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Vascular plants of the Sapa Bog

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Abstract

The vascular plants occurring within an acidic black spruce bog and its surrounding moat in southeastern Wisconsin are listed with observational notes on abundance and habitat. Of the 156 species, at least 20 are at or near the southern extent of their range, and four are currently State designated species of Special Concern.

Introduction

A bog community results from an interaction of climate and hydrogeology. The relative rates of precipitation and evaporation, temperature, bedrock geology and the length of time water is in contact with mineral soil all influence the formation and the type of peat-filled wetland which develops. In general, two types of peatlands occur in glaciated portions of Wisconsin: low nutrient or "ombrotrophic" bogs over granite bedrock, as found in northern Wisconsin, and high nutrient or "minerotrophic" fens over glacial drift and dolomitic bedrock, as found in southeastern Wisconsin. Dissolution of limestone and dolomite establish carbonate ion equilibria which buffer the soil solution at a slightly alkaline pH. This increases the diversity of decomposing organisms, the rate of mineral cycling, and the solubility of major plant nutrients.

The Sapa Bog (Ozaukee County, T10N, R21E) is the southernmost black spruce bog in Wisconsin. The wetland covers about 8 acres (3.3 ha) in a glacial kettle hole with a 14 m maximum peat depth. The ombrotrophic portion of the wetland occupies the central 3 acres where a dense stand of tamarack (*Larix laricina*) and black spruce (*Picea mariana*) surrounds a floating leather leaf and *Sphagnum* mat with few trees but no open water. Hummocks range to 40 cm in height. The range of surface water pH in this ombrotrophic portion of the Bog is 4-5; specific conductance, 30-80 µS/cm at 25° C; and calcium ion concentration, 30-60 µM (1-2 ppm) with a Ca:Mg molar ratio 0.4-0.7.

The lagg or moat, around the perimeter of the wetland, covers about 5 acres and varies between disturbed sedge meadow in the southwest to swamp hardwoods in the north and east. Characteristics of surface water in the moat have greater seasonal fluctuations, but generally pH is near neutral (7), conductivity is 200-300 µS/cm and calcium ion concentration is 300-500 µM with Ca:Mg about 1.5.

Water level measurements made during 1989 and 1990 indicate that generally water levels in the bog are elevated above the local ground water table. During exceptionally dry periods, however, the south end receives calcareous groundwater input near the surface.

This vascular plant species list of the bog and surrounding wetland was compiled from 1988 through 1991 in conjunction with other studies in the bog. Voucher specimens for most species have been deposited in the Field Station Herbarium. The fungi and the non-vascular plants of the bog are treated elsewhere (Parker, 1989; Bowers and Kline, 1991).

Definitions of Terms Used

Family and species names follow Voss (1972, 1985) when available and otherwise Fernald (1970). An asterisk (*) indicates a species which is at or near the southern extent of its range (Gleason and Cronquist, 1963; Reinartz and Reinartz, 1981, 1982). A number sign (#) indicates those species which are currently listed as of Special Concern by the Wisconsin Natural Heritage Inventory.

Letters in parentheses following the common name give an indication of the species abundance:

C, common--present in large numbers, easily found
O, occasional--scattered or present in isolated locations
R, rare--occurring in small numbers and often absent where expected
H, historical record--seen prior to but not during 1988-91

and location in the wetland:

OB, open bog--sunny, *Chamaedaphne-Sphagnum* mat
CW, coniferous woods--dense shade under *Picea-Larix*
OM, open moat--sunny, mainly grasses and sedges
SH, swamp hardwoods--wooded moat, little shrub layer
SB, shrub carr

Sapa Bog Vascular Plant Species List

ACERACEAE

Acer rubrum — Red maple (C; SH)

The moat around the perimeter of the bog was once a more continuous, densely shaded red maple swamp. A period of high water levels, resulting from plugged culverts in a farm road, damaged the hardwoods and resulted in a much lower tree density.

ALISMATACEAE

Alisma plantago-aquatica — Water plantain (O; SH)
Sagittaria cuneata — Arrowhead (O; SH)
S. latifolia — Arrowhead (O; SH)

ANACARDIACEAE

Toxicodendron vernix — Poison sumac (C; SH, CW)

Generally considered an indicator of minerotrophic areas, sumac is found throughout the Sapa Bog up to the edge of the open mat in dense *Sphagnum* lawns. Small seedlings and trees to 3 m are particularly dense at the south end.

