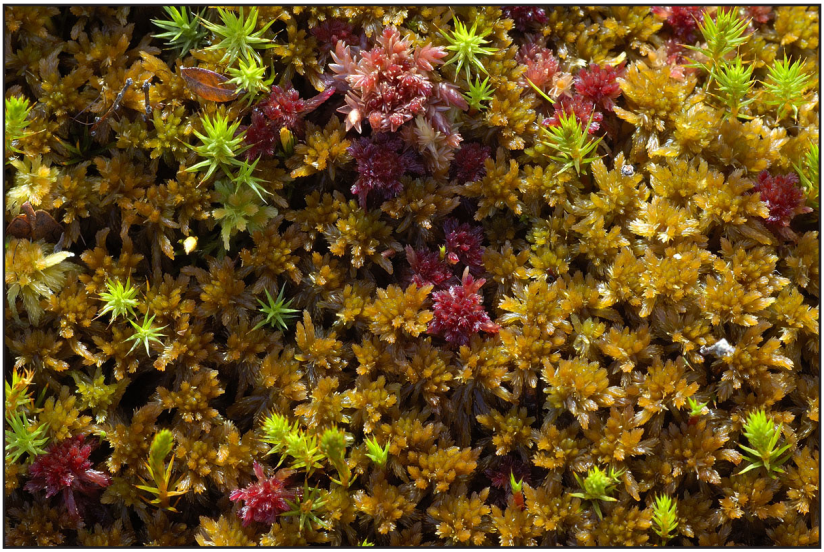
NOTEWORTHY MOSSES & LIVERWORTS OF MINNESOTA

PART I

Illustrated Field Keys



Joannes A. Janssens

2014 Minneapolis

Cite as: Janssens, J.A. 2014. Noteworthy Mosses & Liverworts of Minnesota, Part I: Illustrated Field Keys. Minnesota Department of Natural Resources 2014, 176 pp.

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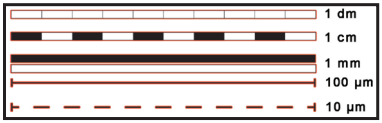
Introduction

As noteworthy mosses and liverworts I have selected those species that are the most frequently recorded in Minnesota's natural ecosystems and are widespread throughout the state. Table 1 lists the five species most commonly found in each of 13 major ecological systems (MN DNR 2003-2006), in addition to four species most frequently encountered in ruderal habitat. Several of these 43 species occur in more than one ecosystem. Fifty other species with a lower importance value are added (Table 2). **Part I** presents keys to these 93 mosses and liverworts, out of a total over 500 species recorded for Minnesota (Janssens & Orf 1990, Janssens 2000, Janssens 2005-2009, 2014a). **Part II** includes species fact sheets, which cover structure and ecology, and provide photographs of field aspect and species-differentiating structures.

The keys focus on features visible in the field with the **naked eye** or **handlens**. Both the **dry and wet aspect** of the patches can be important, so bring along a small mist bottle. Each of the keys is illustrated by photographs. The keys, but without the images, are collated again in Appendix 1. The **photographs** I selected to illustrate features (indicated in the text in **bold**), are as representative as possible of their field aspect. However, I have added some micrographs of specific structures to help in the interpretation, such as cell patterns and costae. The following convention for the bar scales is used:



The structures and character states that are part of the bold text are also defined in a **narrative glossary** in Appendix 2 (see Janssens 2014b for an additional **illustrated glossary** specifically covering this field guide). In addition, Appendix 4 is an **index** to all species names, referencing page numbers where a particular species occurs in the keys, but also those pages that contain some of its images.

Within the main key, each group is identified with a **color-coded label**. The keys for individual groups are marked at the top of their pages by a banner of the same color and an icon specific to the group. These are shown enlarged below in the 'Key Overview'. The species names in Tables 1 and 2 are similarly color-coded to group.

The text in **bold font** describes diagnostic features, while habitat descriptions are given in **green font**. The species names are in black font when no confusion with other species is likely. However, I have used a **blue font** when look-alikes exist, some of which might be frequently encountered. If critical identification is necessary, specimens of species with their names in blue font should be checked carefully—using stereo- and compound microscope—or have their identification annotated. As **reference works** use Schuster 1977 (1953) for liverworts, and for mosses Crum (2004), Crum & Anderson (1981), or the Flora of North America (2007, see also www.efloras.org and www.mobot.org/plantscience/BFNA for current status). I can provide updated **nomenclature** and **checklists** for the entire state and for MN counties and ECS subsections, and would appreciate the possibility of annotating any specimens. A more formal 'Moss Flora of Minnesota' is in preparation and completed chapters can be obtained from me.

Table 1. Most common bryophytes of Minnesota's ECS systems

Upland Forest & Woodland Systems

Fire-Dependent Forest/ Woodland	Mesic Hardwood Forest
Pleurozium schreberi	*Platygyrium repens*
Callicladium haldanianum	*Brachythecium acuminatum*
Platygyrium repens	*Callicladium haldanianum*
Ptilidium pulcherrimum	*Haplocladium microphyllum*
Dicranum flagellare	*Plagiomnium cuspidatum*

Upland Grassland & Sparse Vegetation Systems

Cliff/Talus	Rock Outcrop	River Shore
Gymnostomum aeruginosum	*Weissia controversa*	*Brachythecium rivulare*
Plagiomnium cuspidatum	*Ceratodon purpureus*	*Hypnum lindbergii*
Anomodon rostratus	*Syntrichia ruralis*	*Plagiomnium cuspidatum*
Conocephalum salebrosum	*Grimmia laevigata*	*Hygroamblystegium 'tenax'*
Anomodon attenuatus	*Hedwigia ciliata*	*Hygroamblystegium 'varium'*

Wetland Forest Systems

Floodplain Forest	Wet Forest	Forested Rich Peatland Swamp	Acid Peatland Forested
Haplocladium microphyllum	*Climacium dendroides*	*Pleurozium schreberi*	*Sphagnum angustifolium*
Lindbergia brachyptera	*Plagiomnium ellipticum*	*Plagiomnium ellipticum*	*Pleurozium schreberi*
Hypnum lindbergii	*Hypnum lindbergii*	*Aulacomnium palustre*	*Sphagnum magellanicum*
Pylaisia selwynii	*Thuidium delicatulum*	*Sphagnum warnstorfii*	*Aulacomnium palustre*
Platygyrium repens	*Calliergon cordifolium*	*Callicladium haldanianum*	*Ptilidium pulcherrimum*

Wetland Grassland, Shrubland & Marsh Systems

Acid Peatland Open	Open Rich Peatland	Forested Rich Peatland Alder	Wet Meadow/Carr
Sphagnum magellanicum	*Campylium stellatum*	*Plagiomnium ellipticum*	*Drepanocladus aduncus*
Polytrichum strictum	*Ptychostomum pseudotriquetrum*	*Climacium dendroides*	*Brachythecium salebrosum*
Sphagnum angustifolium	*Scorpidium cossonii*	*Hypnum pratense*	*Plagiomnium ellipticum*
Sphagnum rubellum	*Drepanocladus aduncus*	*Hypnum lindbergii*	*Hygroamblystegium 'varium'*
Aulacomnium palustre	*Aneura pinguis*	*Plagiomnium cuspidatum*	*Brachythecium rivulare*

Ruderal Species (species commonly found in disturbed habitats)

Marchantia polymorpha
Funaria hygrometrica
Ceratodon purpureus
Bryum argenteum

Table 2. Additional species covered in keys

Main Key

Fissidens adianthoides

Plagiothecium denticulatum

Key to Thalloid Liverworts

Riccia fluitans

Key to Leafy Liverworts

Bazzania trilobata

Cladopodiella fluitans

Frullania eboracensis

Lophocolea heterophylla

Plagiochila asplenioides

Key to Sphagnum

Sphagnum capillifolium

Sphagnum centrale

Sphagnum fimbriatum

Sphagnum fuscum

Sphagnum girgensohnii

Sphagnum majus

Sphagnum papillosum

Sphagnum russowii

Sphagnum squarrosum

Sphagnum subsecundum

Sphagnum teres

Sphagnum wulfianum

Key to Polytrichales

Atrichum crispulum

Polytrichum commune

Key to Dicranum

Dicranum montanum

Dicranum ontariense

Dicranum polysetum

Dicranum scoparium

Dicranum undulatum

Dicranum viride

Key to Other Acrocarps

Gemmabryum caespiticium

Leucobryum glaucum

Rhizomnium magnifolium

Tortella tortuosa

Key to Feather Mosses

Hylocomium splendens

Ptilium crista-castrensis

Rhytidiadelphus triquetrus

Thuidium recognitum

Key to Costate Wetland Pleurocarps

Helodium blandowii

Sarmentypnum exannulatum

Tomentypnum falcifolium

Tomentypnum nitens

Warnstorfia fluitans

Key to Costate Upland Pleurocarps

Anomodon minor

Eurhynchiastrum pulchellum

Leskea gracilescens

Leskea polycarpa

Key to Ecostate Pleurocarps on Peat

Calliergonella cuspidata

Scorpidium scorpioides

Key to Ecostate Pleurocarps on Bark, Wood, or Rocks

Entodon cladorrhizans

Hypnum pallescens

Neckera pennata

Acknowledgments

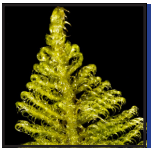
Most of the research, from which this list of noteworthy species of mosses and liverworts for Minnesota is derived, was part of ecological and survey projects completed throughout the state during the last 30 years. Major support was made available for these project by the University of Minnesota Limnological Research Center and Department of Ecology, and by the MN Department of Natural Resources and the USDA Forest Service. Detailed acknowledgments are found in my methods manual on survey techniques (Janssens 2007). For help with reproduction and archiving of this publication I thank Tom Glancy, Sean Hunt, Tom Klein, and Jeannette Leete of the Minnesota DNR.

I greatly appreciate the constructive critiques derived from field use by workshop participants, who have been further testing the keys and providing me with valuable insights for improvements. Most photographs are my own, but a few people have provided excellent images. Their contributions are greatly valued and are marked in the captions.

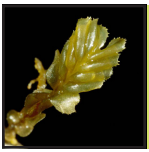
Key Overview

Most of the noteworthy mosses and liverwort species are organized in the following 11 groups:

Thalloid Liverworts
4 species



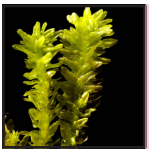
Feather Mosses
6 species



Leafy Liverworts
6 species

Costate Wetland Pleurocarps
12 species

Sphagnum
16 species



Costate Upland Pleurocarps
9 species

Polytrichales
3 species

Ecostate Pleurocarps on Peat
5 species

Dicranum
7 species

Ecostate Pleurocarps on Bark, Wood, Rock
6 species

Other Acrocarps
16 species

Three species, *Fissidens adianthoides*, *Climacium dendroides*, and *Plagiothecium denticulatum*, are included as separate entities in the Main Key.

This group classification of Minnesota bryophytes is purely artificial, but I consider it to be the most convenient differentiation based on their field aspect. Each of the above groups is color coded, and this color, in addition to the icon shown above, is used in the page banners of the individual group keys.

