, the continued loss of SJRHF in the central St. John River Valley threatens their long-term persistence within their current range in northern Maine and the Maritimes.

This section specifically profiles the rare vascular plant species that occur within SJRHF. It presents the distribution of the species in the Maritime provinces and in Maine, and in North America in general, as depicted in Erskine (1960), Roland and Smith (1969), Rousseau (1974), Eastman (1981), Hinds (1986), and Campbell *et al.* (1995). The New Brunswick distribution information comes from the Connell Memorial Herbarium at the University of New Brunswick (UNB), from The Flora of New Brunswick (Hinds 1986), and from extensive field investigations conducted in Carleton and Victoria Counties, New Brunswick by Gart Bishop, Bruce Bagnell, Samantha Hines, and Andrew MacDougall in the spring and summer of 1997 (MacDougall 1997).

The status of the species in other provinces and states, if known, is listed. This information was obtained using listings of rare plants published by the National Museum of Natural Sciences in Ottawa (Maher *et al.* 1978, White and Johnson 1980, Hinds 1983, Bouchard *et al.* 1983, Argus *et al.* 1982-1987, Day and Catling 1991), and by conservation organizations and botanical societies in the United States (Countryman 1978, Mehrhoff 1978, Church and Champlin 1978, Porter 1979, Snyder and Vivian 1981, Thompson 1989, Dibble *et al.* 1989, Gawler *et al.* 1996).

A general description of the physical appearance of each species is given, based on numerous field guides, botanical keys, and other related source materials (Gleason 1952, Cobb 1963, Peterson and McKenny 1968, Fernald 1970, Britton and Brown 1970, Niering 1979, Lellinger 1985). The time of flowering that is presented refers specifically to New Brunswick; most SJRHF species flower earlier (*e.g.*, March or April) in regions to the south.

Habitat preferences are listed, as described in Hinds (1986). While most species are strictly associated with "rich deciduous forest", some species occur in several different habitat types (*e.g.*, round-leaved hepatica, yellow lady's-slipper). Two listed species, seneca-snakeroot and pointed-leaved tick-trefoil, are more typical of calcareous shoreline habitat than of rich deciduous forest. However, both are included because of their conservation significance in New Brunswick, and because they often occur in areas directly adjacent to SJRHF stands.

Pictures or photos depicting the species, plus range maps for Maine, southeastern Quebec, and the Maritimes are provided for each species. On the range maps, the stippled areas indicate regions where the species are most abundant. Solid dots indicate single records that are believed to be extant, though some from Nova Scotia and Maine date back several decades or more. Open dots indicate single records that are now known or believed to be extirpated.

Maidenhair Fern

Species Name: *Adiantum pedatum* L. var. *pedatum*

Family: Pteridaceae (Maidenhair Fern Family)

Habitat: Rich deciduous forest.

Description: Maidenhair Fern is a delicate lacy plant that is easily identifiable and is often picked for ornamental purposes. It has circular or horseshoe-shaped fronds supported by slender, erect, and shiny dark brown or black stalks. The flat fronds vary in size, but are usually 20 - 40 cm broad and have a yellow-green or bluish-green color. Each frond supports five or six leaflets, with each leaflet containing over 20 variably shaped subleaflets. The plant can reach heights of 45 - 60 cm. Fruit dots occur in clusters of 1 - 5 on the lower margins of the small leaflets.

New Brunswick Status: Uncommon (Hinds 1986).

Range in New Brunswick: Multiple sites in Carleton County ranging from Woodstock to Florenceville, plus several sites in southern Victoria County near Perth-Andover and North Tilley. Also recorded on the Matapedia River, and on Keswick Ridge near Fredericton (UNB, Hinds 1986, MacDougall 1997). A record from Belleisle Bay in Kings County exists from earlier in the century but recent surveys of the area in 1993-94 could not rediscover the population and it is believed to be locally extirpated (MacDougall and Loo 1996).

Range in the Maritime provinces and Maine: Several old records exist from Nova Scotia (Roland and Smith 1969), though extant populations have been reduced to one site. It is considered a threatened species in Nova Scotia. Old records, as listed in Erskine (1960), indicate that Maidenhair Fern had been recorded on PEI in the early 1800s, though it is now extirpated. In Maine, most counties have records for this species (Campbell *et al.* 1995).

Range in North America: Ontario to Nova Scotia, south to California and Georgia.



Maidenhair Fern near Woodstock, Carleton County.

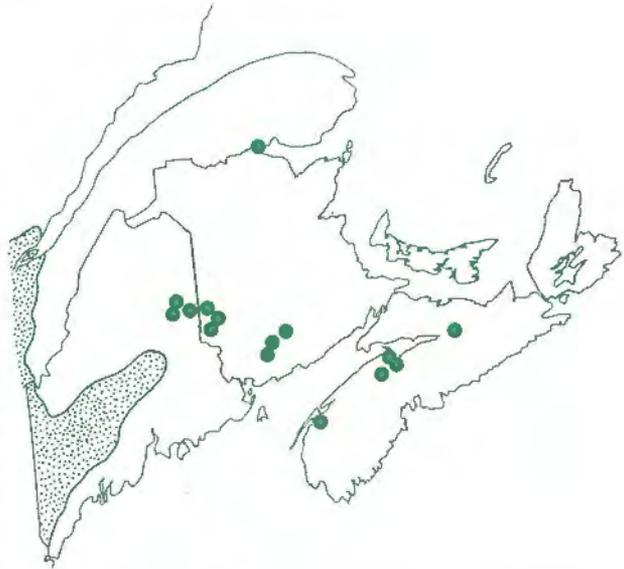
Wild Leek

Species Name: *Allium tricoccum* Ait.

Family: Liliaceae (Lily Family)

Habitat: Moist seepy areas in rich deciduous forests and alluvial bottomlands.

Description: Wild leek is a perennial species with long, flat, lance-shaped, fleshy leaves usually 10 - 30 cm in length. The leaves appear in early spring and have usually shriveled before flowering time. Flowering occurs in late June or July. The flowering stalk, also called a scape, grows 15 - 40 cm in height and supports multiple small white flowers arranged in a hemispheric cluster. The bulb of wild leek is fleshy, 2-5 cm long and has an ovoid, or slightly egg-like, shape. Wild leek often grows in dense colonies, sometimes with hundreds or even thousands of individuals, though such large populations are very infrequent in New Brunswick.



New Brunswick Status: Rare (Hinds 1983, 1986).

Range in New Brunswick: Known from several locations in the Meduxnekeag River watershed, Carleton County; two locations near Sussex in Kings County; the Restigouche River, Restigouche County; and near Bloomfield Ridge, Kings County (UNB, Hinds 1983, 1986).

Range in the Maritime provinces and Maine: Known from four Nova Scotia records (Roland and Smith 1969); not found on PEI. Records exist from most Maine counties (Campbell *et al.* 1995). The species is listed as threatened in Nova Scotia (Maher *et al.* 1979) and rare in Maine (Gawler *et al.* 1996).

Range in North America: Manitoba to New Brunswick and Nova Scotia, south to North Dakota, Missouri, Georgia, and North Carolina. Listed as threatened in Rhode Island, rare in Tennessee and Manitoba. It has not been collected in Manitoba since 1923 (White and Johnson 1980).



Wild Leek near Woodstock, Carleton County.

Wild Ginger

Species Name: *Asarum canadense* L.

Family: Aristolochiaceae (Birthwort Family)

Habitat: Rich deciduous forest.

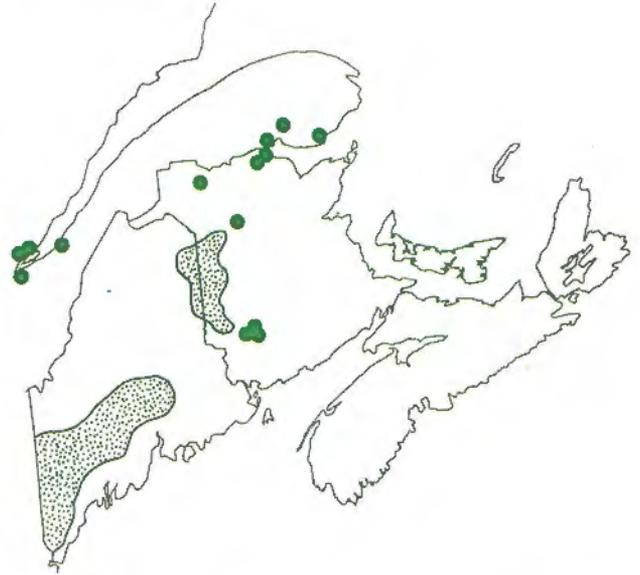
Description: Wild Ginger is a perennial species that grows along the ground sometimes in dense patches that cover several square meters. The leaves are produced in pairs, grow to widths of 7 - 15 cm, are hairy and heart-shaped. The flower occurs at ground level at the juncture between the two leaf stalks. It is 2 - 4 cm wide, cup-shaped, with three pointed lobes, and has a dark purple or dark reddish-brown color. Wild Ginger usually begins flowering in early to mid May.

New Brunswick Status: Uncommonly scattered in New Brunswick, though locally common in some locations.

Range in New Brunswick: Most sites occur in the central St. John River valley (Carleton and Victoria counties) and parts of the Restigouche River valley (Restigouche County). Also recorded from the Tobique River valley (Carleton County) and near Fredericton (York County) (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Does not occur elsewhere in the Maritime provinces. Known from eight counties in Maine, including Aroostook County (Campbell *et al.* 1995). Listed as threatened in Maine (Gawler *et al.* 1996).

Range in North America: Manitoba to New Brunswick, south to Kansas and North Carolina.



Wild Ginger in flower near Woodstock, Carleton County.

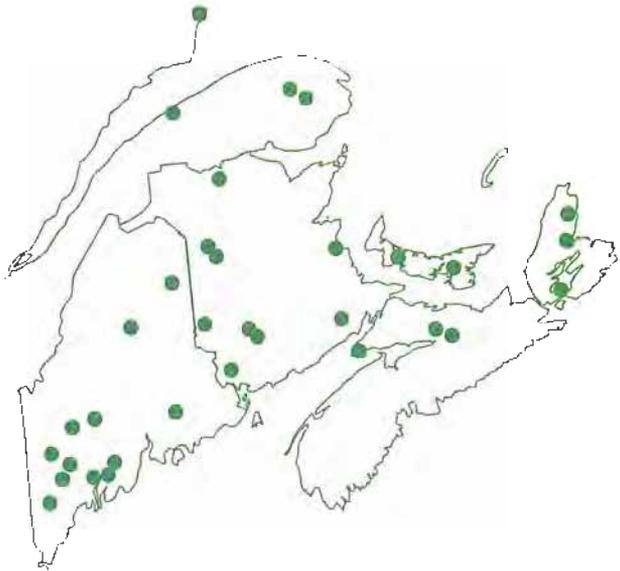
Lance-leaved Grape Fern

Species Name: *Botrychium lanceolatum* (Gmel.) Austr.
ssp. *angustisegmentum* Pease and Moore

Family: Ophioglossaceae (Adder's Tongue Family)

Habitat: Dry to moist open woods and rich deciduous forest.