APIACEAE

Cicuta bulbifera — Water hemlock (O; SH)
C. maculata — Water hemlock (O; SH)
Sium suave — Water parsnip (O; SH)

AQUIFOLIACEAE

Ilex verticillata — Winterberry (C; SB, CW)

Dense areas of winterberry with tamarack dominate the northeast corner of the bog. The canopy it forms is complete and excludes any other vegetation. An earlier survey of the Sapa Bog (Ballou, 1967) mentions the complete absence of winterberry.

**Nemopanthus mucronata* — Mountain holly (C; CW, SB)

ARACEAE

Arisaema triphyllum — Jack-in-the-pulpit (R; SH)
Calla palustris — Calla lily (O; SH)
Symplocarpus foetidus — Skunk cabbage (O; SH)

All the Araceae are found in the northwest corner of the Sapa Bog where the shrub layer is sparse. *Arisaema* is limited to islands caused by tree-falls and upland edges.

ARALIACEAE

Aralia nudicaulis — Aralia (R; SH)

ASTERACEAE

Aster lateriflorus	Aster (R; SH)
A. puniceus	Red stemmed aster (O; SH)
A. simplex	Marsh aster (R; SH)
**A. junciformis*	Aster (R; SH)

A. puniceus and *A. simplex* have a clonal growth habit and can propagate vegetatively. All are generally found in wet meadows and fens except *A. junciformis* which is more characteristic of cold open bogs (Gleason and Cronquist, 1963).

Bidens cernua	Beggar ticks (O; SH)
B. connata	Beggar ticks (O; SH)
Eupatorium maculatum	Joe-pye weed (R; SH)
E. perfoliatum	Boneset (R; SH)
E. rugosum	Snakeroot (R; SH)
Helianthus grosseseratus	Sunflower (R; SH)
Solidago canadensis	Goldenrod (O; SH)
S. gigantea	Goldenrod (O; SH)
S. patula	Rough-leaved goldenrod (O; SH)
S. uliginosa	Bog goldenrod (R; SH)

BALSAMINACEAE

Impatiens capensis	Jewel weed (C; OM)

BETULACEAE

Alnus rugosa	Speckled alder (O; SB)

Alnus is a common shrub in northern bogs of Wisconsin and Minnesota. Ballou (1967) describes dense thickets in the Sapa Bog which have not persisted.

Betula allegheniensis	Yellow birch (C; SH)
B. papyrifera	Paper birch (O; SH)
B. pumila	Bog birch (C; SH, SB)
B. x *sandbergii*	Paper birch-bog birch hybrid (R; CW)

BRASSICACEAE

Cardamine bulbosa	Spring cress (O; SH)
#*C. pratensis* var. *palustris*	Cuckoo flower (O; CW, SH)

Cuckoo flower is found only at the south end of the Sapa Bog.

CAMPANULACEAE

Campanula aparinoides	Bedstraw-bellflower (O; SH)

CAPRIFOLIACEAE

**Linnaea borealis*	Twinflower (H)
**Lonicera dioica*	Wild honeysuckle (O; SB)
**Lonicera villosa*	Mountain fly honeysuckle (O; SB)

CONVOLVULACEAE

Cuscuta gronovii	Dodder (O; OM)

CORNACEAE

Cornus amomum	Silky dogwood (O; CW, SH, SB)
C. canadensis	Bunchberry (O; CW)
C. stolonifera	Red-osier dogwood (O; SH, SB)

CUCURBITACEAE

Echinocystis lobata	Wild-cucumber (O; OM)

CUPRESSACEAE

Juniperus communis var. *depressa*	Dwarf juniper (R; CW)
**Thuja occidentalis*	Northern white cedar (O; CW,SH)

CYPERACEAE

Carex aquatilis	Sedge (O; OB, SH, OM)

Generally considered an indicator of alkaline conditions (J. Zimmerman, pers. comm.), *C. aquatilis is* found both in the moat and in the acidic center of the Sapa Bog. In 1989 several shoots from the same genet in an acidic and an alkaline area were transplanted and grown in a greenhouse under acidic bog conditions; another set from the two areas was transplanted and grown under conditions similar to the more alkaline moat area. No flowering occurred during 1989, but vegetative growth of all shoots from both areas was similar in both treatments. All plants flowered in 1990.