Illustrated Main Key

1a. Plants **thalloid** . . . . . THALLOID LIVERWORTS
1b. Plants **leafy** . . . . . 2.

thalloid

leafy (moss)

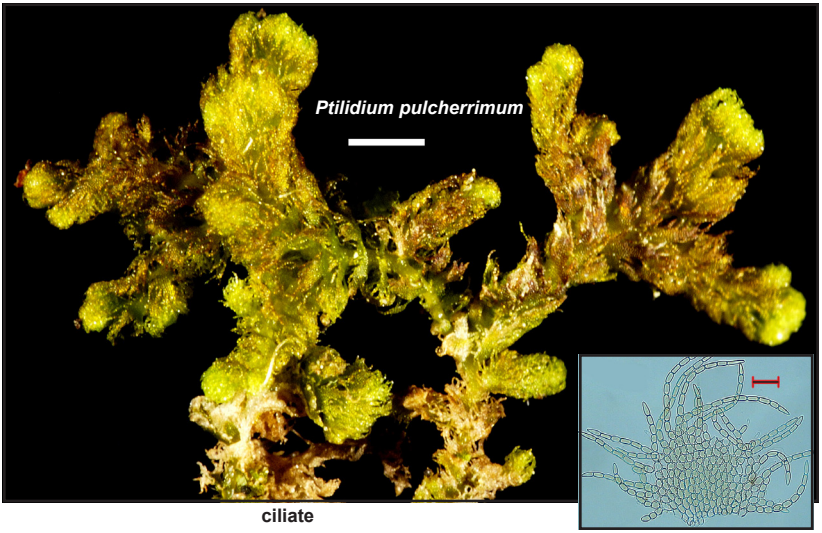
Main Key

2a. Leaves without a **costa** (= medial nerve), often irregularly shaped, **lobed**, or **ciliate**, always inserted in two or three longitudinal rows; the leaves that form the third, ventral row (**underleaves**), if present, are smaller and quite different in shape from the dorsal ones . . . . . **Leafy Liverworts**

2b. Leaves with or without a **costa**, unlobed and mostly longitudinally symmetric, **spirally** (= helically) inserted, or rarely **distichously** (= strictly in two rows), but then with costae. . . . . 3. Mosses

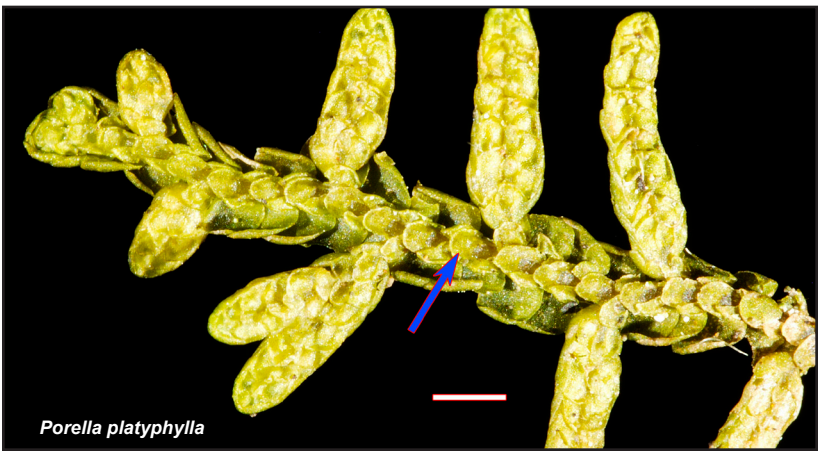
leafy (liverwort)

costa (medial nerve)



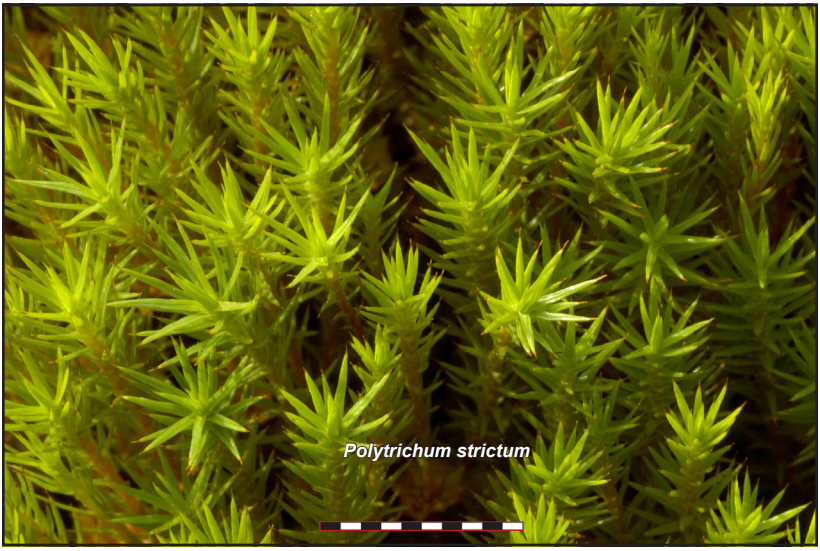
ciliate

lobed



underleaves (arrow)

distichous (2-row insertion)



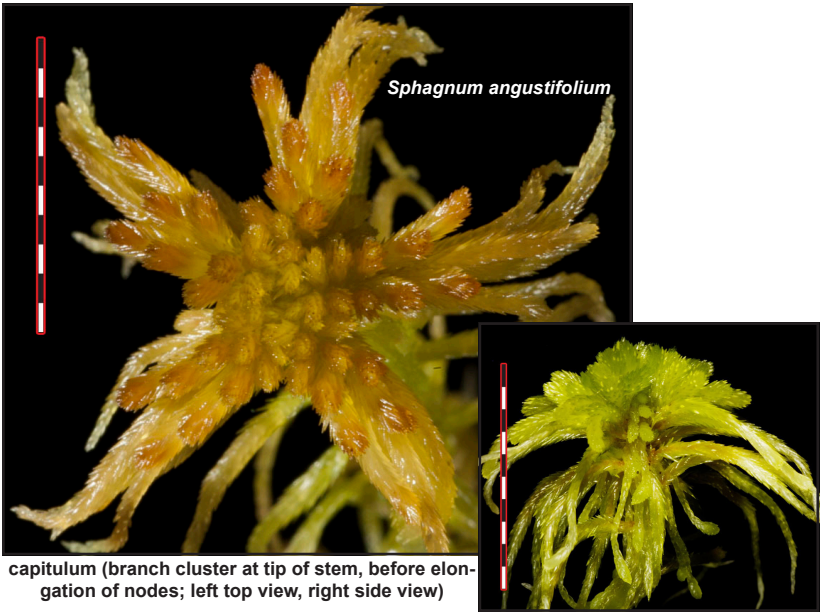
spiral (helical insertion)

3a. Plants with branches in bundles ('**fascicles**') spirally arranged around the stem and usually clustered in a dense head ('**capitulum**') at the tip; color pale green in shade but in exposed habitats plants often pigmented with **yellow-brown**, **brown**, **yellow**, or **red** . . . . . **SPHAGNUM**

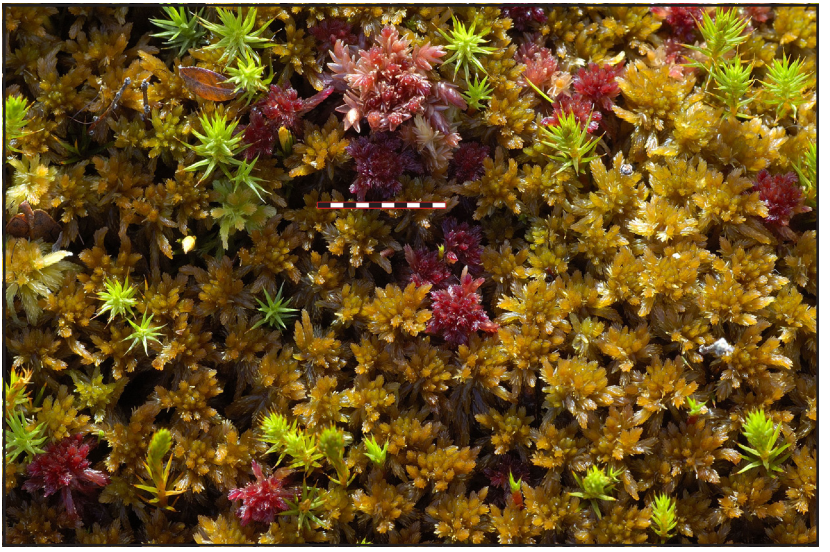
3b. Plants unbranched, or if branched, branches not clustered in fascicles or capitula; plants with younger leaves mostly yellow-green to dark green, without dense reddish pigments . . . . . True Mosses 4.

fascicle (bundle of branches attached to stem, at arrow)

capitulum at the growing apex of the plant

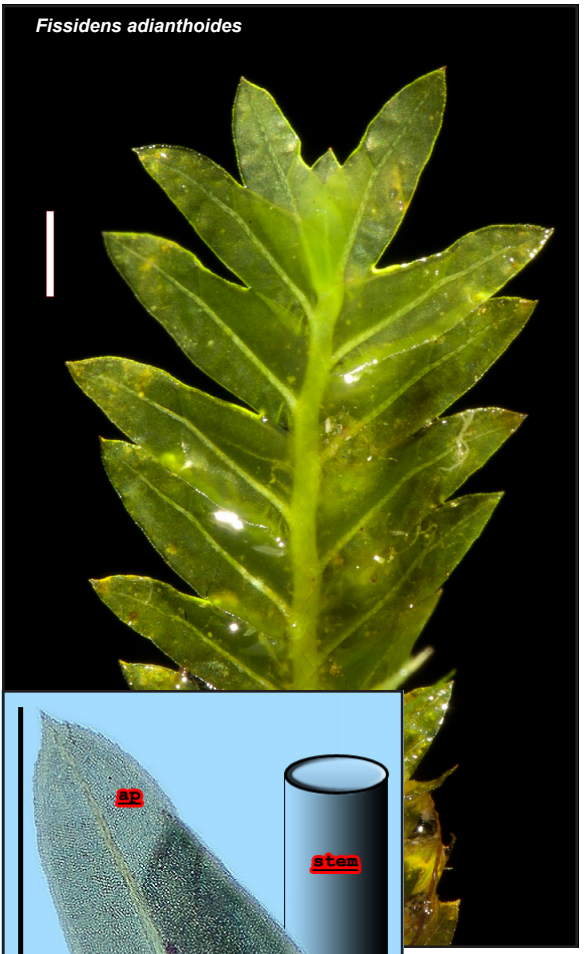


capitulum (branch cluster at tip of stem, before elongation of nodes; left top view, right side view)

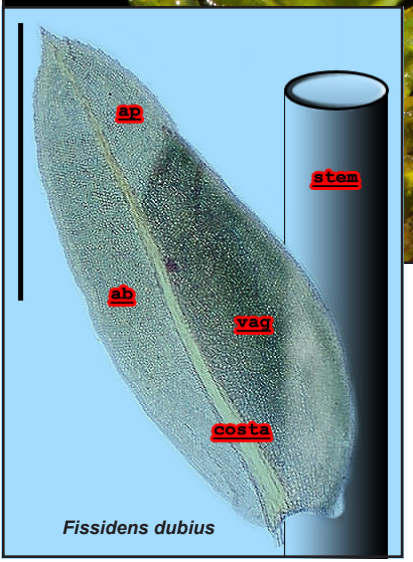


capitula of *Sphagnum fuscum* (small brown), *S. rubellum* (small red), *S. angustifolium* (larger yellow-brown), and *S. magellanicum* (large red) forming a dense carpet