Description: The Lance-leaved Grape Fern has a solitary sterile frond that, as the name suggests, is triangular or "lance" shaped. The sterile frond is 2 - 4 cm long, dark green in color, smooth, and is cut into three parts with each part having deeply toothed edges. It occurs high up on the stalk and is almost stemless. The stalk is a lighter green color and usually reaches 7 - 14 cm in height. The fertile frond, or "sporophyll", of this species occurs above the sterile frond at the terminal end of the stalk. It has ascending somewhat widespread branches with the "sporangia" (the spore cases) tightly clustered along the branches.

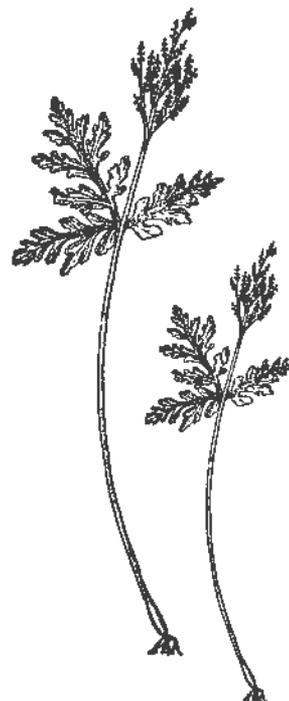


New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Scattered across several counties in southern New Brunswick, with most records from Carleton and York Counties. One record from northern New Brunswick in Restigouche County (Hinds 1986) and another from Gloucester County.

Range in the Maritime provinces and Maine: Known from several locations in Nova Scotia in the Cobequid Mountains and in Cape Breton; considered rare (Roland and Smith 1969). Recorded in most counties in Maine, including Aroostook County (Campbell et al. 1995).

Range in North America: Alaska to Newfoundland, south to Ohio, Pennsylvania, and New Jersey. Also occurs in Greenland, Iceland, and Eurasia. Listed as rare in Rhode Island, Ontario, Quebec, and Minnesota; endangered in Ohio; threatened in Wisconsin.



Fertile and sterile frond of the Lance-leaved Grape Fern. (Illustration reprinted with permission from The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, copyright 1952. The New York Botanical Garden.)

Cut-leaved Toothwort

Species Name: *Cardamine concatenata* (Michx.) Wood

Family: Brassicaceae (Mustard Family)

Habitat: Rich alluvial hardwood forests and calcareous shorelines.

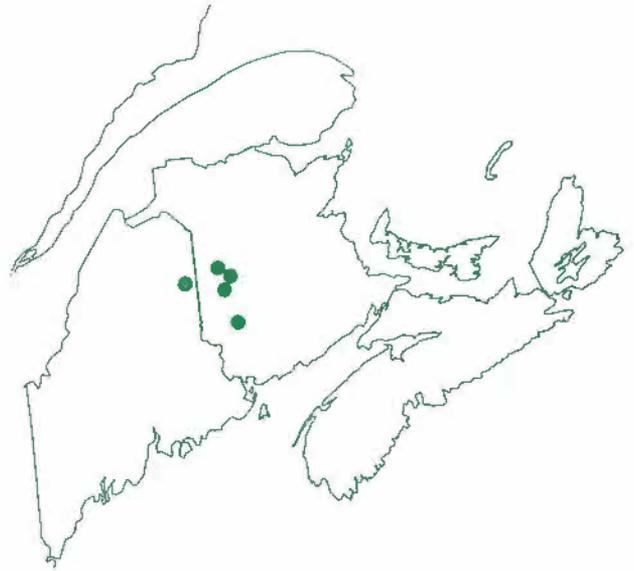
Description: Cut-leaved Toothwort is a perennial species with a whorl of three leaves occurring above the middle of the stem. Each leaf is 5 - 13 cm wide and is deeply cleft into three sharply toothed segments. The flowers are produced at the terminal end of the stem, are white to whitish-pink in color, and have four 2-cm long petals. The axil, or "rachis", that supports the flowers tends to be slightly hairy. This species grows to heights of 20 - 40 cm. It flowers in mid May or early June.

New Brunswick Status: Very rare (Hinds 1986).

Range in New Brunswick: Known from only four locations; two in Carleton County (Upper Woodstock and Moose Mountain), and one each in Victoria (Perth-Andover) and York (Lower Queensbury) counties (Hinds 1983, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Does not occur elsewhere in the Maritimes. In Maine, only known from Aroostook County (Campbell *et al.* 1995). Listed as endangered in Maine (Gawler *et al.* 1996).

Range in North America: Ontario to New Brunswick, south to Kansas, Texas, and Florida. Listed as rare in Quebec, New Hampshire, and Texas.



Cut-leaved toothwort after flowering near Upper Woodstock. This spring ephemeral species finishes its annual cycle soon after canopy closure and is no longer apparent after mid July.



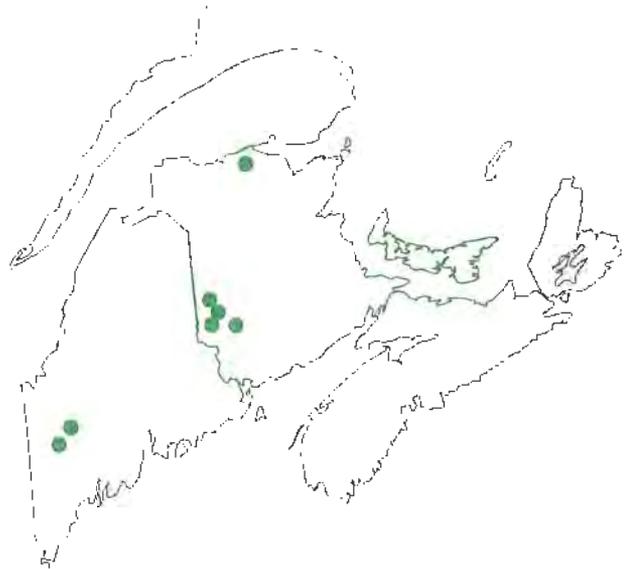
Thin-leaved Sedge

Species Name: *Carex cephaloidea* (Dewey) Dewey

Family: Cyperaceae (Sedge Family)

Habitat: Rich hardwood forest.

Description: The most notable feature of Thin-leaved Sedge is the oblong cluster of 4 - 8 spherical spikes that occurs at the end of the stem. Each spike contains a dense aggregation of sharply tapered "perigynia", which are the sacs that encase and protect the plant's ovary. The Thin-leaved Sedge has a dark green color, with its "sheath" (a tubular 'envelope' that encases the lower part of the stem) having green and white mottling. The stem or "culm" is slender and erect, ranges in height from 30 - 120 cm, and has a very rough texture above. The leaves are flat, thin, and soft, have a width of 5 - 8 mm, and are somewhat shorter than the culm.

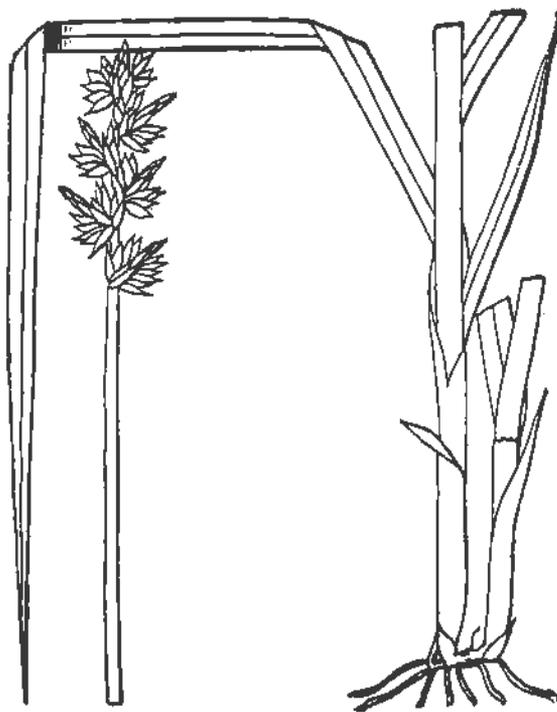


New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Known from two locations in Carleton County (Upper Woodstock and Meductic), and one record near Robinsonville in Restigouche County (UNB, Hinds 1986).

Range in the Maritime provinces and Maine: Not recorded elsewhere in the Maritime provinces. Only two counties in Maine, both in the southern half of the state (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick, south to New Jersey, Ohio, and Illinois.



Lower culm, leaves, and terminal cluster of spikes of Thin-leaved Sedge. (Illustration reprinted with permission from *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada*, copyright 1952. The New York Botanical Garden.)

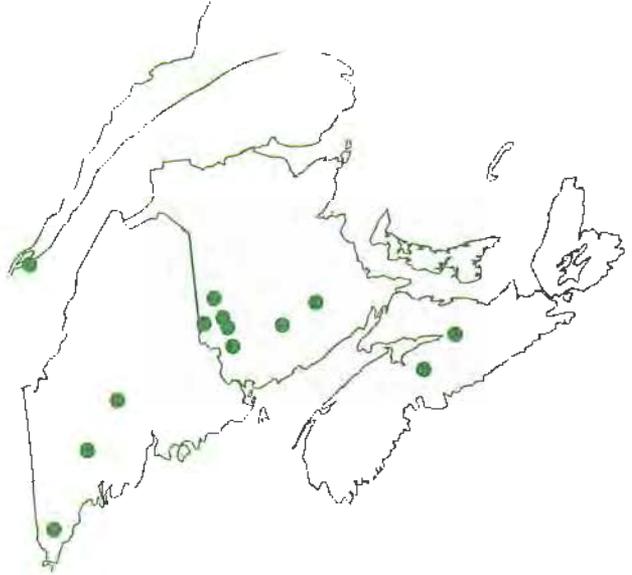
Pubescent Sedge

Species Name: *Carex hirtifolia* MacKenzie

Family: Cyperaceae (Sedge Family)

Habitat: Rich deciduous woods, calcareous rocky flood-plains.

Description: The Pubescent Sedge, as the name suggests, is pubescent, or hairy, throughout. It is bright green colored but reddened at its base. The stems, or "culms", reach lengths of 120 cm, and are ascending, straight, or arching. The leaves are flat, soft and flaccid, 3 - 7 mm wide, with two easily seen mid-lateral veins on the upper side. The leaves occasionally overtop the spikes. Pubescent Sedge has 2 - 4 oblong shaped spikes. The end, or "terminal", spike, differs in appearance and function from the spikes below. It is 1 - 2 cm long, compact, slender, and "staminate", meaning it is unisexual and contains only stamens. The lower spikes are longer, ranging from 2 - 4 cm, are more loosely arranged, and are "pistillate", meaning they are also unisexual but contain only pistils. The "perigynium" (the inflated sac enclosing the ovary) of the Pubescent Sedge is sharply triangular in shape.