C. bebbii	Sedge (C; SH, OM)
**C. brunnescens*	Sedge (O; SH, CW)
**C. canescens*	Sedge (C; CW)

C. canescens and *C. brunnescens* often occur together with *C. brunnescens* extending further into the moat. Both were among to first plants to invade disturbed areas of the *Sphagnum* mat.

C. cephalantha	Sedge (O; CW)
C. comosa	Sedge (C; OM)
**C. disperma*	Sedge (C; OB, CW; see *C. trisperma*)
C. hystericina	Sedge (O; OM)
C. intumescens	Sedge (O; SH)
C. lasiocarpa	Sedge (C; OB; see *C. oligosperma*)
**C. limosa*	Sedge (C; OB, CW)
C. oligosperma	Sedge (C; OB)

Both *C. lasiocarpa* and *C. oligosperma* have air-filled root or rhizome systems and are commonly found in floating mats of bogs or poor fens. They are, however, difficult to distinguish without reproductive parts and very little flowering was observed.

**C. paupercula*	Sedge (O; CW)
C. pauciflora	Sedge (O; OB, CW)

C. rostrata Sedge (O; OM)
C. stipata Sedge (C; OB, CW, OM)

Carex stipata also is characteristic of wet meadows and alkaline areas but grows and reproduces sexually in the most acidic areas of the Sapa Bog.

C. stricta Hummock Sedge (C; OM)
*,#*C. tenuiflora* Sedge (O; OB, CW; see *C. trisperma*)
C. trisperma Sedge (C; OB, CW)

Typically found with *C. disperma* and *C. tenuiflora* in the *Sphagnum* mat. Flowering was rare in 1989 and very common in 1990.

Dulichium arundinaceum Three way sedge (R; CW)
Eleocharis erythropoda Spike rush (O; CW)
E. smallii Spike rush (O; CW, SH)
Eriophorum angustifolium Cottongrass (O; OB,CW)
*(Some possibly *E. viridi-carinatum*)
E. virginicum Cottongrass (C; OB)
Rhynchospora alba Beak rush (C; OB)
Scirpus atrovirens Bulrush (R; OM)
Scirpus cyperinus Wool grass (O; CW)

DROSERACEAE

Drosera rotundifolia Round-leaved sundew (C; OB, CW)

The leaves of round-leaved sundew are unusual for the genus in being confined to a basal rosette. The internodes of *D. intermedia*, more common in open bogs, and *D. linearis*, found in fens, can elongate to accomodate fluctuating water levels. Round-leaved sundew, however, avoids being covered with expanding *Sphagnum* during warm wet periods by forming additional rosettes which stair-step up the hummock.

ERICACEAE

Andromeda glaucophylla Bog rosemary (R; CW, OB)
Chamaedaphne calyculata Leather leaf (C; OB)
Gaultheria procumbens Wintergreen (R; CW)
Gaylussacia baccata Huckleberry (O; CW)
**Kalmia polifolia* Pale laurel (R; CW)
Vaccinium angustifolium Early blueberry (O; CW)
V. macrocarpon Cranberry (O; CW)
V. myrtilloides Velvet leaf bilberry (O; CW)
**V. oxycoccus* Small cranberry (C; OB, CW)

EQUISETACEAE

Equisetum fluviatile Swamp horsetail (C; SH)

FABACEAE

Amphicarpa bracteata Hog peanut (O; SH)

FAGACEAE

Quercus bicolor	Swamp white oak (R; SH)

GENTIANACEAE

Menyanthes trifoliata	Buckbean (C; OB)

Buckbean, like marsh cinquefoil, was one of the first plants to invade disturbed areas of the bog mat with thick rhizomes just below the *Sphagnum* surface.

GROSSULARIACEAE

Ribes hirtellum	Swamp gooseberry (O; SH)

IRIDACEAE

Iris versicolor	Blue flag (O; SH)

JUNCAGINACEAE

#Triglochin maritimum	Arrow grass (R; OB)

LAMIACEAE

Lycopus uniflorus	Water horehound (O; SH)
Scutellaria galericulata	Marsh skullcap (O; SH)
S. lateriflora	Side-flower skullcap (O; SH)

LILIACEAE

Maianthemum canadense	Wild lily of the valley (C; CW)
**Smilacina trifolia*	Three-leaf Solomon's plume (C; CW)

OLEACEAE

Fraxinus nigra	Black ash (C; SH)