4a. Leaves **distichously** inserted, of the ***Fissidens*** type (leaves alternate, in two opposite rows, giving the plants the aspect of small fern fronds, with an apical and abaxial lamina and two adaxial vaginant laminae, forming a boat-shaped structure inserted on the stem); in dark-green turfs in rich fens and along the edge of pools and creeks . . . . . *Fissidens adianthoides*

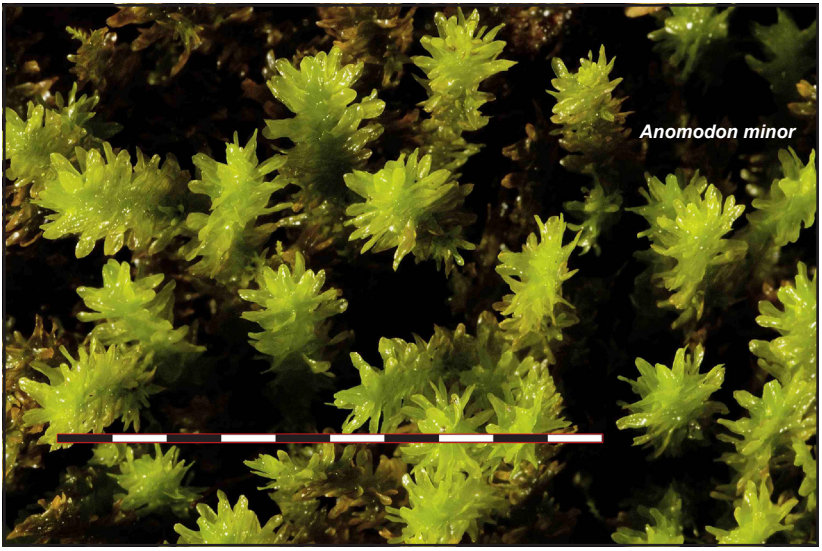


distichous (2-row insertion)

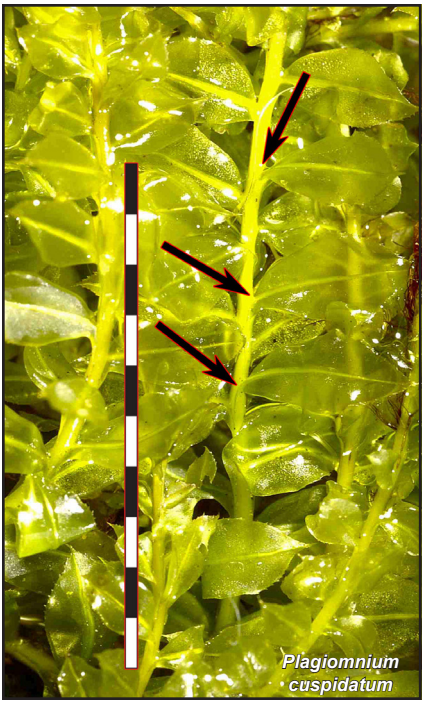


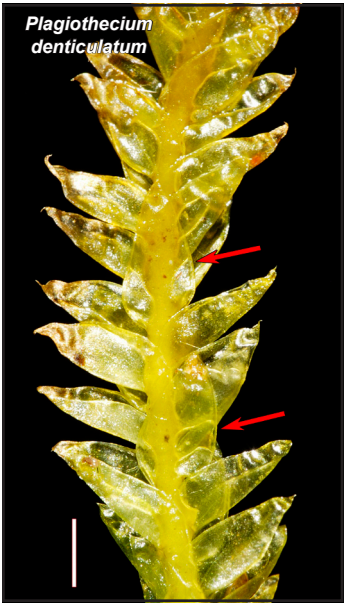
Fissidens **leaf, double vaginant laminae clasping around stem, apical lamina as an extension of one of the vaginant laminae between costa and stem, and abaxial lamina on opposite side of costa**

4b. Leaves spirally inserted along stems and branches (even when plants have a **complanate** (= flattened) aspect, the leaf insertions are still helically arranged around the stem) . . . . . 5.



complanate (flattened) aspect





complanate insertion: leaf insertions follow a helical trace (left, black arrows) but the leaf laminae are exposed in the same plane to the light (right, red arrows)

5a. Plants terrestrial, growing upright as a **cushion** or **turf** (see table below), stems without branches, or if branched, by stem-like **innovations** from below (but also check *Hedwigia ciliata*) . . . . . 6.

5b. Plants **dendroid** or growing as a **mat** or **weft** (see table below), frequently profusely branched with distinct 2nd order branches, theses either **irregularly, sub-pinnately**, or **pinnately** arranged, or if poorly branched, stems and branches growing closely along the substrate (also including aquatics) . . . . . Pleurocarps 8.

Growth-form table, specific only for the species further covered below

Cushion	Rounded domes, shoots clearly radiating from central point of origin (never aquatic)
	Small cushion: radiating shoots short, a few cm at most
	Large cushion: radiating shoots often one to several dm long
Turf	Parallel stems mostly growing vertically; branches, if present, are innovations, eventually becoming stems (never aquatic)
	Short turf: stems up to a few cm tall
	Tall turf: stems from several cm to up to several dm tall
Dendroid	Upright stems unbranched below, branches densely clustered above (never aquatic)
Mat	Many side branches of determinate growth on horizontal stems of indeterminate growth, usually firmly attached to substrate when terrestrial; but also includes aquatics* and fan-shaped clones
	Smooth mat: stems and branches growing appressed to the substrate, often attached to it by rhizoids
	Rough mat: main stems adhering to the substrate, but branches growing in oblique or vertical directions
Weft	Intertwining side branches on intertwining and straggling main stems, the entire clone very loosely attached to substrate (never aquatic)

* plants growing semi-terrestrially or aquatically have no obvious attachment to substrate, but still have evident branches in the older parts

right: small cushion
below: large cushion
(mark scales)

left: short turf
below: tall turf
right: a single gametophore pulled from a tall turf with two large innovations from previous years and one smaller, recent innovation at red arrow (mark scales)

dendroid

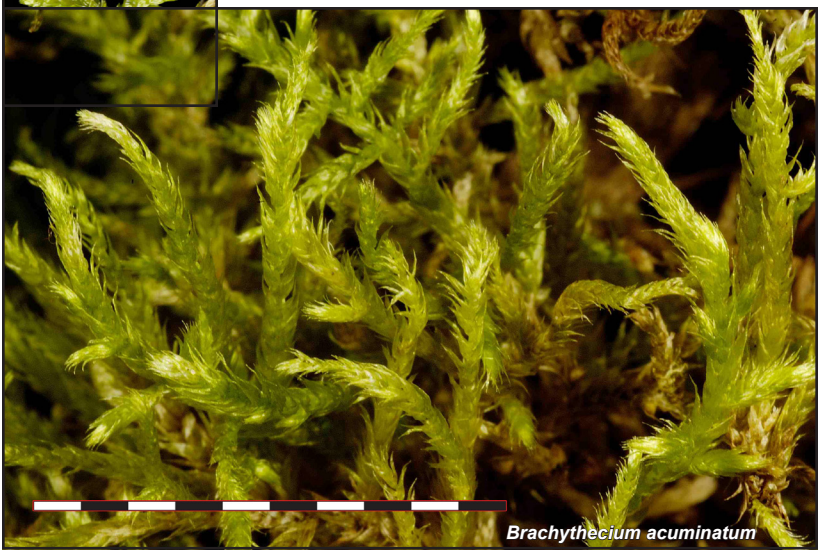
smooth mat

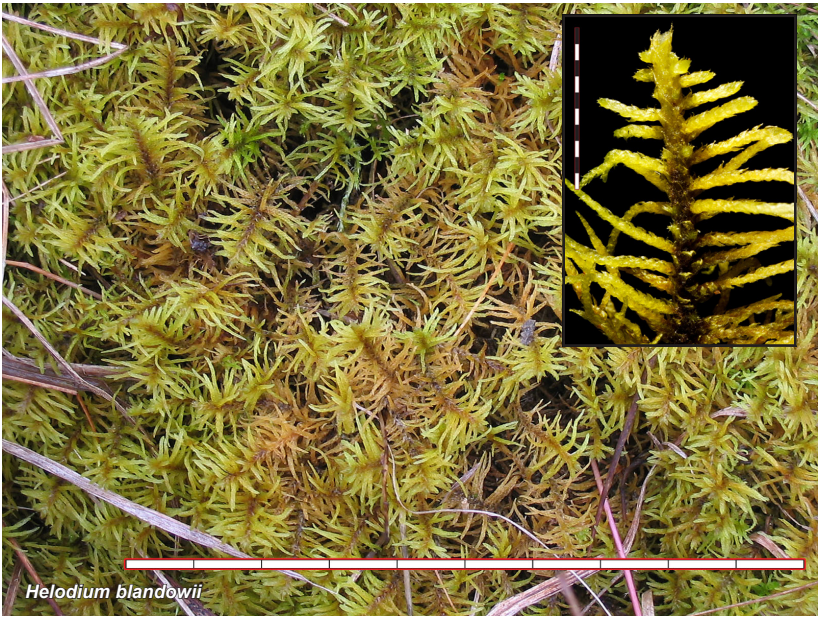
rough mat

weft

weft (inset: single stem)

irregular or sub-pinnate (inset) branching

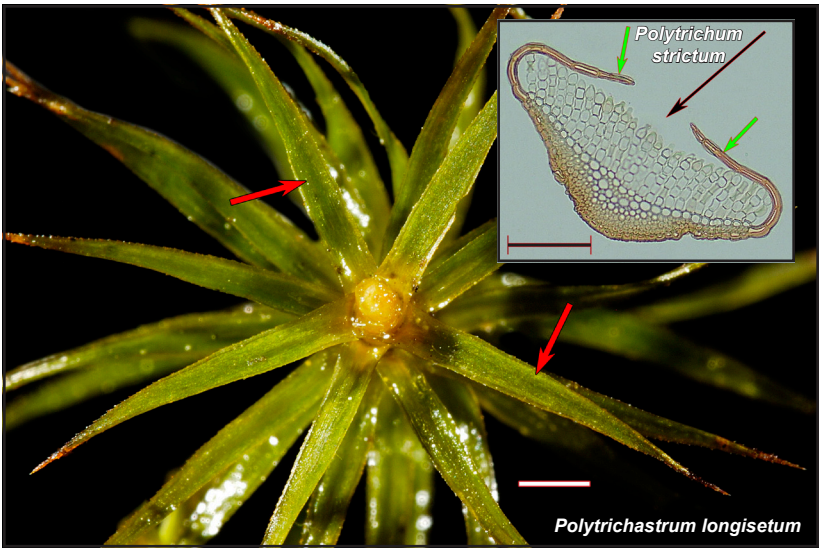




pinnate branching

6a. Leaves with few to many upright **adaxial lamellae** (low, upright cell plates implanted in longitudinal direction on a narrow or wide costa, visible as darker green lines from above, sometimes hidden below translucent **overfolding** leaf laminae) . . . . . POLYTRICHALES