New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Seven New Brunswick records, five of which are in Carleton County in either the Eel or Meduxnekeag River valleys. The remaining two records are from Hatfield Point (Kings County) and Petitcodiac (Westmorland County) (UNB, Hinds 1986, MacDougall 1997).

Range in the Maritime provinces and Maine: Recorded as scattered to common at two Nova Scotia locations: Shubenacadie and Brookfield (Roland and Smith 1969). Known from three Maine counties in the central and southern sections of the state (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick, Nova Scotia, south to Kansas and Maryland. Listed as rare in Virginia.



Culm, leaves, and terminal cluster of spikes of Pubescent sedge. (Illustration reprinted with permission from The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, copyright 1952. The New York Botanical Garden.)

Plantain-leaved Sedge

Species Name: *Carex plantaginea* Lam.

Family: Cyperaceae (Sedge Family)

Habitat: Rich deciduous woods.

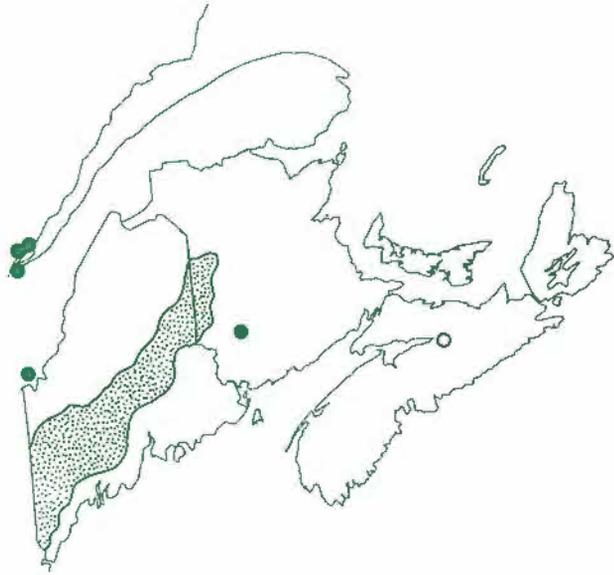
Description: Plantain-leaved Sedge is probably the most easily identifiable sedge in New Brunswick. Its leaves are long, from 15 - 60 cm, and broad, from 1.5 - 3 cm, and are colored yellowish- to dark green with deep purplish bases. The leaves are evergreen. The stem, or "culm", rises laterally to heights from 30 - 60 cm in the spring, supporting both a terminal "staminate" spike and 2 - 4 lateral "pistillate" spikes. The terminal spike contains only stamens, which have long, conspicuous anthers. The lateral spikes are widely separated and alternate, and contain only pistils, which are the female reproductive organs. This species flowers in May or early June in New Brunswick.

New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Known almost entirely from Carleton County, except for one record near Keswick Ridge, York County from 1960. Found at at least 15 sites in the county from Meduxnekeag River valley to the Guisguig Stream valley, and at two sites in the Monquart Stream valley on the eastern side of the St. John River (MacDougall 1997).

Range in the Maritime provinces and Maine: Known from only one site in Nova Scotia near Brookfield (Roland and Smith 1969). Listed as rare in Nova Scotia (Maher *et al.* 1978). Known from seven Maine counties in all parts of the state, including Aroostook County (Campbell *et al.* 1995).

Range in North America: British Columbia to New Brunswick, south to New Jersey and Montana. Listed as endangered in Minnesota and South Carolina.



Plantain-leaved Sedge near Woodstock, Carleton County.

Sprengel's or Long-Beaked Sedge

Species Name: *Carex sprengelii* Dewey

Family: Cyperaceae (Sedge Family)

Habitat: Rich alluvial hardwood forest, plus calcareous banks and slopes.

Description: Sprengel's Sedge is a visually distinctive sedge most notable for its long (1 - 5 cm) often-drooping compact spikes. The stems, or "culms", of this plant are slender, sharply angled, rough or "scabrous" at their summit, and range from 30 - 100 cm in length. Each culm possesses 1 - 4 spikes, though usually has two or more. The leaves are flat, hairless, loose, and narrow, with widths of 3 - 4 mm. It flowers between late May and July.

New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Most records from Carleton County, with single observations in Sussex, near Fredericton, at Doaktown, on the Restigouche River (UNB, MacDougall 1997), and in Victoria County (J. Goltz, *pers. comm.*).

Range in the Maritime provinces and Maine: Not recorded elsewhere in the Maritime provinces. Only known from two counties in Maine, both in the southern half of the state (Campbell *et al.* 1995). Listed as endangered in Maine (Gawler *et al.* 1996)

Range in North America: British Columbia to New Brunswick, south to New Jersey and Montana.



Sprengel's Sedge near Upper Woodstock, Carleton County.

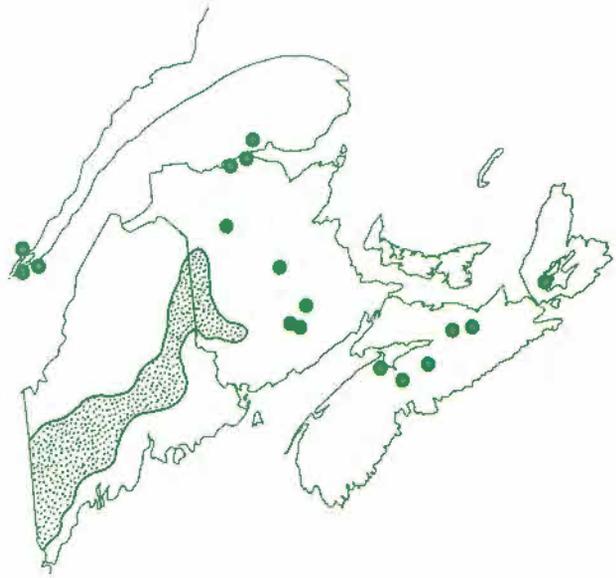
Blue Cohosh

Species Name: *Caulophyllum thalictroides* (L.) Michx.

Family: Berberidaceae (Barberry Family)

Habitat: Rich deciduous forests.

Description: Blue Cohosh is a perennial species that grows to 100 cm in height and produces deep blue berry-like seeds in late summer. It flowers in May and June, producing small purple-brown or yellow-green flowers with six petal-like sepals. The flowers appear before the leaves are fully formed. Blue Cohosh has two compound leaves. The lower leaf is large sized and highly divided into twenty-seven three-lobed leaflets. The upper leaf is smaller with 9 - 12 leaflets.



New Brunswick Status: Uncommon (Hinds 1986).

Range in New Brunswick: Scattered in western and southern New Brunswick, with most records from Carleton County. Also recorded on the Restigouche, Matapedia, Southwest Miramichi, and Nashwaak Rivers, near Fredericton (York County), and near Sussex and Havelock (Kings County) (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Known from several locations in Nova Scotia (Roland and Smith 1969) though the species is considered endangered (Keddy 1979). Known from most Maine counties except for those along the coast (Campbell *et al.* 1995).

Range in North America: Manitoba to New Brunswick, Nova Scotia, south to South Carolina, Kansas, and North Dakota. Listed as threatened in Rhode Island, and South Carolina; rare in North Dakota; endangered in Kansas and South Dakota.



Blue Cohosh near Havelock, New Brunswick (King's County). The seeds turn deep blue later in the summer.

Honewort

Species Name: *Cryptotaenia canadensis* (L.) DC

Family: Apiaceae (Parsley Family)

Habitat: Rich intervalle hardwoods.

Description: Honewort is a perennial species growing 30 - 100 cm in height with an overall appearance that is slender and freely branching. Flowers are white and are arranged in irregular umbels (an "umbel" is a flattish-topped cluster of stalked flowers that arise from single point, similar to an upside-down straw broom). Flowering occurs in late June or July. The lower and basal leaves have long stalks, or "petioles", are three-divided, and are sharply and irregularly serrated along the leaf edges. The upper leaves are serrate, meaning they have no petiole and thus are attached directly to the stem. Leaf lengths range from 3 - 10 cm.

New Brunswick Status: Extirpated (Hinds 1983, 1986).

Range in New Brunswick: Previously known from only four locations: Tobique River, Salmon River, Bull Island near Woodstock (now flooded by the head pond of the Mactaquac dam), and Sussex. Has not been recorded in New Brunswick since 1914.

Range in the Maritime provinces and Maine: Not recorded in Nova Scotia or PEI. Also listed as extirpated in Maine. Records exist from eight stations in two counties but it has not been recorded in Maine since 1936 (Dibble *et al.* 1989).

Range in North America: Southeast Manitoba to New Brunswick, south to Texas, Arkansas, Alabama, and Georgia. Listed as rare in Manitoba.



Honewort in flower.

Northern Wild Comfrey

Species Name: *Cynoglossum virginianum* var. *boreale*
(Fern.) Cooperrider

Family: Boraginaceae (Borage Family)

Habitat: Rich deciduous woods and thickets.

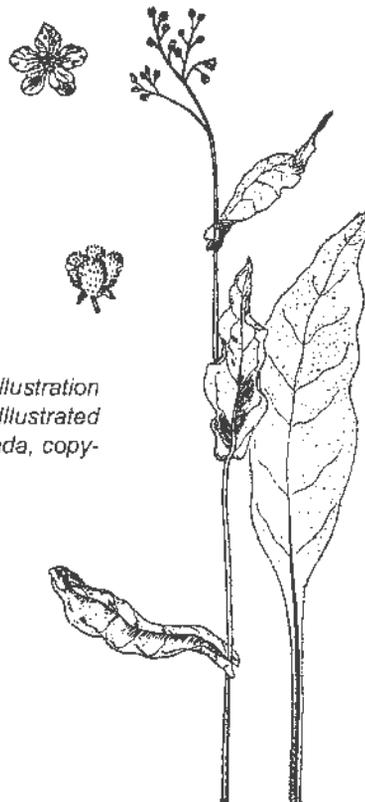
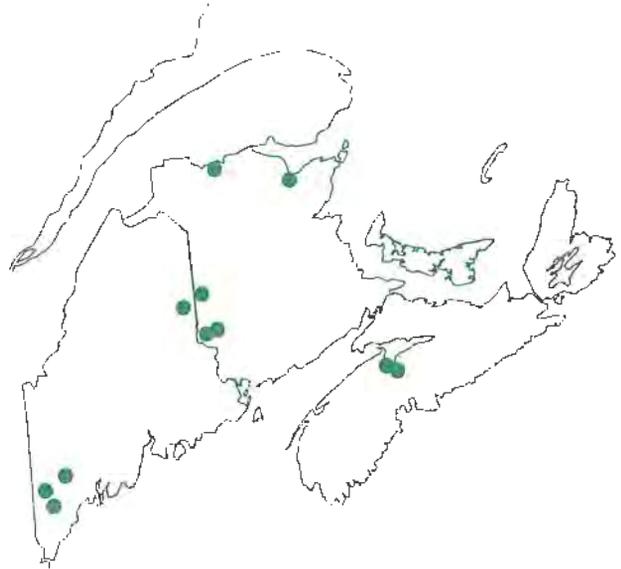
Description: Northern Wild Comfrey is a perennial species that is coarsely hairy throughout and grows to heights up to 100 cm. Its flowers are blue, with petals 6 - 8 mm wide, oblong, and not overlapping. The leaves have an elliptic-oblong shape and are 10 - 20 cm long. The stem is leafy mostly towards the base, with the lower leaves being larger and often "petioled" (having stems) and the upper leaves being smaller and clasping the stem. Following flowering, a small cluster of nutlets are formed bearing conspicuous, stout barbed or hooked bristles.