ONAGRACEAE

Epilobium coloratum	Willow herb (O; OM)
E. leptophyllum	Narrow-leaf willow herb (O; OM)

ORCHIDACEAE

Calapogon puchellus	Grass pink (O; OB, CW)

This is the only *Calapogon* to extend this far north and is also called *C. tuberosus*. It is typically found in the wettest and most acidic portions of the *Sphagnum*. The new plant grows from a corm at the base of the flowering scape. As a result, the new plant is slightly higher than the old plant, but as the moss grows the relative position of the corm remains the same. It blooms typically in late June to July, and many non-flowering plants occurred. Marked plants persisted from year to year in spite of very different weather conditions.

**Cypripedium acaule* Mocassin flower (O; CW)

Mocassin flower occurred in the acidic but drier areas of the bog, usually on *Sphagnum* hummocks among spruce and tamarack. It typically blooms in May to early June and late frosts damaged the flowering scape but not the leaves. Marked plants persisted from year to year.

#C. calceolus var. *parviflorum* Small yellow lady's slipper (R; CW)

This species was observed only in 1988 and 1990 and was found with spruce and tamarack but without *Sphagnum*.

**Habenaria hyperborea* Northern green orchis (R; CW)

Some authors divide the genus *Habenaria* and refer to this species as *Plantanthera hyperborea*. It is a true northern species which only extends south to the Great Lakes. Next year's plant starts as a bud on one of this season's roots. Once this bud develops its own roots or tubers, the old plant senesces. Marked plants persisted from year to year without increasing in number.

Liparis liliifolia Purple twayblade (R; SH)

This southern species grows from a corm at or just on the surface, generally among mosses other than *Sphagnum*. Rodent predation on the corms was frequent.

L. loeselli Green twayblade (R; CW)

This species occurred in more acidic, wet *Sphagnum* depressions. Since the lip is light green, it is easily overlooked and may in fact be more common.

**Malaxis monophylla* var. *brachypoda* Malaxis (R; CW)

This northern species is also easily overlooked and was found among mosses, other than *Sphagnum*, in wet trails.

Pogonia ophioglossoides Rose pogonia (C; OB)

Rose pogonia occurred as dense colonies, spreading by roots, in very wet areas of open *Sphagnum* lawn. Some seed production was observed.

OSMUNDACEAE

Osmunda cinnamomea Cinnamon fern (O; SH)
O. regalis Royal fern (O; SH, CW)

PINACEAE

Larix laricina Tamarack (C; SH, CW)
**Picea mariana* Black spruce (C; CW)

The frequency of black spruce is relatively constant throughout the bog. The frequency of tamarack is lower than that of black spruce in the center of the bog and higher than that of black spruce at the edge.

POACEAE

Bromus ciliatus Fringed brome (O; SH)
Calamagrostis canadensis Blue joint grass (C; OM, SH)

Glyceria striata Manna grass (O; SH)

Manna grass is very common in shaded wet areas with high mineral content in the soil.

Leersia oryzoides Rice cut grass (C; OM)

Rice cut grass is easily established in disturbed areas since it produces seed sexually and, late in the season, produces smaller panicles wholly enclosed in the sheath. This late season seed, carried by the water of spring snow melt, germinates easily on exposed mud flats. Once established, it forms a dense root system and also propagates vegetatively.

Muhlenbergia mexicana Muhly grass (O; SH)

Phalaris arundinacea Reed canary grass (C; OM)

Limited to the south end of the wetland.

Poa palustris Fowl meadow grass (O; CW, SH)

POLYGONACEAE

Rumex orbiculatus Dock (O; OM)

Polygonum punctatum Smartweed (O; OM, SH)

P. sagittatum Tear-thumb (O; OM)

POLYPODIACEAE

Dryopteris cristata Shield fern (O; SH)

D. thelypteris Marsh fern (C; SH, CW)

Onoclea sensibilis Sensitive fern (O; SH)

PRIMULACEAE

Lysimachia terrestris Loosestrife (R; OM)

L. thyrsiflora Tufted loosestrife (C; CW)

Trientalis borealis Starflower (C; CW)

PYROLACEAE

Moneses uniflora One-flowered pyrola (O; CW)

RANUNCULACEAE

Caltha palustris Marsh marigold (O; SH)

Coptis trifolia Goldthread (C; SH)

Goldthread was limited to drier sites such as treed hummocks at the north end of the bog.