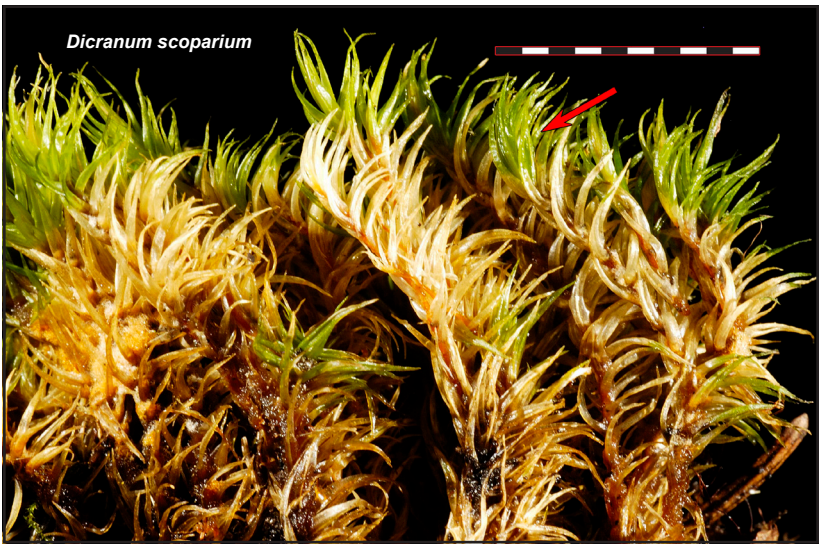
adaxial lamellae on narrow costa



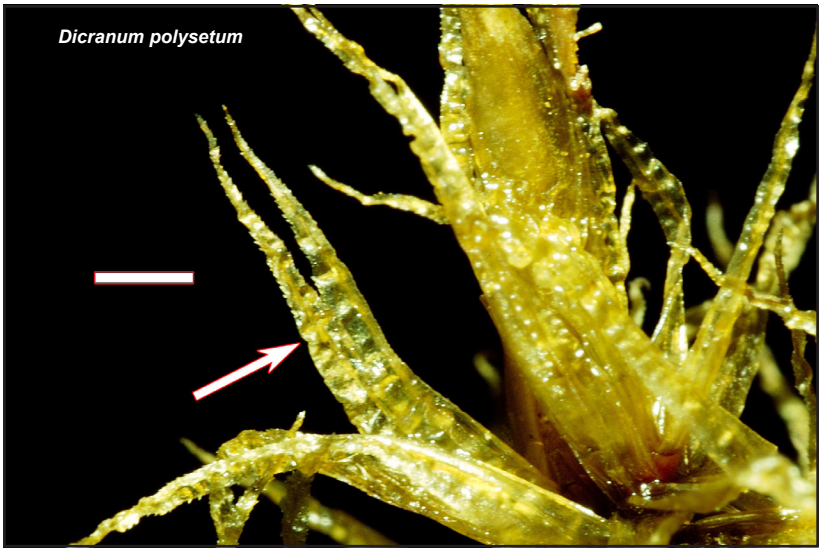
adaxial lamellae on wide costa, either exposed,
or as in inset (tr.s.), covered by the overfolded laminae, green arrows

6b. Costa without adaxial lamellae . . . . . Acrocarps 7.

7a. Most leaves **curved** to one side to strongly **falcate-secund** *when wet,* sometimes undulate . . . . . **DICRANUM**



curved/falcate-secund leaves (falcate = sickle shaped; secund = turned to one side)

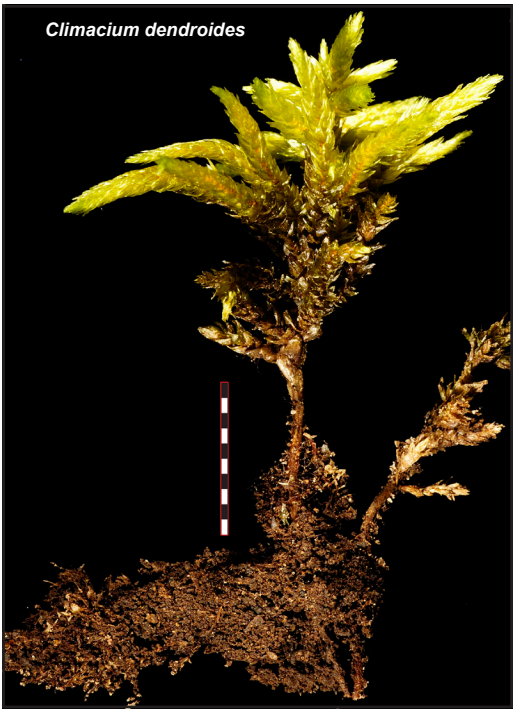


undulate leaves

7b. Most leaves straight or at the most somewhat wavy when wet, not distinctly undulate, but sometimes strongly **contorted** and **crisped** when dry . . . . . OTHER ACROCARPS

contorted/crisped leaves (dry)

8a. Plants distinctly **dendroid**; in forested swamps, most commonly in cedar swamps *Climacium dendroides*
8b. Plants not obvious dendroid, either growing as mats or wefts . . . . . 9.



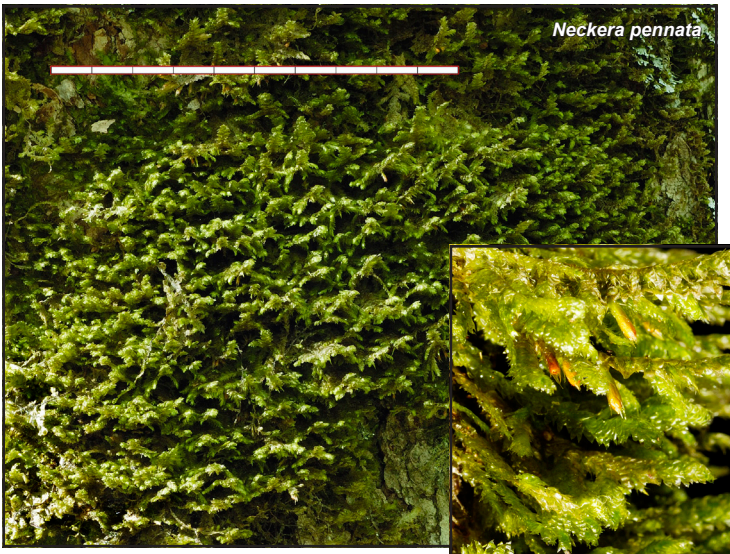
dendroid turf formed by mature plants (below), each (left, a less mature plant) rising from a underground rhizome, with an upright primary branch ("stem") and an apical crown of branches

9a. **Wefts**: plants in thick, loose carpets, very loosely attached to substrate and thus easy removed, growing on the drier parts of the forest floor in mesic mesohabitats and swamps (not aquatic) . . . . . **FEATHER MOSSES**

9b. **Mats,** terrestrial or **epiphytic**, including **pendent fans on tree trunks**: plants not as easily removed from their substrate; or aquatics and **semi-aquatic mats** in open wetlands and in pools of swamps . . . . . Other Pleurocarps 10.

weft: intertwining and straggling shoots, stem and branches ascending and arching, loosely attached

epiphytic mat: main stems parallel with substrate, firmly attached

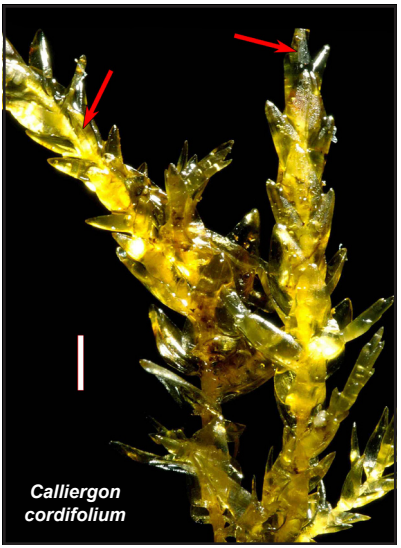


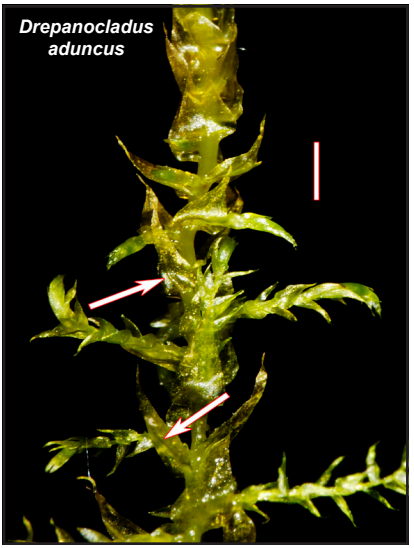
pendent fan: branches curving away from vertical substrate

semi-aquatic mat: obviously branched plants, partly emergent

Main Key

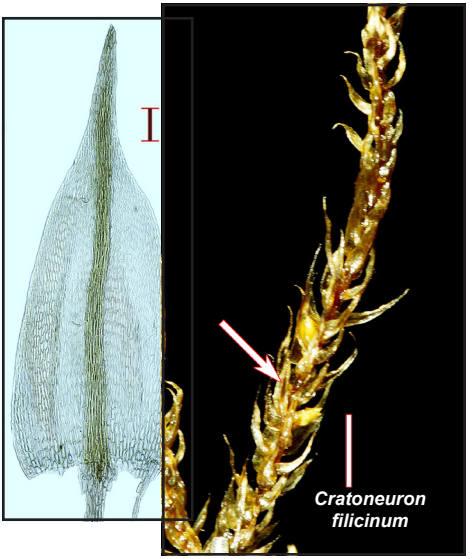
The next dichotomy is hard to use in the field with only a handlens as tool, except with a 20 x: try to strip a wet stem of most leaves and hold it up against the sky as background lighting. Using transmitted light, it should be possible to see if there is a single, thickened central vein in at least one of the remaining leaves — then the moss is costate. This costa doesn't always extends all the way to the tip of the leaf but might stop halfway or 3/4 up. Some ecostate leaves (leaves without costae) might actually have a short double costa, which starts immediately at the insertion of the leaf as two different, but short prongs, rarely reaching half-way up the leaf (see next page).