New Brunswick Status: Very rare (Hinds 1986).

Range in New Brunswick: Known from several locations in the central St. John River Valley (both Carleton and Victoria counties), as well as two locations in the northern section of the province (Restigouche and Gloucester counties) (Hinds 1983, Hinds 1986)

Range in Maritime provinces and Maine: Known from two locations in Nova Scotia near Windsor (Roland and Smith 1969); listed as rare (Maher *et al.* 1978). Recorded in five Maine counties in both the north and south sections of the state, and including Aroostook County (Campbell *et al.* 1995).

Range in North America: British Columbia to Newfoundland, south to Iowa and Connecticut. Listed as rare in Quebec, Connecticut, Massachusetts, and Vermont; endangered in Ohio.



Upper stem, leaves and flowers of Northern Wild Comfrey. (Illustration reprinted with permission from The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, copyright 1952. The New York Botanical Garden.)

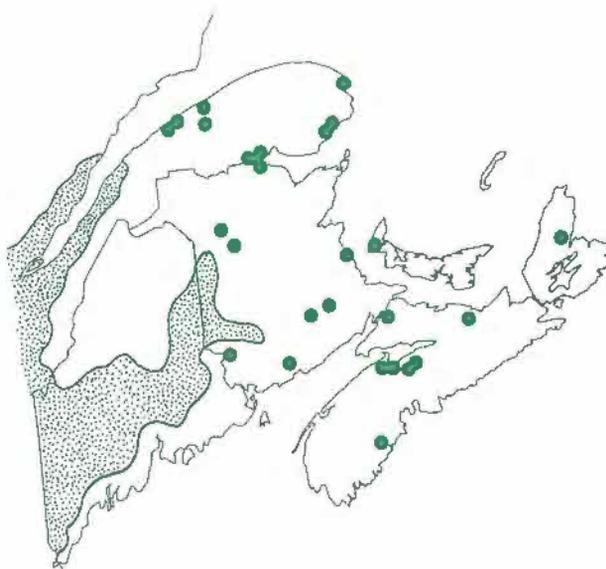
Yellow Lady's-Slipper

Species Name: *Cypripedium pubescens* Willd.

Family: Orchidaceae (Orchis Family)

Habitat: Rich deciduous forest; wet calcareous cedar woods.

Description: The Yellow Lady's-Slipper is a perennial orchid species that grows to heights of 20 - 80 cm and produces large, slipper-shaped yellow flowers. The stalk is finely pubescent and is leafy, usually supporting 3 - 7 leaves. The leaves reach lengths of 20 cm, are lance- or elliptic-shaped, and have pronounced parallel veins. The flowers consist of a 3 cm long, fleshy yellow lip, two spirally twisted greenish yellow to purplish-brown lateral petals, and several greenish-yellow, lance-shaped sepals. One of the sepals arises vertically above the back of the lip and can be 4 - 7 cm long. The other sepals extend behind and below the lip and are united. Flowers in June and early July.



New Brunswick Status: Uncommonly scattered (Hinds 1986). Threatened by both habitat loss and picking.

Range in New Brunswick: Most records from Carleton and Victoria counties, though also known sporadically from sections of northern and southern New Brunswick. Rare in the eastern lowlands (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Two records known from western PEI (Erskine 1960). Numerous Nova Scotia records: near Windsor, in the Cobequid Mountains, and in Cape Breton (Roland and Smith 1969), though now considered threatened in the province (Maher *et al.* 1979). Known from most counties in Maine (Campbell *et al.* 1995).

Range in North America: Saskatchewan to New Brunswick, Nova Scotia, south to Missouri and Georgia. Listed as threatened in Washington; rare in Iowa, Louisiana, Oklahoma, Wyoming, Rhode Island, and Virginia.



Yellow Lady's-Slipper near Reid's Lake, Carleton County.

Pointed-leaved Tick-trefoil

Species Name: *Desmodium glutinosum* (Mulh.) Wood

Family: Fabaceae (Pea Family)

Habitat: Dry rich woods; calcareous rocky shorelines.

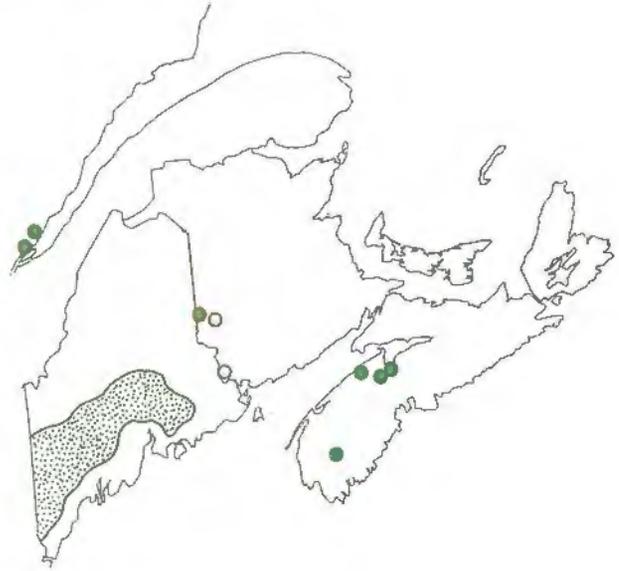
Description: Pointed-leaved Tick-trefoil is a perennial species that is slightly pubescent throughout and grows to heights of 120 cm. The leaves are formed in a cluster or whorl at the end of a short stem and have long stems, or "petioles". They are "trifoliate" (having three leaflets), with each leaflet being egg-shaped, or "ovate", and pointed at the end. The leaflets are nearly as wide as they are long. Also rising from the end of the stem is a long, slender flower stalk which supports purple or purplish-pink flowers ranging from 6 - 8 mm long. The fruit forms as a jointed pod, with usually three triangular-shaped segments that each contain seeds.

New Brunswick Status: Thought to be extirpated (Hinds 1983, 1986, NBCOES 1995) until one new population discovered in 1997 by Gart Bishop and Bruce Bagnell (MacDougall 1997).

Range in New Brunswick: Old records exist from Bull Island near Woodstock and Spragues Falls on the St. Croix River. Both these sites were flooded by hydroelectric dams. The 1997 record was from Jackson Falls, Carleton County. Before this discovery, this species had not been collected in New Brunswick since 1899.

Range in Maritime provinces and Maine: Known from three sites in Nova Scotia (Roland and Smith 1969), and listed as rare (Maher *et al.* 1979). Recorded in most Maine counties, though not seen in Aroostook County (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick, Nova Scotia, south Texas and Florida. Listed as rare in Delaware,



Pointed-leaved Tick-trefoil in flower near Jackson Falls, Carleton County.

Leatherwood

Species Name: *Dirca palustris* L.

Family: Thymelaeaceae (Mezereum Family)

Habitat: Rich deciduous or mixed woods.

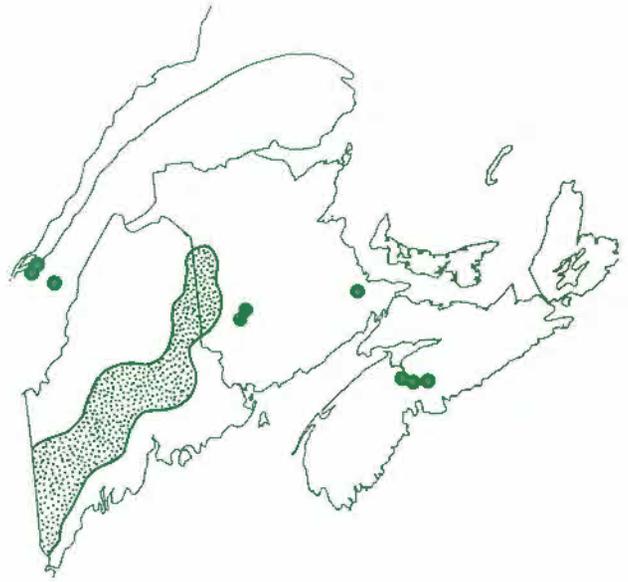
Description: Leatherwood is a freely branched shrub that grows to heights of 300 cm or more. Its most distinguishing characteristics are its jointed twigs and its very tough, leathery bark. Leatherwood flowers in early spring, usually mid to late May, producing lateral clusters of small, stemless pale yellow flowers. The flowers are narrowly bell-shaped, and 7 - 10 mm long. The leaves are alternately arranged along the twigs, broadly egg-shaped, 5 - 8 cm long, with 2 - 5 mm stalks or "petioles". The fruit is a "drupe", meaning it is fleshy with a hard stone in its center, and is about 8 mm long.

New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Most records from Carleton County, scattered from Woodstock to Beechwood. Also recorded in York (two sites near Fredericton) and Albert (near Weldon) counties (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Recorded from two locations in Nova Scotia (Roland and Smith 1969). Known from most counties in Maine (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick, Nova Scotia, south to Louisiana and Florida.



Leatherwood in mid summer following flowering.

Clinton's Wood Fern

Species Name: *Dryopteris clintoniana* (D. C. Eaton) Dowell

Family: Dryopteridaceae (Wood Fern Family)

Habitat: Rich deciduous forest.

Description: Clinton's Wood Fern is a large, leathery, bluish-green-colored fern with leaflets that ascend up the stem in a ladder-like formation. The lowest pair of leaflets are each shaped as a broad-based triangle. Fronds are up to 20 cm wide, 90 - 135 cm long, and are "lanceolate", meaning they are lance-shaped with a long, tapered apex and a short, tapered base. The fronds are also deeply "bipinnatifid", meaning that the leaflets and subleaflets (also called "pinnules") are both deeply lobed. The lower stem is 2 - 4 mm thick and covered with numerous darkish 1-cm long scales. The fruit dots along the back of the fertile subleaflets occur in pairs of 3 - 7 and are borne near the mid-vein.