Ranunculus abortivus Small-flowered crowfoot (O; OM)

R. sceleratus Cursed crowfoot (O; OM)

RHAMNACEAE

Rhamnus cathartica Buckthorn (O; SB)

R. frangula Glossy buckthorn (C; SH)

Both buckthorns are non-native species. *R. cathartica* is found only in the upland edge at the south end of the wetland. *R. frangula* was found throughout the entire

area but was most dense and most productive in the northeast swamp hardwoods outside the spruce-tamarack edge. Plants growing loosely rooted in the *Sphagnum* mat were stunted in comparison. Because of the extensive growth of glossy buckthorn in the Cedarburg Bog (Reinartz and Kline, 1988), the Field Station initiated a control program in the Sapa Bog. All shoots were removed from the central 1.5 acres of the bog in 1989. Small shoots were removed with roots intact, larger plants were cut as close to the soil as possible and treated with glyphosate. Very little resprouting was observed in 1990 and additional plants were removed from the central 2 acres.

ROSACEAE

Aronia prunifolia — Black chokeberry (O; SH)
Potentilla palustris — Marsh cinquefoil (R; CW)

Marsh cinquefoil and buckbean increased in abundance in disturbed areas of the mat and along foot trails.

Rubus hispidus — Swamp dewberry (C; CW, SH)

RUBIACEAE

Galium aparine — Cleavers (O; SH)
G. labradoricum — Bedstraw (O; SH, CW)
Mitchella repens — Partridge berry (R; CW)

SALICACEAE

Populus deltoides — Cottonwood (O; SH)
Salix bebbiana — Bebb's willow (O; SB)
S. discolor — Pussy willow (O; SB)
S. pedicellaris — Bog willow (R; SB)
S. serissima — Autumn willow (R; SB)

Bog willow and Autumn willow were limited to the south end of the bog.

SARRACENIACEAE

Sarracenia purpurea — Pitcher plant (C; OB, CW)

SAXIFRAGACEAE

**Mitella nuda* — Miterwort (O; CW)
Parnassia glauca — Grass-of-Parnassus (H)

SCROPHULARIACEAE

Chelone glabra — Turtlehead (O; SH, CW)

SOLANACEAE

Solanum dulcamara — Nightshade (O; OM)

TYPHACEAE

Typha latifolia Broad leaf cattail (O; CW, OM)

Cattail was observed in 1967 (Ballou) and apparently increased during years of higher water level when a farm road dammed the natural drainage of the moat. Natural water levels have been restored, and some non-flowering cattails persist even in the most acidic areas of the bog.

ULMACEAE

Ulmus americana American elm (O; SH)

URTICACEAE

Pilea pumila Clearweed (C; OM)

VIOLACEAE

Viola pallens White bog violet (O; CW)

VITACEAE

Parthenocissus quinquefolia Virginia creeper (O; SH)

Discussion

In spite of its hydrologic connection to calcium rich groundwater, the center of the Sapa Bog remains ombrotrophic. Most of the water entering the bog comes from rain and snowmelt. Ombrotrophic bogs are unique, but not generally floristically rich. A typical bog may contain fewer than 40 vascular plant species, compared to 100 or more in a rich fen or dry prairie. Bogs in the southern Great Lakes area, however, have greater species richness than more northern ombrotrophic bogs. Soil temperatures, critical to the growth and distribution of many species, are moderated by the insulating properties of *Sphagnum* moss. In summer, evaporation from the moss surface cools the root zone to temperatures well below that of dry soil; in winter, the lower root zone rarely drops much below freezing. As a result, temperatures in these southern bogs are low enough to fall within the tolerance of northern species in summer, and are high enough in winter to support the hardier southern species (Case, 1987). In addition, the bogs of the Great Lakes Region harbor some species, like *Trientalis, Gaylussacia* and *Pogonia*, which are common to the Atlantic Coastal Plain. Of the 156 species found in the Sapa Bog, 65 occur in the open mat or conifer woods. Half of these belong to only three plant families (Cyperaceae, 21 species; Ericaceae, 9 species; Orchidaceae, 7 species). The remaining species generally have southerly distributions and grow in the moat. A few species typically found in boreal bogs, such as Labrador tea and the pyrolas, are conspicuously absent from the Sapa Bog.