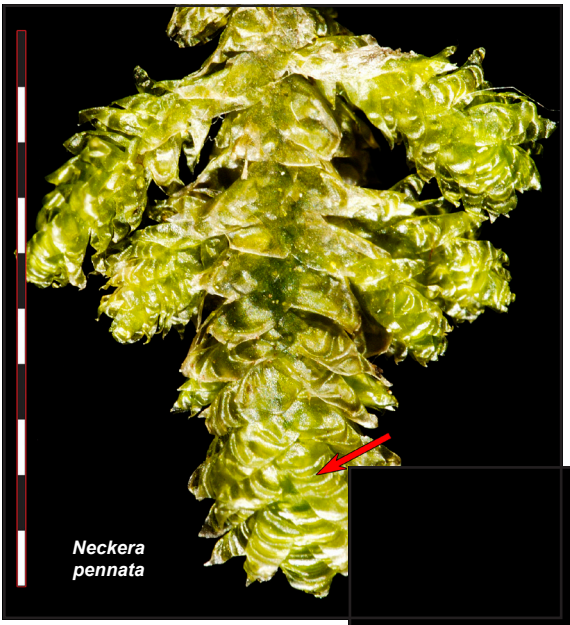


poorly visible costate leaves, costae either thin or not reaching apex

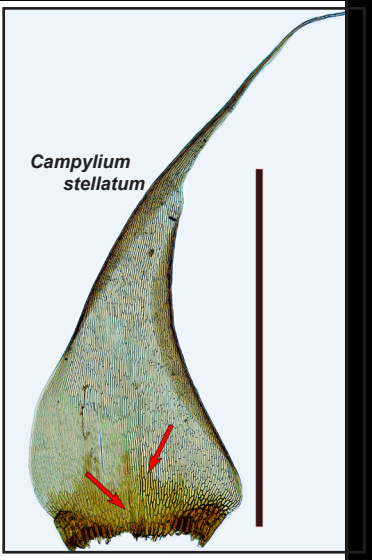
easily visible costate leaves, stout, colored, and reaching apex or even excurrent



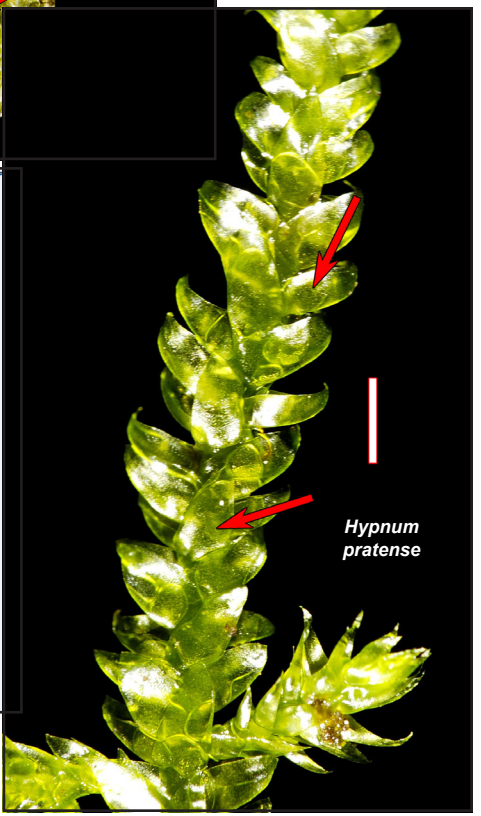
10a. Leaves **costate** . . . . . Costate Pleurocarps 11.
10b. Leaves **ecostate** (without a costa or with a short double costa, hardly visible with a handlens) . . . . . Ecostate Pleurocarps 12.



ecostate leaves (don't confuse leaf margins from underlying leaves for costae)

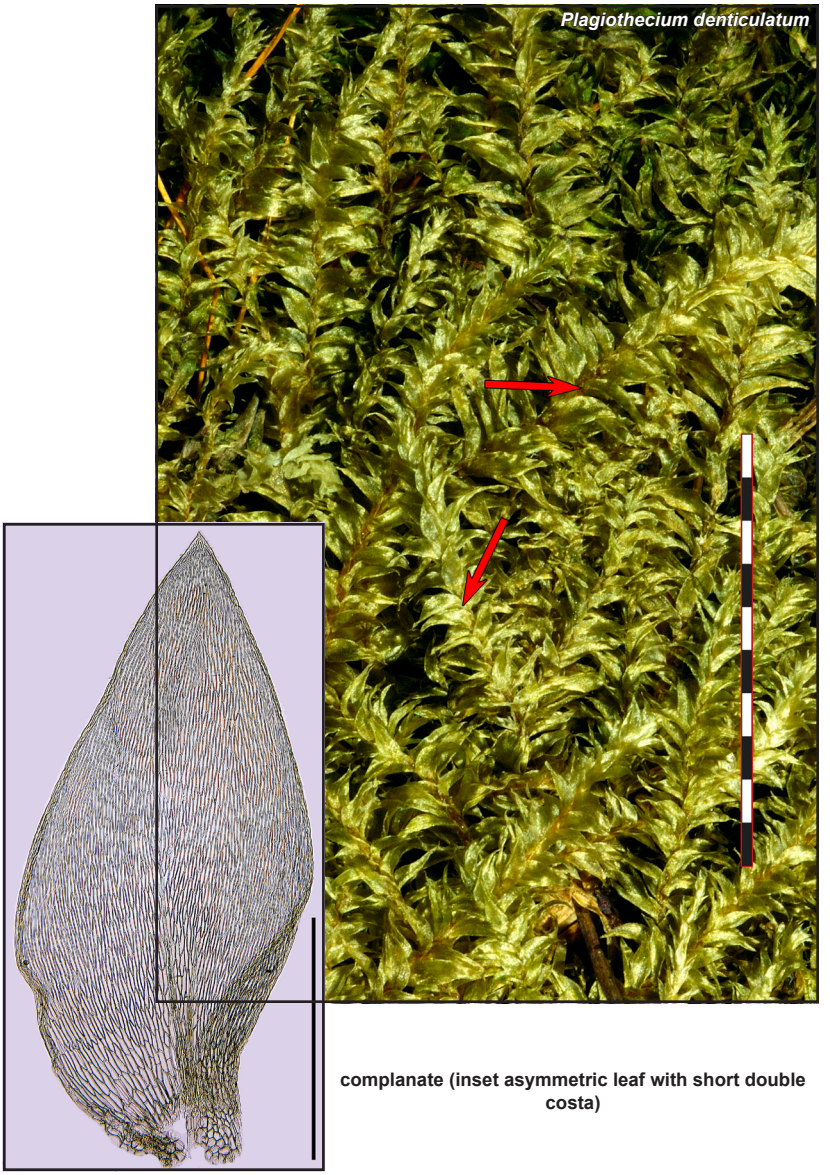


a very short double costa, unlikely to be seen even with a 20x handlens



11a. Wetland plants (always growing close or at the surface water table in mires and swamps) . . . . . COSTATE WETLAND PLEUROCARPS

11b. Upland plants (sometimes found in swamps and on floodplains, but then as epiphytes or on logs, not at the water table or submerged) . . . . . COSTATE UPLAND PLEUROCARPS



complanate (inset asymmetric leaf with short double costa)

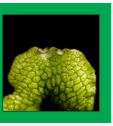
12a. Translucent and extremely **complanate** (flattened) plants; leaves distinctly asymmetric ovate-lanceolate . . . . . *Plagiothecium denticulatum*

12b. Matte or glossy plants with branches with rounded or a less complanate aspect; leaves mostly symmetric . . . . . 13.

13a. Plants growing on peat in swamps and rich fens . . . . . **ECOSTATE PLEUROCARPS ON PEAT**

13b. Plants growing as epiphytes on bark of living trees in forested mires or in swamps, or on bark, rotten wood, and rocks in forested upland mesohabitats (also check out *Hedwigia ciliata* in 'Other Acrocarps', which grows on rocks and boulders, is ecostate, and has a somewhat mat-like habit; however, it is still considered an acrocarp) . . . **ECOSTATE PLEUROCARPS ON BARK, WOOD, OR ROCK**

NOTES:



Illustrated Key to Thalloid Liverworts

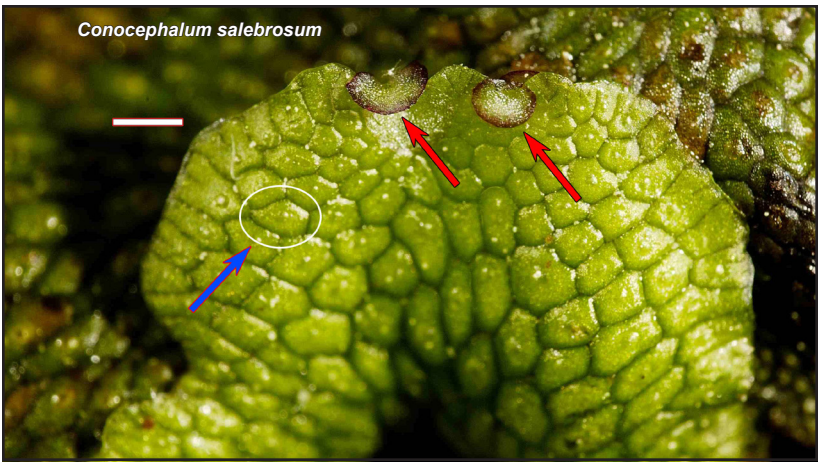
1a. Thallus **thick and often > 1 cm wide**, surface **opaque**, **ventral** and dorsal side looking distinctly **different**, on ventral side with **scales** sprouting a dense mat of **rhizoids** . . . . . 2.
1b. Thallus more **translucent** and **narrower**, ventral and dorsal side much less strongly differentiated, rhizoids rare or absent (specimens with abundant rhizoids belong to species not covered in this guide). 3.

large, thick, and opaque thalli (left) versus narrower, thinner, and translucent thalli (right)

ventral surface distinct from dorsal (see next page), with scales (red arrows) and rhizoid bundles (white arrows)

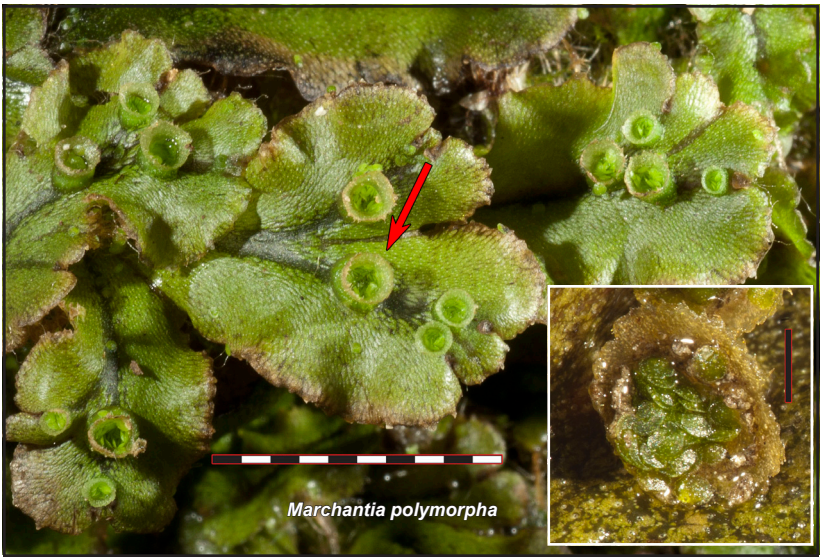
2a. Dorsal side of thallus patterned with **large** hexagonal areas (**areolae**) **CLEARLY visible** to the naked eye; plant, when crushed, with a distinct aromatic smell like citrus; thallus without gemmae cups; in wet forests, swamps, and on moist cliffs . . . . . *Conocephalum salebrosum*

areolae clearly visible with naked eye

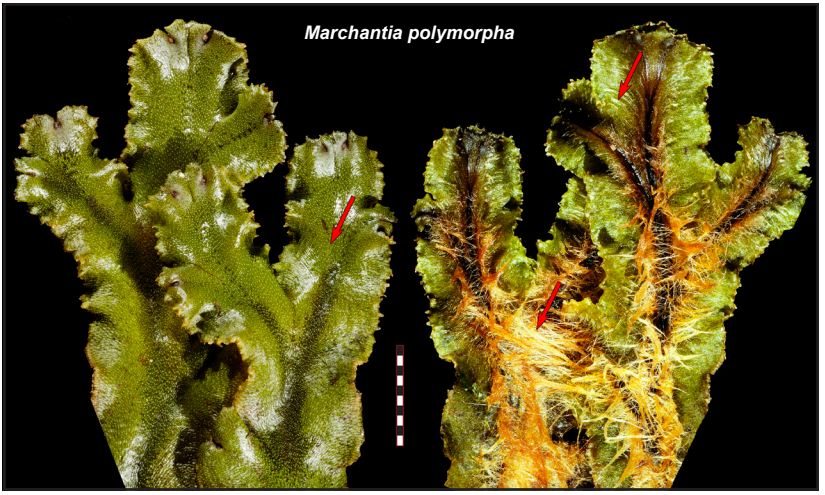


areola large, one outlined (blue arrow), with central pore; upturned scales protecting apical meristem (red arrows)