Affiliated Sterile Hybrids: 1) Dowell's Wood Fern (*Dryopteris X dowellii*): a hybrid between Clinton's Wood Fern and the Fancy Fern (*Dryopteris intermedia*). 2) Simulated Log Fern (*Dryopteris clintoniana X Dryopteris goldiana*), a hybrid between Clinton's Wood Fern and Goldie's Fern.

New Brunswick Status (Clinton's Fern only): Very rare (Hinds 1986). The two fertile hybrids were discovered in 1997 (by Jim Goltz, validated by J. Goltz and D.M. Britton) and were the first records for the province.

Range in New Brunswick: Clinton's Wood Fern: known from only two locations, Maplehurst Marl Pit and Reid's Lake, both in Carleton County. Dowell's Wood Fern: known only from Reid's Lake. Simulated Log Fern: known only from Reid's Lake (Hinds 1986, MacDougall 1997).

Range in the Maritime provinces and Maine: None of these three taxa have been recorded elsewhere in the Maritime provinces. Clinton's Wood Fern: recorded in six Maine counties, all in the southern half of the state (Campbell *et al.* 1995). Dowell's Wood Fern: known from one county in southern Maine. Simulated Log Fern: known from two counties in southern Maine (Campbell *et al.* 1995).

Range in North America: Clinton's Wood Fern: southern Ontario to western New Brunswick, south to Indiana, Pennsylvania and New Jersey. Associated hybrids likely have similar distribution, though not as abundant.



Clinton's Wood Fern near
Reid's Lake, Carleton County.

Goldie's Fern

Species Name: *Dryopteris goldiana* (Goldie) Gray

Family: Dryopteridaceae (Wood Fern Family)

Habitat: Rich deciduous forest.

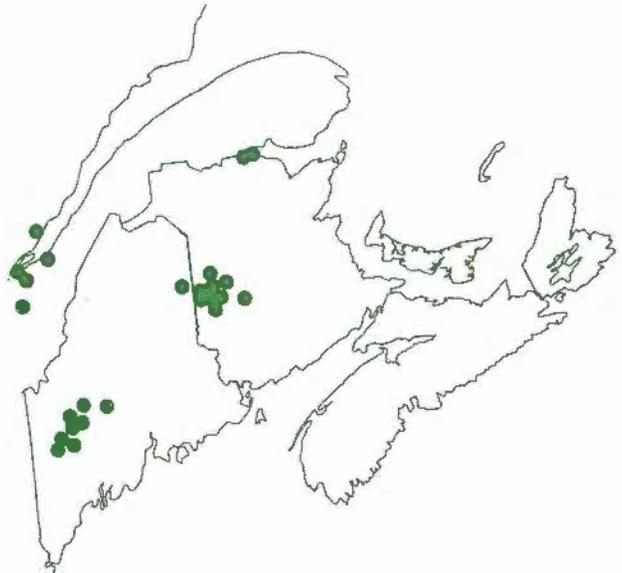
Description: Goldie's Fern is a large erect woodland fern with a crown of fronds that each have widths up to 30 cm wide and often exceed lengths of 120 cm. The fronds have a leathery texture and a two-toned dark green/olive color. The base of the fronds, down to the rootstock, is densely covered with light brown scales. Each frond is composed of 12 or so leaflets that are double-tapered with short stems. The leaflets near the base of the frond often tilt downward and outward. The fruit dots on Goldie's Fern are small and widely spaced, and occur closer to the midvein than the edge of the leaflet.

New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Multiple sites in Carleton County ranging from Woodstock to Upper Knoxford. Limited occurrence elsewhere. Two records exist from the Restigouche River valley; one from Keswick Ridge (UNB, Hinds 1986, MacDougall 1997).

Range in the Maritime provinces and Maine: Known from six counties in Maine including Aroostook County (Campbell *et al.* 1995). Listed as rare in Maine (Eastman 1981), though does not appear on recent state lists (e.g., Gawler *et al.* 1996).

Range in North America: Minnesota to New Brunswick, south to North Carolina, Tennessee, and Iowa.



Goldie's Fern near Mill Brook, Carleton County.

Bottle-brush Grass

Species Name: *Elymus hystrix* L. var. *bigeloviana* (Fern.)
Bowden

Family: Poaceae (Grass Family)

Habitat: Rich hardwoods and clearings.

Description: Bottle-brush Grass is a tall grass, ranging in height from 60 - 150 cm, that has flat leaf blades and terminal spikes. The leaf blades have widths of 0.8 - 1.5 cm and lengths ranging from 10 - 30 cm, and are smooth underneath and rough on the upper leaf surface. The spike can be large, ranging in length from 7 - 15 cm and is composed of numerous somewhat widely spaced spikelets. The spikelets possess long terminal bristle-shaped appendages (called "awns") that range from 1.5 - 4 cm in length. Bottle-brush Grass flowers in late June and July.

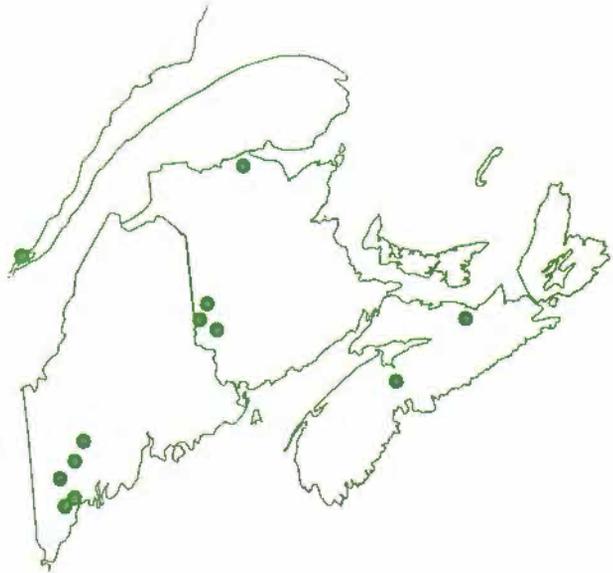
New Brunswick Status: Very rare (Hinds 1986).

Range in New Brunswick: Known from only four sites.

Three are in Carleton County on the Eel River, the Meduxnekeag River near Jackson Falls, and near Reid's Lake. It has also been recorded on the Upsalquitch River near Grog Brook. (UNB, MacDougall 1997).

Range in the Maritime provinces and Maine: Recorded from two locations in Nova Scotia, near Windsor and in the Cobequid Mountains northwest of Truro (Roland and Smith 1969). Listed as rare in Nova Scotia (Maher *et al.* 1978). Recorded from five counties in Maine, all in the southern half of the state; not known from Aroostook County (Campbell *et al.* 1995).

Range in North America: Southern Manitoba to New Brunswick and Nova Scotia, south to North Dakota, Oklahoma, and Georgia. Listed as endangered



Bottle-brush Grass taken near Reid's Lake, Carleton County.



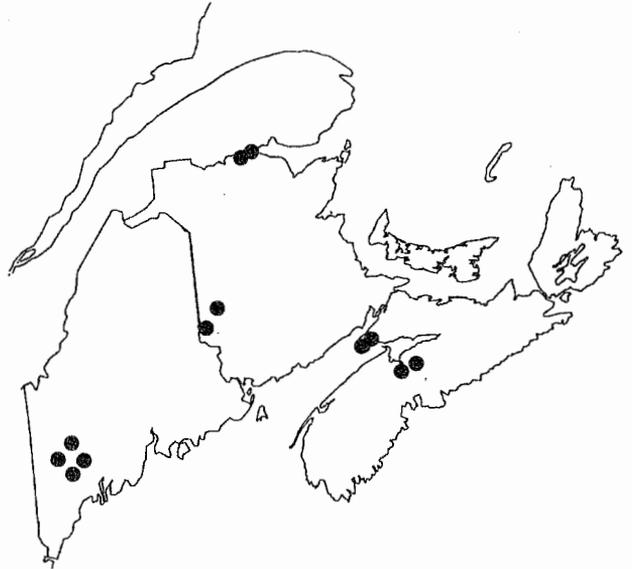
Nodding Fescue

Species Name: *Festuca subverticillata* (Pers.) Alexeev

Family: Poaceae (Grass Family)

Habitat: Rich shaded alluvial hardwood forest.

Description: Nodding Fescue is a perennial grass, with flat, long, rather dark green blades ranging from 4 - 8 mm wide and 10 - 60 cm long. The blades tend to be smooth underneath and rough on the upper surface. The stems or "culms" of this grass tend to be solitary or few, erect, and grow from 40 - 120 cm high. The flower-bearing spikelets are arranged in a very loose compound cluster (this cluster is called a "panicle") that tends to droop or "nod", hence the common name of the species. The spikelet-bearing branches range in length from 2.5 - 8 mm and have a triangular shape.

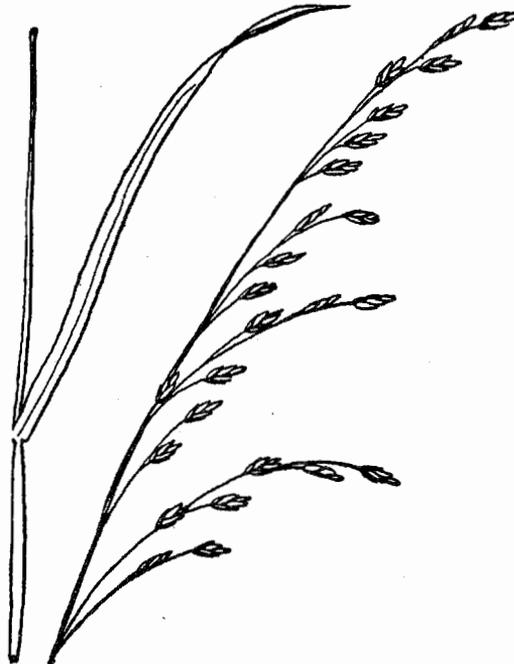


New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Known from two sites in Carleton County (Jackson Falls and near Reid's Lake), and in the Restigouche River valley (UNB, MacDougall 1997).

Range in the Maritime provinces and Maine: Recorded in five Nova Scotia locations, all in proximity to the Minas Basin (Roland and Smith 1969); listed as rare in Nova Scotia (Maher *et al.* 1978). Not recorded in PEI. Known from only four counties in Maine, all in the southern section of the state (Campbell *et al.* 1995).

Range in North America: Manitoba to Nova Scotia, south to Texas and Florida. Listed as rare in Manitoba.



Panicle of Nodding Fescue (Illustration reprinted from *An Illustrated Flora of Northern United States and Canada* by Britton and Brown (1970). Dover Publications, Inc.)