Many of the plant species of these southern bogs are at the limit of their range or disjunct from the central part of their range. These outlying, or marginal populations, which

experience extreme or "marginal" ecological conditions, may differ genetically from centrally located populations due to long isolation or unusual selection pressures. As a result, these isolated populations may represent a disproportionately large amount of the genetic diversity of the species as a whole. Considerations of the wetland's uniqueness led to the purchase of the Sapa Bog by The Nature Conservancy in 1983. In 1986 it was deeded to the University of Wisconsin and became a State Natural Area.

All the vascular plants found in the Sapa Bog are also found in the various vegetation types of the more minerotrophic, and much larger, Cedarburg Bog about 1 km away. The abundance of several species, most notably black spruce, and the sedges and orchids common in acidic areas, is strikingly greater in the Sapa Bog. A neighboring black spruce bog, not subject to the artificial water level changes which occurred in the Sapa Bog, has similar vegetation but a more intact moat and greater abundance of *Gaylussacia* and *Vaccinium* species.

The increasing dominance of tamarack over spruce at the bog periphery is associated with naturally fluctuating water levels in the moat. This fluctuation results in higher oxygen and nutrient levels and higher summer temperatures (Lieffers and Rothwell, 1987). Seedlings and established trees of both species grow more vigorously and have higher foliar nitrogen levels in drier sites. Tamarack responds more than spruce, however, (Lieffers and Macdonald, 1990), and so has a competitive advantage over spruce in the moat.

The small size and isolation of the Sapa Bog suggest that it requires some minimal management in order to preserve the quality of its vegetation. Water levels must be monitored to insure the moat is not flooded during the growing season when nutrient levels are high. The water chemistry of the moat in spring and after storm events is determined largely by agricultural practices on adjacent land. The ability of the vegetation in the moat to absorb excess nutrients is remarkable but limited. Minimizing fertilizer applications and growing forage crops with lower nutrient demands, rather than row crops, reduce the potential for the vegetation of the moat to encroach into the center of the bog. Whenever possible, access to the floating mat is best limited to winter, when nutrient levels at the surface are not increased by foot traffic or other disturbance. Finally, removal and exclusion of glossy buckthorn is required to keep it from changing the character of the bog's vegetation through shading.

Literature Cited

Ballou, S. 1967. A vegetation survey of a black spruce bog. University of Wisconsin-Milwaukee, unpub. ms.

Bowers, F. and J. Kline. 1991. A prelimimary survey of the bryophytes of the Sapa Bog. UWM Field Station Bull. In press.

Case, F. W, Jr. 1987. Orchids of the Western Great Lakes Region, 2nd ed. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 251 pp.

Fernald, M. L. 1970. Gray's Manual of Botany. 8th ed. Van Nostrand Co., New York. 1632 pp.

Gleason, H. A. and A. Cronquist. 1963. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Van Nostrand, Princeton, New Jersey. 810 pp.

Lieffers, V. J. and S. E. Macdonald. 1990. Growth and foliar nutrient status of black spruce and tamarack in relation to depth of water table in some Alberta peatlands. Can. J. For. Res. 20: 805-809.

Lieffers, V. J. and R. L. Rothwell. 1987. Rooting of peatland black spruce and tamarack in relation to depth of water table. Can. J. Bot. 65: 817-821.

Reinartz, J. A. and J. Kline. 1988. Glossy buckthorn (*Rhamnus frangula*), a threat to the vegetation of the Cedarburg Bog. UWM Field Station Bull. 21(2): 20-35.

Reinartz, J. A. and G. E. Reinartz. 1981. Vascular plants near the margins of their range in the Cedarburg Bog. Part I. Gymnosperms and Monocots. UWM Field Station Bull. 14(2): 1-13.

Reinartz, J. A. and G. E. Reinartz. 1982. Vascular plants near the margins of their range in the Cedarburg Bog. Part II. Dicots. UWM Field Station Bull. 15(1): 16-21.

Parker, A. D. 1989. A preliminary survey of the fungi of the Sapa Spruce Bog. UWM Field Station Bull. 22(1): 12-16.

Voss, E. 1972. Michigan Flora. Part I. Gymnosperms and Monocots. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 488 pp.

Voss, E. 1985. Michigan Flora. Part II. Dicots (Saururaceae-Cornaceae). Cranbrook Institute of Science, Bloomfield Hills, Michigan. 724 pp.

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