2b. Dorsal side of thallus with **areolae barely** visible, only obvious with a handlens; plants not aromatic; dorsal thallus surface often with **gemmae cups**; in similar habitats as *Conocephalum*, but also in disturbed ones such as on recently burned forest floor . . . . . *Marchantia polymorpha*



areolae barely visible with naked eye, but note gemmae cups



areolae small, with central pores (white dots); ventral side with scales and rhizoids

3a. Thallus > 3 mm wide, at the most 1 cm, smooth, fleshy and greasy looking when wet, filmy when dry, **irregularly branched**; in calcareous and rich fens and on beaches . . . . . *Aneura pinguis*

irregular branching

3b. Thallus < 1 mm wide, **regularly dichotomously branched,** sometimes forming rosettes, the more common **aquatic modification** forming tangled mats; floating in pools and lakes, sometimes stranded and thallus then shorter and wider . . . . . *Riccia fluitans*
(*R. rhenana* is a slightly larger and diploid form of *Riccia fluitans* and might also occur frequently)

regularly dichotomous branching

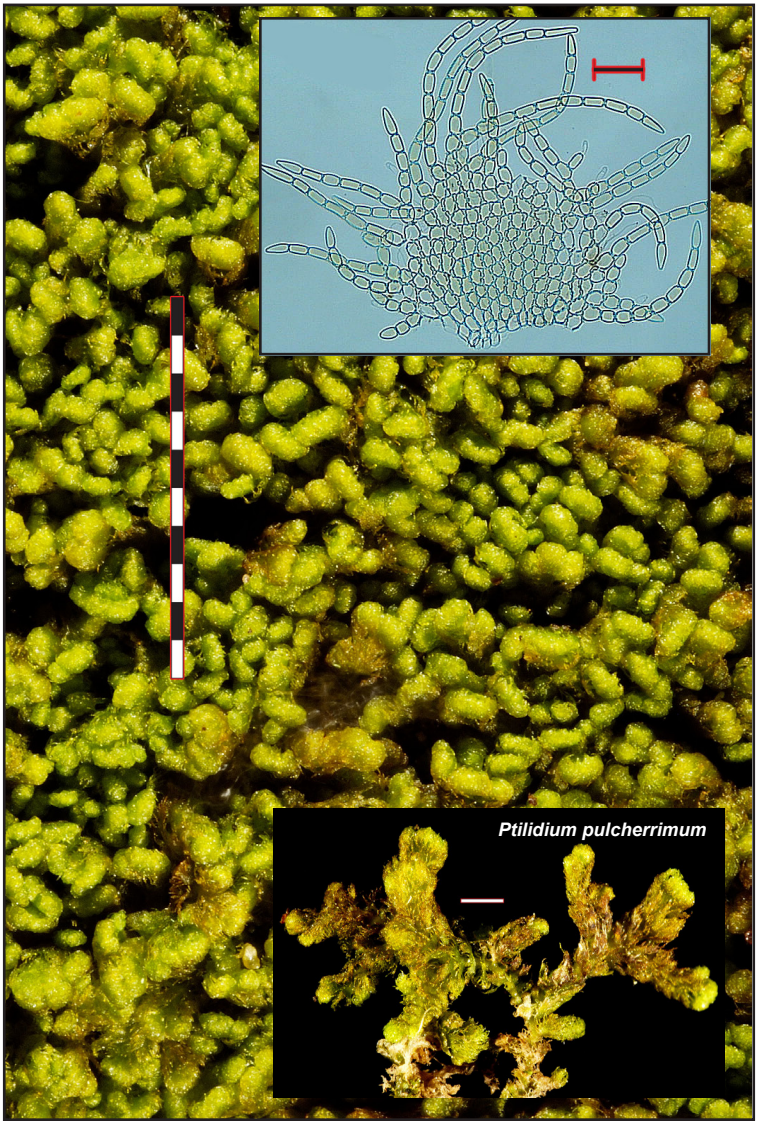
semi-terrestrial modification of *R. fluitans* above, aquatic form of the somewhat larger *R. rhenana* to the right

NOTES:

Illustrated Key to Leafy Liverworts

The leafy liverworts are a numerous and complex group; proper identification is usually only possible by studying small microscopic structures. Most species have many look-alikes, but the ones listed here are all very common.

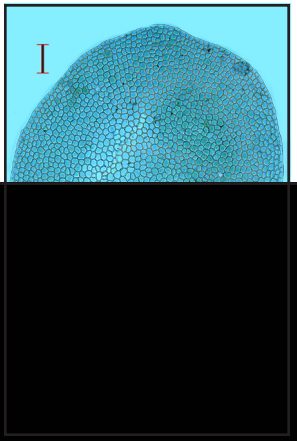
1a. Leaves with marginal **cilia**, giving the plants a fuzzy look under the handlens plants in tightly adhering mats on the lower bark of conifers, also frequently on dead wood . . . . . *Ptilidium pulcherrimum*



leaves with marginal cilia, giving fuzzy look to plants

1b. Leaves without cilia . . . . . 2.

2a. Leaves unlobed and **simple**, but margins often **reflexed** and appearing folded (very obvious when dry), with serrated margins in well-developed plants; often in cedar swamps forming substantial flat patches in drier microhabitats or along the edges of pools. . . . . *Plagiochila asplenioides*

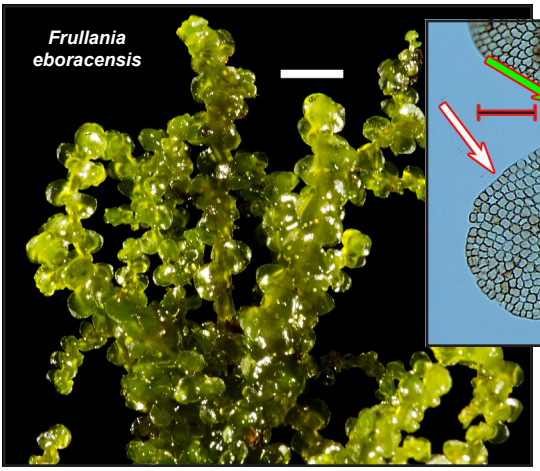


simple leaf (but margins reflexed; inset a flattened and non-serrated leaf)

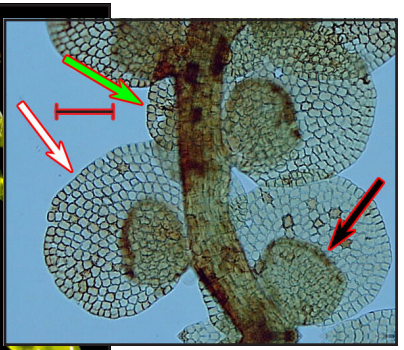
2b. Leaves with a more complex leaf shape (with large teeth, or retuse, lobed, or complicate-bilobed, see descriptions below) . . . . . 3.

3a. Leaves **complicate-bilobed**: with large dorsal lobe and a smaller ventral lobe hidden underneath which is transformed into a small water sac or **lobule**; on bark of both hardwood and cedar trees . . . . . *Frullania eboracensis*

complicate-bilobed leaves, aspect



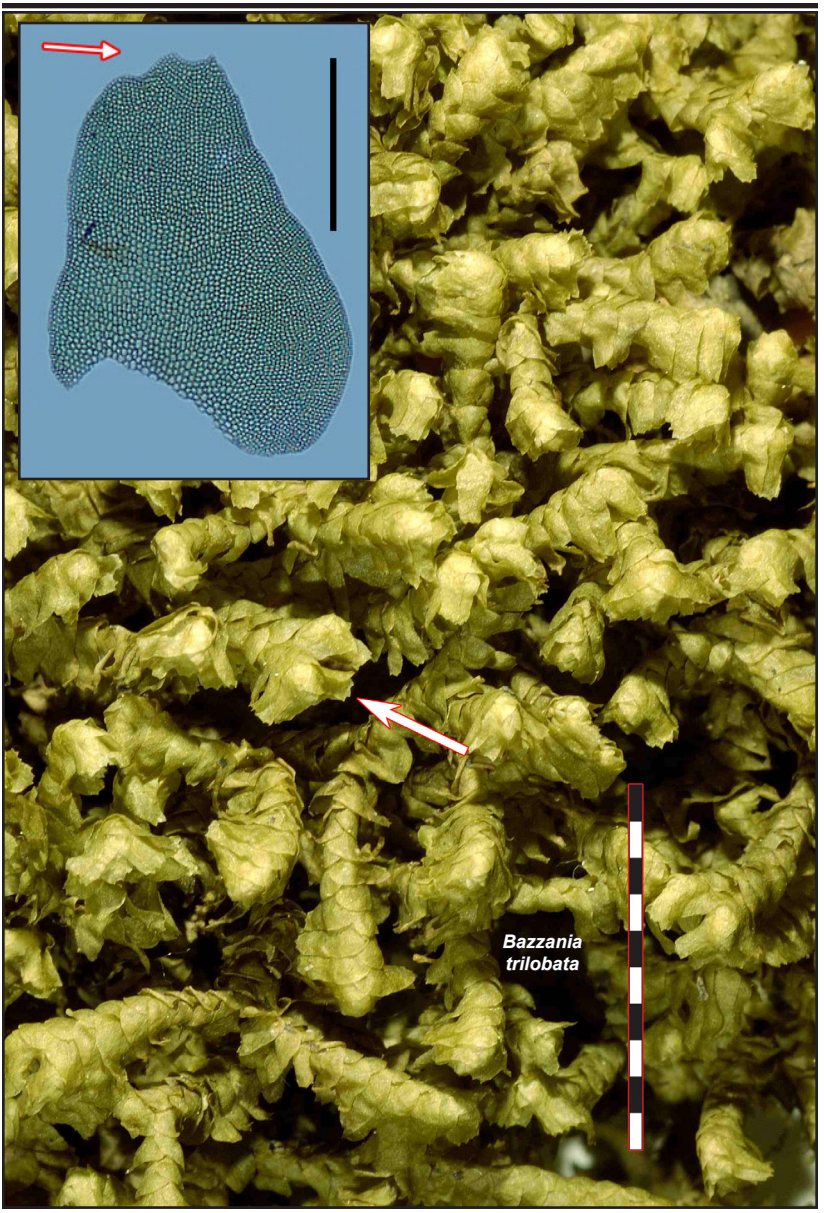
complicate-bilobed leaves, branches



dorsal lobe (white arrow), ventral lobe = lobule (black arrow), and underleaf (green arrow)

3b. Leaves not complicate-bilobed . . . . . 4.

4a. Leaves with three, bluntly acute, **apical teeth**, but basically unlobed; plants with obvious stolons (narrow, thread-like branches with minute leaves) growing downward; in drier transitional forests often forming hemi-spherical small hummocks on the forest floor . . . . . *Bazzania trilobata*



apical teeth

4b. Leaves **bilobed** and/or **retuse** (obscurely lobed or merely notched); plants without obvious stolons (species with leaves with more than 2 lobes are not covered in this field guide and need microscopic examination for proper identification) . . . . . 5.