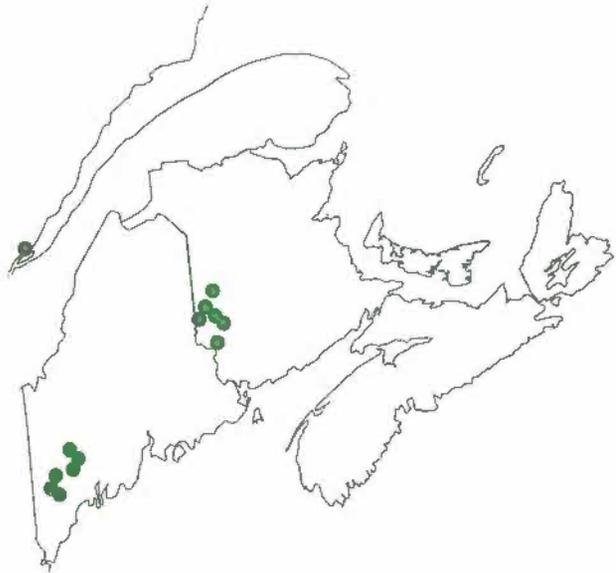
Showy Orchis

Species Name: *Galearis spectabilis* (L.) Raf.

Family: Orchidaceae (Orchid Family)

Habitat: Rich deciduous forest.

Description: Showy Orchis is a perennial orchid with two glossy, dark green basal leaves from which arises a short stalk that supports several flowers. The flowers are 2.5 cm long, and usually have an extended white-colored lip and spur that emerge from a purple or rose-colored hood formed by sepals and lateral petals. Occasionally, the flower has a lip and spur that are also colored rose or pink, though this form is only known from one site in New Brunswick (Upper Woodstock). This form (*G. spectabilis* f. *willeyi* (Seymour) P.M. Brown) is also known from Ontario and Quebec (Reddoch and Reddoch 1997). The leaves range in length from 8 - 15 cm. The flower stalk, or "scape", can reach heights of 20 cm. Showy Orchis flowers in early to mid June.



New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Known from ten sites in Carleton County, mostly in or near the Meduxnekeag River watershed (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Not found elsewhere in the Maritime provinces. Known from four counties in southern Maine (Campbell *et al.* 1995); listed as threatened in the state (Gawler *et al.* 1996).

Range in North America: Ontario to New Brunswick, south to Kansas and Georgia. Listed as rare in New Hampshire and Quebec.



Showy Orchis near Reid's Lake, Carleton County.

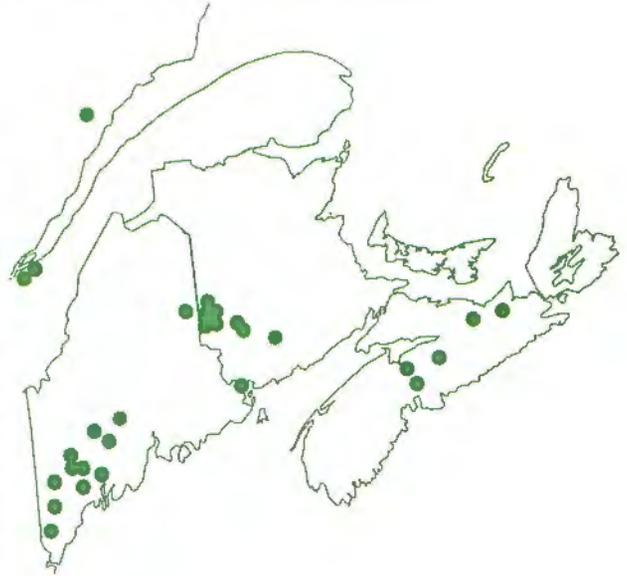
Round-leaved or Round-lobed Hepatica

Species Name: *Hepatica nobilis* P. Mill. var. *obtusata* (Pursh) Steyermark.

Family: Ranunculaceae (Crowfoot Family)

Habitat: Dryish mixed or deciduous forest, often on calcareous substrate. Also upland pine-oak woods.

Description: Round-leaved Hepatica grows low to the ground and has round-lobed basal leaves. Each leaf has three lobes, is evergreen (meaning it persists through the winter), and ranges in width from 5 - 6.5 cm. Round-leaved Hepatica has one or several hairy stalks that support single white, lavender-blue, or pinkish flowers. Time of flowering is early spring, sometimes as early as mid-May. Flowers are 1.5 - 2.5 cm wide, have 5-9 petal-like sepals, and three oval-shaped bracts at the base of the flower. This plant, like its close relative the Sharp-leaved Hepatica, was at one time believed to have medicinal properties suitable for treating liver ailments. Apparently it was heavily harvested in parts of its range, with "bales" of dried plants exported to Europe (Foster and Duke 1977).



New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Most records from Carleton County, and to a lesser degree in York County, within the St. John River Valley watershed, with single records from Restigouche, Charlotte, and King's counties. At least one station, recorded from Belleisle Bay in King's County (1927), has not been relocated and may be locally extirpated (MacDougall and Loo 1996).

Range in Maritime provinces and Maine: Originally recorded from several Nova Scotia counties (Roland and Smith 1969) but is now considered threatened (Maher *et al.* 1978). Records exist from most Maine counties (Campbell *et al.* 1995).

Range in North America: Manitoba to Nova Scotia, south to Missouri and Florida. Listed as threatened in Rhode Island and rare in Manitoba and Florida.



Round-leaved Hepatica in flower near Debec, Carleton County.

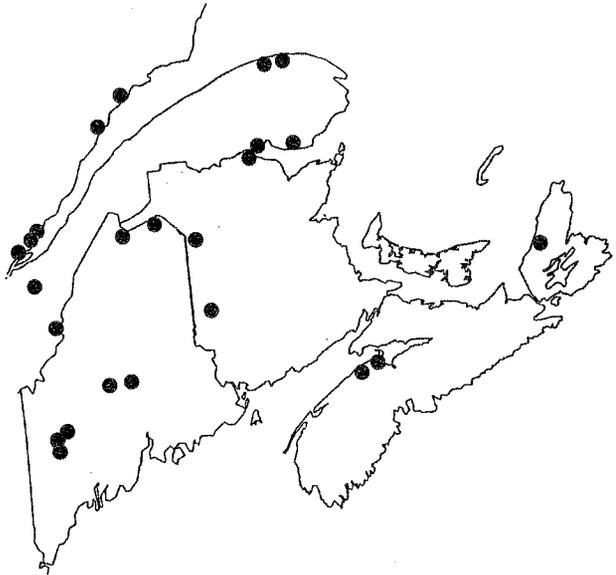
Pale Touch-Me-Not

Species Name: *Impatiens pallida* Nutt.

Family: Balsaminaceae (Touch-Me-Not Family)

Habitat: Moist seepy, sometimes rocky, areas in rich deciduous or mixed forest and meadows on calcareous soils.

Description: Pale Touch-Me-Not is an annual species with pale yellow, 2.5 to 4-cm long flowers that are either sparingly dotted with reddish-brown dots, or spotless. A spur at the base of the flower is bent at right angles to the sepal, unlike the more common spotted touch-me-not (*Impatiens capensis*) which has a longer spur that is strongly curved but not bent. In New Brunswick, pale touch-me-not usually begins flowering in mid-August or later. It grows to 60 -150 cm in height. The leaves are alternate, thin, pale green in color, coarsely blunted-toothed, hairless, and 4 - 9 cm long.



New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Known from only three locations: Upper Woodstock (Carleton County), Salmon River (Victoria County), and the lower Restigouche River (Restigouche County) (UNB, Hinds 1986). A historic report is known from Richmond Corner (J. Goltz, *pers. comm.*).

Range in the Maritime provinces and Maine: Several records from Nova Scotia (Roland and Smith 1969). Known from four counties in Maine, including Aroostook County (Campbell *et al.* 1995). Listed as threatened in Maine (Gawler *et al.* 1996).

Range in North America: Ontario to Newfoundland, south to Kansas, Tennessee, and Georgia. Listed as rare in New Hampshire.



Pale Touch-Me-Not in flower, plus a seed in the foreground. (Illustration reprinted from An Illustrated Flora of Northern United States and Canada by Britton and Brown (1970). Dover Publications, Inc.)

Lopseed

Species Name: *Phryma leptostachya* L.

Family: Phrymaceae (Lopseed Family)

Habitat: Rich deciduous forest.

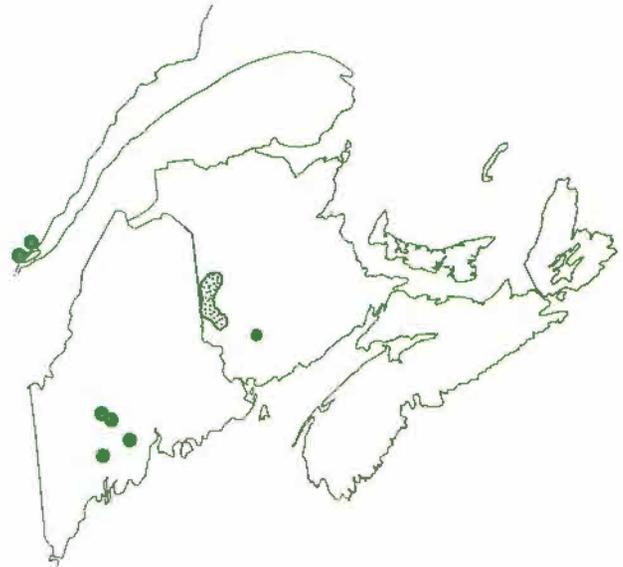
Description: Lopseed is a perennial species that grows from 30 - 90 cm in height. Leaves are bright green, opposite, 5 - 15 cm in length, and very sparingly pubescent, with prolonged marginal teeth that are sometimes double. Flowers are small, white or pinkish-lavender, and occur in pairs in narrow, elongated spike-like clusters. The flowers are approximately 6 mm long and are two-lipped, with the lower lip much longer than the upper. The fruit is enclosed in a seed case which hangs down against the stem, hence the common name "lop seed". In New Brunswick, usually flowers in July or August.

New Brunswick Status: Uncommon (Hinds 1986).

Range in New Brunswick: Central St. John River Valley, mostly in Carleton County but one site on Keswick Ridge near Fredericton (UNB; Hinds 1986).

Range in Maritime provinces and Maine: Does not occur in Nova Scotia or PEI. Recorded in three counties in south-central Maine (but now believed to be extirpated there - J. Goltz, *pers. comm.*); not recorded in Aroostook County (Campbell *et al.* 1995).

Range in North America: Manitoba to New Brunswick south to Florida and Texas.



Lopseed near Jackson Falls, Carleton County.