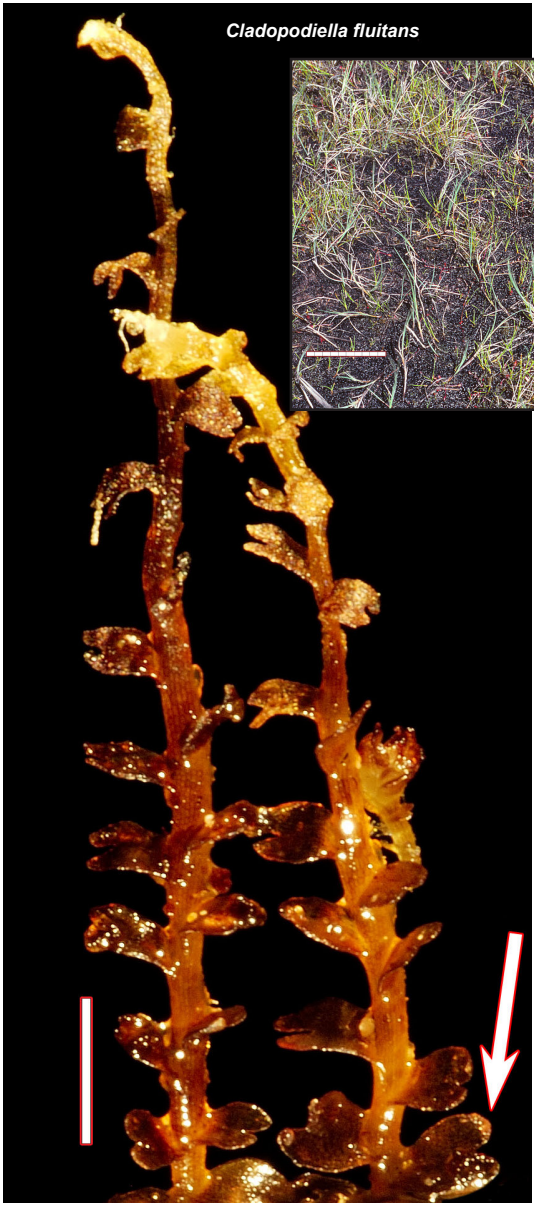
5a. **Bilobed** leaves, sharp-tipped on the younger branches, and with two rounded lobes or merely **retuse** leaves on the more mature branches; leaf insertion highly **oblique**, nearly parallel with the branch; on dead wood in shaded and humid microhabitats . . . . . *Lophocolea heterophylla*
(Other look-alike, entirely bilobed or entirely retuse species occur, but this one is the most common and the only one with sharply-tipped, round-lobed, and retuse leaves on branches of the same patch; others need careful observation of gametangial or microscopic structures for proper identification)

younger branches with sharply-pointed leaves and mature ones with more retuse leaf apices, leaf insertion highly oblique

5b. All leaves similar, distinctly **bilobed** with **rounded tips**; leaf insertion nearly **transverse**; forming smooth, often blackish, mats on mud bottoms in bogs and poor fens or scattered among Sphagnum plants . . . . . *Cladopodiella fluitans*

Cladopodiella fluitans

field aspect



bilobed leaves with rounded tips, leaf insertion transverse

Illustrated Key to *Sphagnum*

Note: *Sphagnum* identification relies mainly on technical characters, best studied with stereo- and compound microscope. However, of the 25-30 species occurring in Minnesota, half might be identified with more or less reliability in the field. These species are presented in the key below. Those species names printed in blue font have very similar look-alikes (but with much rarer occurrence), and need to be confirmed when critical identification is necessary. Study only medium-sized branches and their leaves near the center of the capitulum.

1a. Branch leaves with **cucullate** (hood-shaped) apex, not pointed, apex rough at the back (abaxial side) . . 2.
1b. Branch leaves **pointed** (sometimes truncate and inrolled, appearing rounded), apex smooth at back . . . 4.

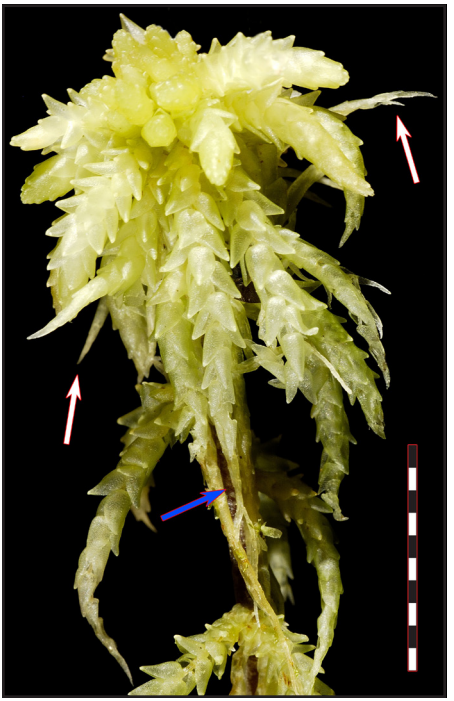
cucullate branch-leaf apices (inset: sketch of branch leaf)

pointed branch-leaf apices (inset: sketch of branch leaf)

2a. Commonly with **red pigment**, if not visible in the branch leaves, **at least in the translucent stem**; forming low hummocks in bogs and poor fens, as well as in forested and open habitats. . . . . *S. magellanicum*
2b. Without red pigment, green, yellow-green, or light to dark brown . . . . . 3.

red pigment throughout (above, larger plants), but if green stem cortex still flecked with red (right, arrow)

3a. Very **light-green** to yellowish-brown, loose plants, often with **long narrowly-pointed pendent branches**; in shaded alkaline habitats such as tamarack, alder, and cedar swamps, usually forming small hummocks . . . . . *S. centrale*



light-green loose plants with long narrowly-pointed pendent branches (arrows)

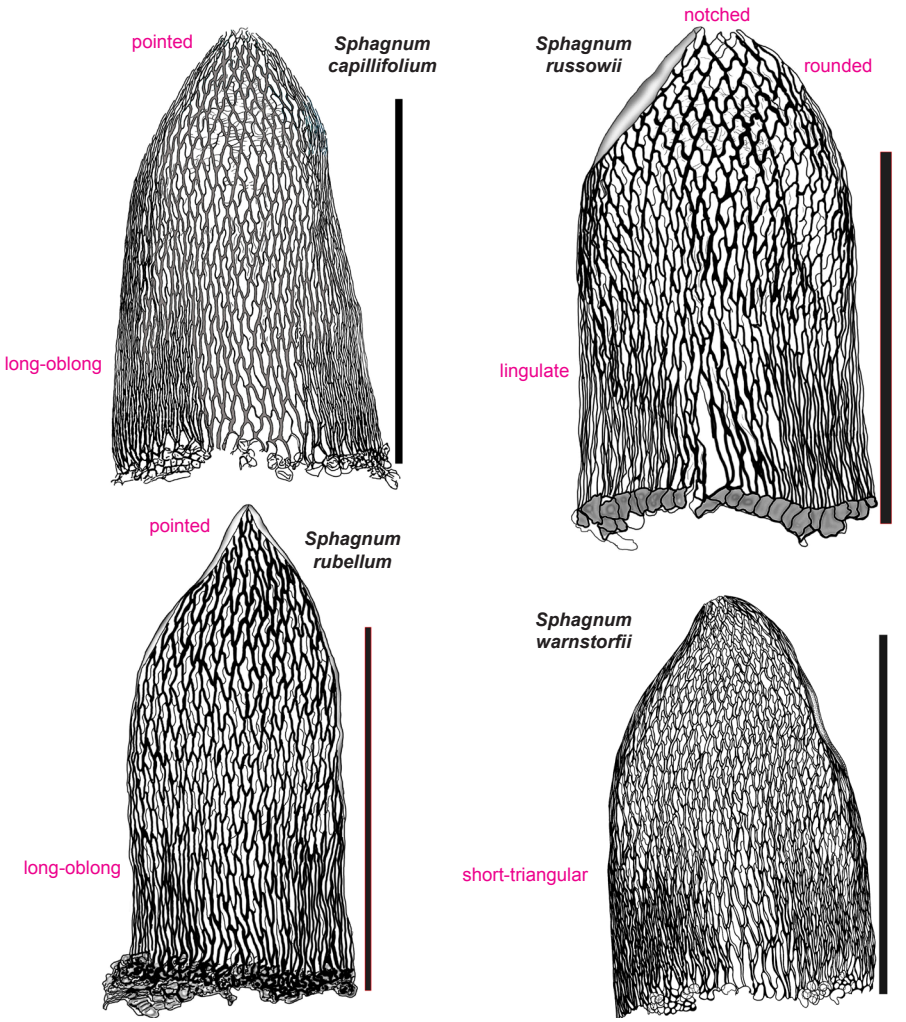
3b. **Brown compact carpets**, plants usually with short, **stubby branches**; often in exposed habitats, forming extensive wet lawns in poor fens . . . . . *S. papillosum*

brown compact carpet and stubby branches (arrow)

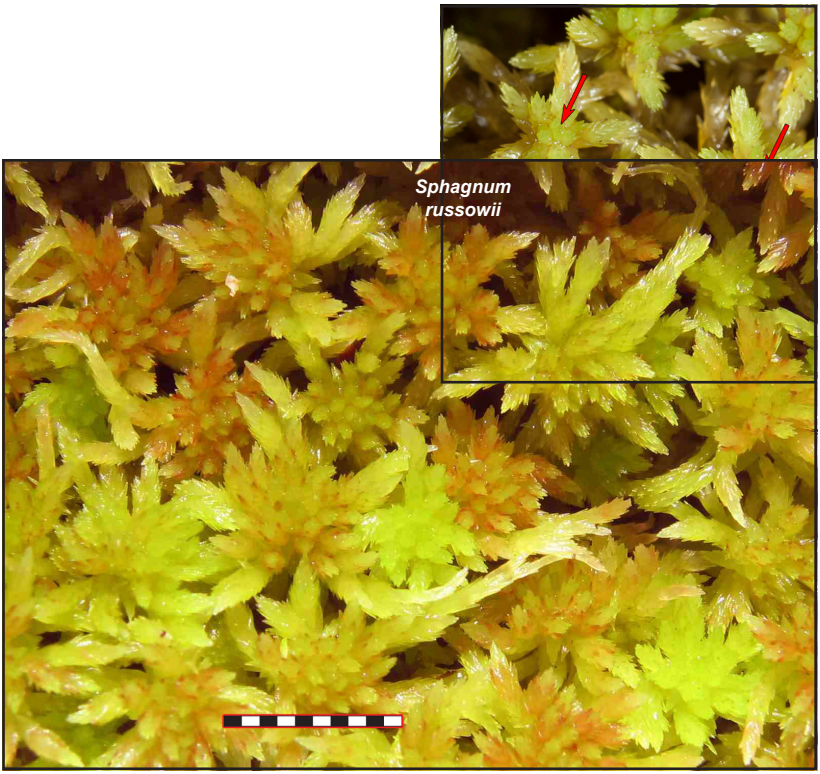
4a. Plants red or splotched red-green (deep-shade specimens might be evenly green, and will need to be identified using structural characters, mainly stem-leaf attributes, see figures below) . . . . . 5.
4b. Plants without significant red pigment . . . . . 8.

The following four species are quite difficult to differentiate in the field. The only reliable characters are either microscopic, or the stem-leaf shape (see figures on this page, from 'Janssens, J.A. 2013. Illustrated Bryophyte Flora of Minnesota — Sphagnaceae: modified from the keys published in Flora of North America, Volume 27, limited to the species occurring in Minnesota, and illustrated by Joannes A. Janssens': there are also a number of much more rare, very similar look-alikes occurring in Minnesota.) Stem leaves are not easily to study in the field, but with a bit of practice and a 20x handlens it might be possible to differentiate the four very common species. They can conveniently be grouped as 'small red section Acutifolia species'. These species are, however, distinctly different in their preferred habitat.