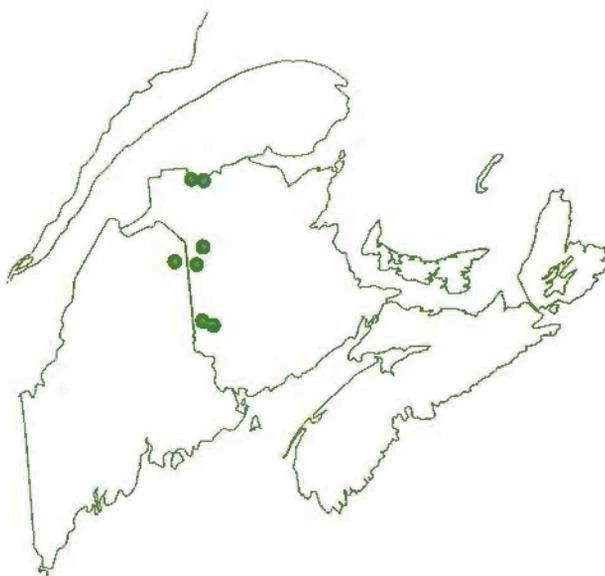
Seneca-Snakeroot

Species Name: *Polygala senega* L.

Family: Polygalaceae (Milkwort Family)

Habitat: Calcareous shorelines (also known from railway beds).

Description: Seneca-Snakeroot is a perennial species that grows 10 - 50 cm tall and has a slender, dense, and elongated cluster of tiny, white flowers at its terminal end. Several stems commonly arise from one base, with each stem usually unbranched and very finely pubescent. The leaves are arranged alternately along the stem, are lance-shaped, and are 1.5 - 7 cm long and 5 mm wide. It flowers in June or early July. Seneca-Snakeroot is not a species of rich deciduous forest, but can be found in adjacent calcareous shoreline habitats.



New Brunswick Status: Uncommon (Hinds 1986).

Range in New Brunswick: Occurs mostly in Carleton and Victoria counties along the Meduxnekeag and Aroostook Rivers. Also recorded on the lower St. John River near Bear Island (York County), and on the Restigouche and Patapedia Rivers (Restigouche County) (UNB, Hinds 1986).

Range in Maritime provinces and Maine: Not known from other Maritime provinces. In Maine, known only from Aroostook County (Campbell *et al.* 1995) on the shorelines of the Aroostook River. Listed as threatened in Maine (Gawler *et al.* 1996).

Range in North America: Alberta to New Brunswick, south to South Dakota, Tennessee, and Georgia.



Seneca-Snakeroot in flower near Jackson Falls, Carleton County.

Black Raspberry

Species Name: *Rubus occidentalis* L.

Family: Rosaceae (Rose Family)

Habitat: Open deciduous forests, shores, and thickets in calcareous areas.

Description: Black raspberry is a perennial species with white, 5-7 cm broad flowers that usually appear in July. The fruit is purple-black and shiny. The leaves have three to five digitate leaflets, are coarsely incised along the edges, and have fine hairs underneath. The stems of black raspberry are cane-like and bowed, often rooting at the tip, and are covered with a whitish-blue tinge. The prickles are small-sized, hooked, possess no bristles or glands, and are sparingly distributed along the stem. It is often found growing in small clusters, favoring areas with high understorey light levels compared to typical closed canopy conditions in mature SJRHF.

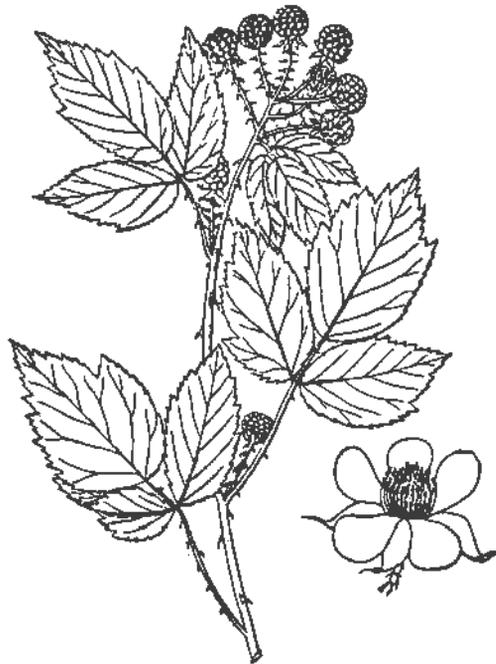


New Brunswick Status: Rare (Hinds 1983, 1986).

Range in New Brunswick: Most sites in Carleton County, with two records in York County and one in King County. All locations associated with the St. John River valley watershed (UNB, Hinds 1983, 1986).

Range in the Maritime provinces and Maine: Not recorded elsewhere in the Maritime provinces. Known from most Maine counties though not recorded in Aroostook County (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick south to Minnesota, Oklahoma, and Georgia.



Leaves, fruit, and flower of Black Raspberry (Illustration reprinted from *An Illustrated Flora of Northern United States and Canada* by Britton and Brown (1970). Dover Publications, Inc.)

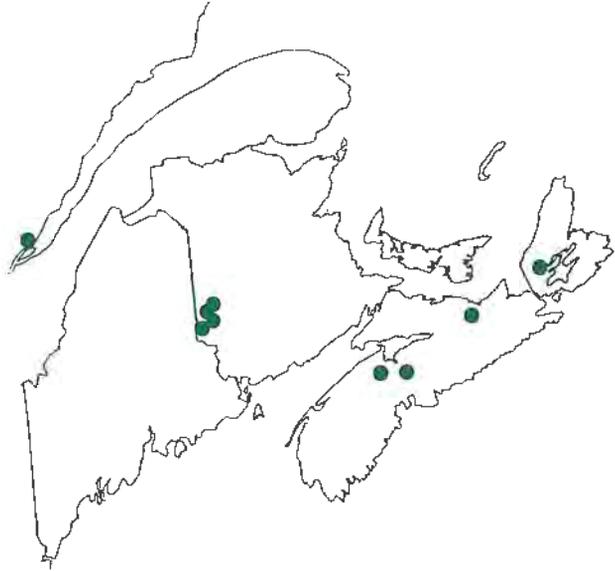
Fragrant Snakeroot

Species Name: *Sanicula odorata* (Raf.) Pryer and Phillippe

Family: Apiaceae (Parsley Family)

Habitat: Rich deciduous forest.

Description: Fragrant Snakeroot is a perennial species that grows 30 - 80 cm high and has smooth, thin, dark green 5-parted leaves. The edges of the leaves are sharply and doubly toothed, and each of the five leaf segments is lance-shaped and slightly stalked. This species has slender branches that are "umbellate", meaning they arise from a common point on the stem. The flowers are small, with yellowish petals and bright yellow anthers. The sepals are blunt-ended and much shorter than the petals. The fruit is stalked (2.5 - 4 mm long), nearly spherical in shape, and thickly coated with hooked bristles. The flower's "styles" (the section of the flower's reproductive organ that connects the stigma and ovaries) are considerably longer than the other rare *Sanicula* species, *Sanicula trifoliata*, and remain conspicuous following fruit formation.



New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Confirmed from five New Brunswick locations, all in Carleton County (UNB, MacDougall 1997). Records indicated in Hinds (1983) from near Campbellton and St. John could not be located in the UNB herbarium.

Range in Maritime provinces and Maine: Known from four locations in Nova Scotia, including sites in Kings County, Pictou County, and Inverness County in Cape Breton (Roland and Smith 1969). The only SJRHF species not recorded in Maine.

Range in North America: Ontario to New Brunswick, Nova Scotia, south to North Dakota, Texas, and Florida. Listed as threatened in New Hampshire; rare in North Dakota.



Leaf, flower, and fruit of Fragrant Black Snakeroot (Illustration reprinted with permission from *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada*, copyright 1952. The New York Botanical Garden.)

Large-fruited Snakeroot

Species Name: *Sanicula trifoliata* Bickn.

Family: Apiaceae (Parsley Family)

Habitat: Rich deciduous forest.

Description: Large-fruited Snakeroot is a biennial species that grows 30 - 80 cm high and has smooth, thin, dark green tripartite leaves. The edges of the leaves are sharply and doubly toothed and the two lateral leaflets are deeply lobed. This species has branches alternating up the stem, with each branch forking into several branchlets. The flowers are small, white, and nondescript, with sepals that are lance shaped and exceed the petals in length. The fruit is oblong shaped, 6 - 8 mm long, and coated with fewer hooked bristles than found on other *Sanicula* species. As the fruit develops, the flower's "styles" (the section of the flower's reproductive organ that connects the stigma and ovaries), which are only 1 mm long, become hidden among the longer fruit bristles. The other rare *Sanicula* species, *Sanicula odorata*, has longer styles that remain conspicuous following fruit formation.



New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Known from several sites in Carleton County (Hartland, Eel River, Mill Brook, Richmond Corner, Hovey Hill), plus one record from the Kennebecasis River valley (Kings County) in the late 1800s.

Range in Maritime provinces and Maine: Not recorded elsewhere in the Maritimes. Known from only two counties in southern Maine (Campbell *et al.* 1995).

Range in North America: Ontario to New Brunswick, south to Tennessee and North Carolina.



Large-fruited Snakeroot near Richmond Corner, Carleton County.

Wild Coffee

Species Name: *Triosteum aurantiacum* Bickn.

Family: Caprifoliaceae (Honeysuckle Family)

Habitat: Rich alluvial hardwood forests and calcareous shorelines.

Description: Wild Coffee is a large coarse plant growing in height from 60 -120 cm, and has leaves that are 10 - 25 cm long, lance-shaped, and unstalked. The stem is hairy and has a sticky texture. The leaves are opposite, and each pair are fused together and seem to be pierced by the stem. The flowers have a tubular shape with five long petal-like sepals, are colored bright red, and occur in the axils of the upper leaves along the stem. Flowering occurs in mid- to late May through July. The berries have a yellow or orange-yellow color.

New Brunswick Status: Rare (Hinds 1986).

Range in New Brunswick: Scattered in the St. John River watershed in Carleton County, with three records from York County. Most observations are from the Meduxnekeag River valley (UNB, Hinds 1986, MacDougall 1997).

Range in Maritime provinces and Maine: Rare in Nova Scotia, known from only four sites in the Cobequid Mountain region and in southwestern Cape Breton (Roland and Smith 1969, Maher *et al.* 1978). Known from only three Maine counties, two in the extreme south of the state, plus Aroostook County (Campbell *et al.* 1995). Listed as rare in Maine (Eastman 1981).

Range in North America: Ontario to New Brunswick, Nova Scotia, south to Iowa and Georgia. Listed as endangered in New Hampshire and Georgia, and rare in Iowa.



Wild Coffee in flower, near Woodstock, Carleton County.

Canada Violet

Species Name: *Viola canadensis* L.

Family: Violaceae (Violet Family)

Habitat: Rich deciduous forest.

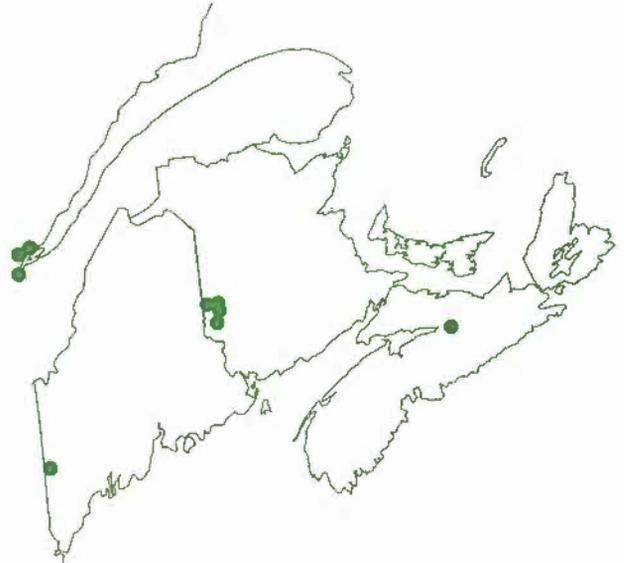
Description: Canada Violet is a perennial species with very finely toothed, heart-shaped leaves and fragrant white flowers that have a yellowish eyespot and brown-purple veins near the base. The flowers appear in June, occur on the same stem as the leaves, and are 2 - 2.5 cm wide with five petals. The leaves are 5 - 10 cm long, hairless, and long-tapering at the tip. The stems are 20 - 40 cm tall and arise, along with several long-stemmed basal leaves, from a short woody root or "rhizome".

New Brunswick Status: Very rare (Hinds 1983, 1986).

Range in New Brunswick: Known from only seven locations, six of which are in the Meduxnekeag River valley of Carleton County. The other site occurs in the St. John River valley in Victoria County (UNB, Hinds 1983, MacDougall 1997).

Range in Maritime provinces and Maine: Known from only one location in Nova Scotia near the Windsor limestone deposits (Roland and Smith 1969); listed as rare in the province (Maher *et al.* 1978). Known from only one location in Maine, which was discovered in 1993 (Rooney and Weber 1994), though this scarcity in the state may reflect limited collection effort (J. McMahon, *pers. comm.*).

Range in North America: Ontario to New Brunswick, Nova Scotia, south to Wisconsin, Alabama, and South Carolina. Endangered in New Jersey; threatened in Rhode Island and South Carolina; rare in Connecticut and Illinois.



Canada Violet in flower near Richmond Corner, Carleton County.

Section V: Current Status and Recommendations

Current status of St. John River Valley Hardwood Forest assemblages

It is estimated that SJRHF once occupied at least 200,000 hectares within New Brunswick's central St. John River Valley, based on the topography and distribution of well-drained calcareous soils within the region (MacDougall 1997). This figure increases when eastern Aroostook County is included, though the exact quantity of suitable habitat there is unknown. This pre-European forest would have been mostly continuously distributed, occupying the well-drained bottomland areas and flat and gently-sloped uplands within the valleys of the region.

Today, only 0.8% of the area deemed suitable for SJRHF actually supports mature hardwood forests (MacDougall 1997). Fifty-five percent of the remaining land base is permanently cleared for farming, settlements, or roads (Figure 12). Most existing forest patches are second-growth stands of poplar, white birch, white spruce, and young tolerant hardwood on abandoned farm land or on areas that have been logged. The few locations that still support mature SJRHF tend to be small-sized, averaging just over 10 ha, and are isolated. Further complicating the issue is on-going disturbance of remnant SJRHF stands. A recent assessment of SJRHF patches determined that even though they only occupy a small percentage of the total landscape, 44% of the known sites had been completely or partially clearcut within the past 16 years (1981-1997), and only 6% of the stands showed no evidence of at least some past cutting (MacDougall 1997). If these trends continue, there will soon be little or no mature tolerant hardwood left in the central St. John River Valley.



Figure 12. Recently cleared mature tolerant hardwood forest near Grand Falls.

Remnant SJRHF assemblages in the central St. John River Valley are largely confined to the isolated mature patches. Few SJRHF ground flora species, especially rare species, are found in the younger, regenerating stands, likely for a range of reasons (Matlack 1994, Meier *et al.* 1995, Damman and Cain 1998). First, the chances of sparsely distributed ground flora being eliminated by intense disturbance events are much higher than for species widely distributed within a patch – species that are found throughout a site are more likely to leave surviving individuals than those represented by only a few plants.

Second, the limited dispersal ability of SJRHF ground flora hampers the recolonization of second-growth hardwood stands, especially new stands that are not directly connected to adjacent patches with established ground flora populations. Species that regenerate mostly by vegetative spread are especially disadvantaged.

Third, understorey microclimate conditions found in regenerating tolerant hardwood forest can be substantially different from conditions in mature forest, which in turn affects the ability of SJRHF flora to persist. Canopy removal resulting from intense disturbance alters the understorey microclimate at the site, resulting in increased light intensity, higher ground temperatures, and reduced understorey humidity. These changes may be especially detrimental to epiphytic bryophyte species that require moist, shady, and cool understoreys to persist. Increased understorey light levels lead to invasion by fast-growing weed species that normally cannot establish under mature forest canopies. Invading weeds grow and reproduce much faster than perennial forest herbs and thus quickly outcompete them for space, light, and other essential resources.

Conversely, while too much understorey light is detrimental, some SJRHF species require occasional localized understorey light increases from tree-fall canopy gaps. Species such as black raspberry and butternut require these pulses of higher understorey light to successfully establish, and many of the shade-tolerant herbs respond to high light with increased growth rates. In second-growth forest, trees are young and even-aged, tree fall is uncommon, and when it does occur, the size of the canopy gap is small. In mature forest with an

uneven-aged canopy, the fall of large-sized old trees carries enough force to bring down smaller adjacent trees and open up gaps in the canopy of 200 m² or more.

Finally, younger regenerating forest does not have the same seasonal variation in understorey light intensity found in mature stands. Mature stands are characterized by high light intensity in the early spring, followed by dark understorey shading once canopy formation has occurred. In second-growth forest, the dominant tree species, usually poplar, balsam fir, white spruce, and white birch, are either evergreen or leaf considerably earlier in the year than tolerant hardwood species such as sugar maple and beech (Figure 13). As a result, spring ephemeral species requiring high light intensities in early to late May may not be able to receive sufficient solar exposure to complete their annual life cycle.

Given the factors that limit species-rich ground flora assemblages in second-growth forest, it may require a century or more for regenerating stands to accumulate understorey communities that approach pre-disturbance levels. If nearby seed sources are unavailable, the species composition of stands may never be re-established (Duffy and Meier 1992).

Compounding the problems caused by the inability of SJRHF species to recolonize new sites are the negative consequences associated with small population sizes. Small, isolated populations tend to face greater risks of local or regional extirpation than do large, well-established populations of common species (Shaffer 1987). Small populations are vulnerable to natural catastrophes, such as wind throw, or to other random natural events such as disease or intense browsing by deer or other herbivores. Populations with few individuals are also prone to loss of genetic variation caused by genetic drift and inbreeding which limits the ability to adapt to environmental change. Given that population expansion and long-range genetic exchange is limited under natural conditions and becomes worse in a fragmented landscape, SJRHF species may be at risk even if the current distribution of populations can be maintained.



Figure 13. Mature tolerant hardwood stand in early spring before canopy formation (middle), surrounded by stands of young regenerating balsam fir and intolerant hardwood.

Recommendations for protecting St. John River Valley Hardwood Forest assemblages

The highly restricted distribution of remnant SJRHF stands, combined with the on-going threat of habitat destruction and the potential effects of small population sizes, suggests that direct conservation measures are required to ensure the long-term persistence of SJRHF assemblages in New Brunswick. The following ten recommendations are believed to be necessary to protect this ecosystem and ensure its continued occurrence.

1. Identify the location of remnant stands and the SJRHF species composition within each, especially in Madawaska and Restigouche counties in New Brunswick, and eastern Aroostook County, Maine, where systematic surveys have not been conducted.
2. Design a conservation strategy to conserve the identified SJRHF stands, especially those richest in species or containing very rare species, to halt further loss of sites. Given that most sites will not be acquired due to the high cost, a multifaceted strategy that includes conservation easements and other types of cooperative partner-

ships with local landowners will be needed. Such a program has recently been initiated by the Nature Trust of New Brunswick (September 1997) to attempt to conserve known high-priority SJRHF sites within the province.

3. In SJRHF sites where cutting occurs, use existing knowledge of the life history strategies of SJRHF ground flora to design ecologically sensitive operational strategies. Such strategies should attempt to: (a) maintain sufficient canopy cover to shade the understorey and prevent invasion by weedy plant species (estimated minimum cover: 60% of full canopy), (b) simulate canopy gaps when cutting, producing a patchwork of small canopy openings as opposed to clearcutting part of the stand, (c) harvest during the winter to minimize soil compaction and damage to the herbaceous ground cover, (d) leave an uncut, full-canopied buffer around all seepage zones within the stand to protect the existing hydrological regime (best-guess minimum buffer: 25 m on all sides). Most seepage zones occupy a small percentage of the total patch area, so effects of the buffer on harvest will not usually be substantial.

4. Increase the percentage of mature tolerant hardwood stands within the central St. John River Valley as a means to increase available habitat as well as to ensure a long-term, sustainable supply of mature hardwood timber. Increases should be made in the number of stands, and in the average size per stand. Larger-sized stands provide more cool, shady "interior" habitat required by SJRHF perennials as well as neotropical migrant bird species (*e.g.*, scarlet tanager, warbling vireo, wood thrush) that breed in broad-leaved forests of the central St. John River Valley.
5. Re-establish forested connections between isolated SJRHF patches to serve as corridors for the movement of dispersers and pollinators. The most suitable location for corridors is along river valley bottomlands.
6. For sites known to host rare bryophyte species, maintain existing shaded understorey conditions as completely as possible to protect remnant populations. Current knowledge of the life history of bryophytes is more limited than for vascular plants, and protecting the habitat conditions is the best way to ensure persistence at a site.
7. Design re-introduction strategies to increase the number of populations, especially for species now limited to one or a few sites. Any re-introduction program should be preceded by a carefully planned pilot study to determine the best means to ensure successful transplanting. Many perennials are difficult to transplant, and failure, especially for very rare species, can be more detrimental than doing nothing at all. In cases where a population is restricted to a few individuals, transplanting should only occur as a last resort when the site is threatened with destruction.
8. Initiate demographic studies and monitoring programs to better understand the life history requirements of SJRHF species and to track population trends over time. Increased knowledge of population dynamics will assist in fine-tuning or adjusting conservation management strategies for these species.
9. Initiate population genetic analyses to assess existing genetic variation for rare species within the central St. John region and in northeastern North America in general. Such analyses would shed light on the current levels of variability in the isolated populations, as well as determining the level of differentiation between our disjunct northern populations, and the more southerly populations at the central part of their range.
10. Increase public awareness of SJRHF, including its threatened status, to facilitate the implementation of conservation initiatives that work with local landowners and interested community organizations.

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