5a. Stem leaves **lingulate** with **rounded and notched** apex, or **short-triangular**. . . . . 6.
5b. Stem leaves **long-oblong** with **enrolled** or **pointed** apex . . . . . 7.



6a. **Terminal bud somewhat obvious**; stem leaf **lingulate** with **rounded** and often **notched** apex; branch leaves usually not obviously five-ranked; carpets usually **mottled green-red**; in poor to intermediate open or forested fens, growing in lawns or forming low hummocks . . . . . *S. russowii*

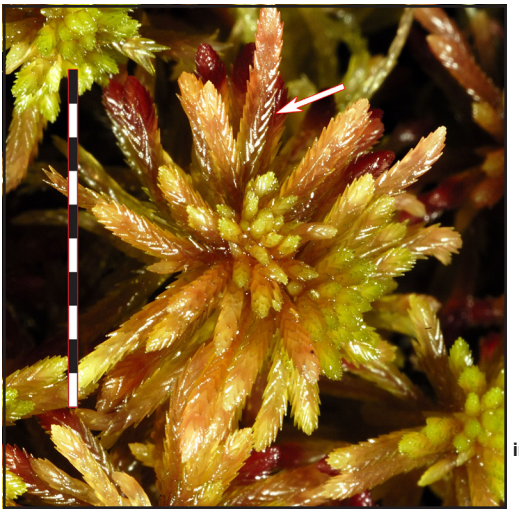


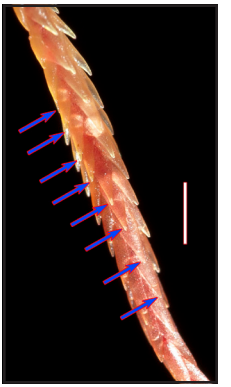
mottled green-red carpet with flat capitulum, terminal bud somewhat obvious (inset, within ellipse at arrows)

lingulate stem leaf (notched at rounded apex) (as seen with the compound microscope on right)

6b. **Terminal bud not differentiated**; stem leaf usually **short-triangular**; branch leaves usually strongly **five-ranked**; plants brownish green to red, and then **often with a bluish tint**; in highly minerotrophic forested peatlands . . . . . *S. warnstorfii*

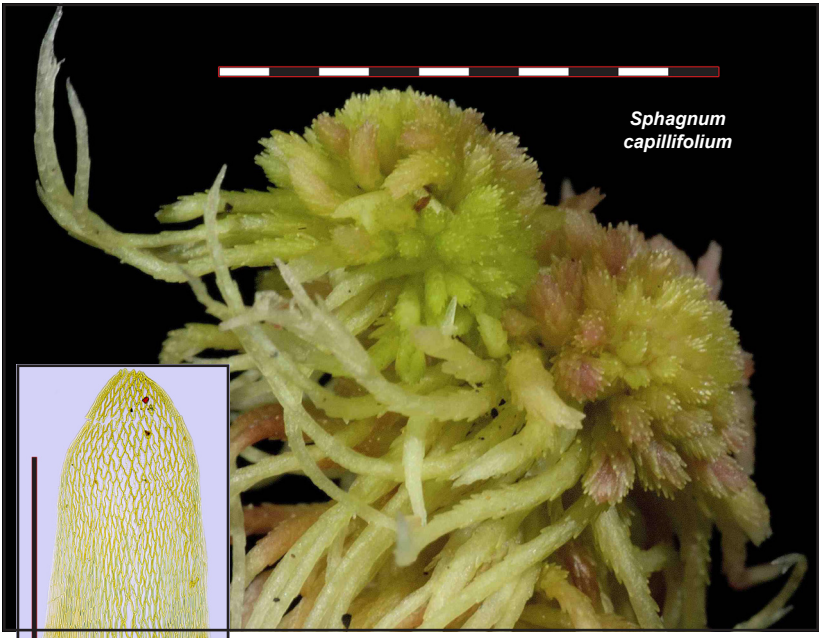
plants often with bluish tint

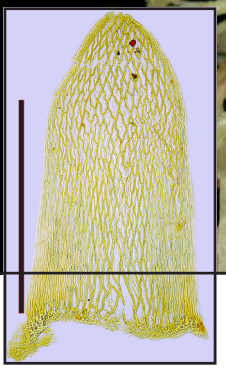




terminal bud not obvious; 5-ranked branch leaves (arrows: individual branch with median leaf axes lining up in 5 longitudinal rows)

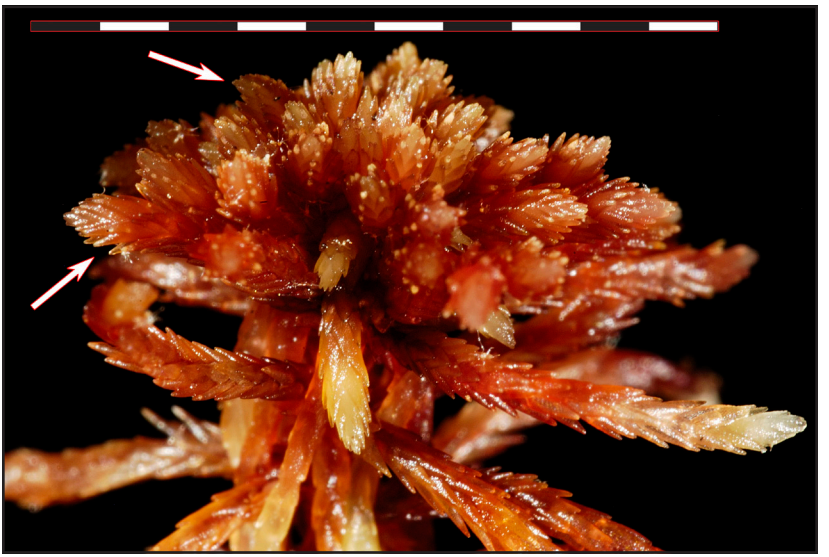
7a. **Rounded capitulum**; branch leaves straight, not five-ranked; plants rarely solid red; usually in open or forested bogs and poor fens, forming low to high hummocks . . . . . *S. capillifolium*





rounded capitulum, terminal bud not visible, long oblong stem leaf with pointed apex, plants green with red antheridial branches

7b. **Flat capitulum**; many branch leaves **slightly secund**, **somewhat five-ranked**; plants usually **solid red**; in open bogs and poor fens, forming extensive lawns and low hummocks. . . . . *S. rubellum*



usually solid-red small plants (above, the smaller plants among the larger *S. magellanicum* plants, also red), with flat capitulum (below); branch leaves in capitulum somewhat five-ranked and slightly secund (arrows)

8a. Plants **dull brown** to olive-green**, usually forming high hummocks**; if green, **stem still distinctly darkened**; **capitula** small, **densely packed**; in bogs and poor fens, usually in open areas . . . . . *S. fuscum*

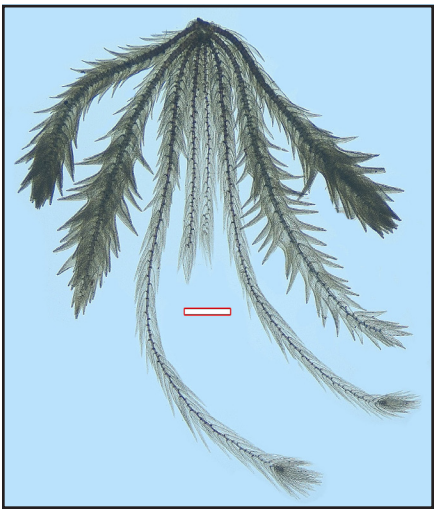
dull brown plants forming high hummocks, capitula densely packed

plants strongly interlocked with long mature branches below a relatively small and tight capitulum; stem still brown even in green form

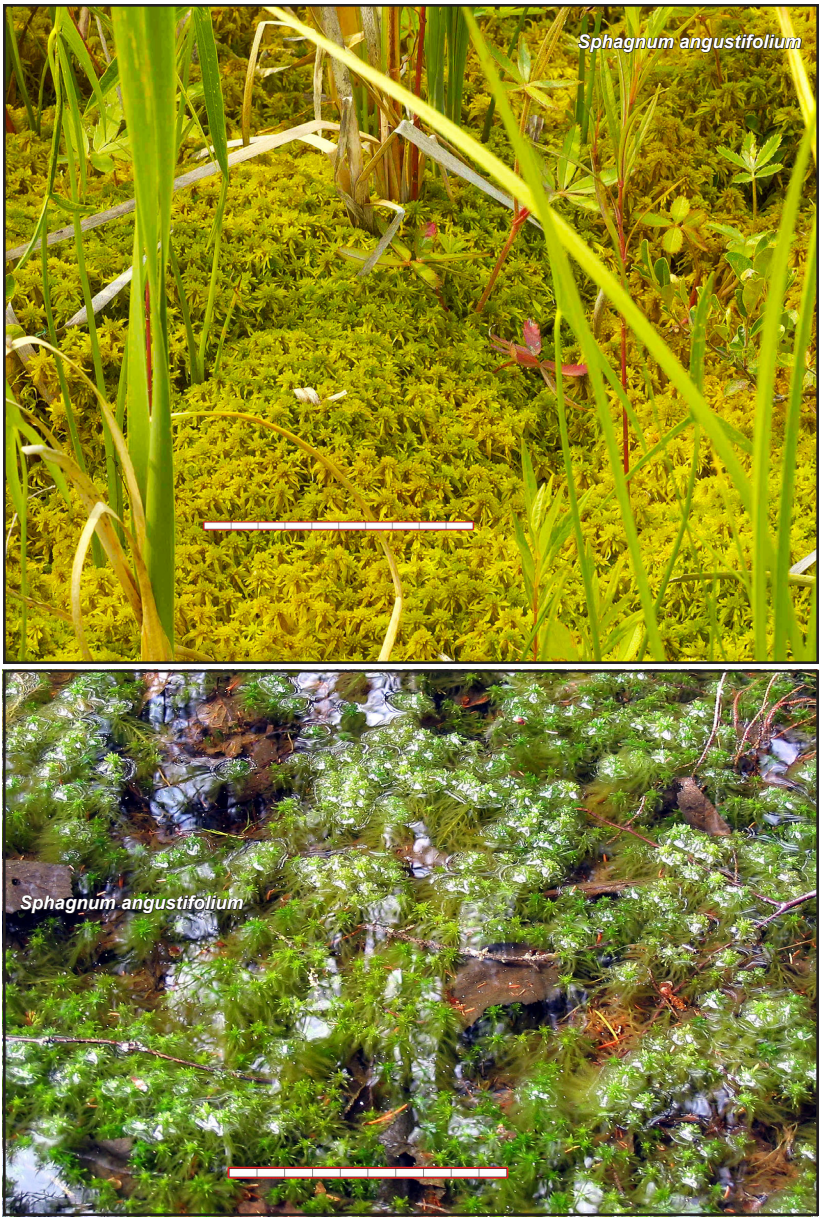
8b. Plants not brown, or if brown, not forming high, densely compacted or tall hummocks . . . . . 9.

9a. Capitula **spherical**, plants individually elevated at different heights, forming a rough carpet that is obvious from a good distance, on fairly dry organic substrate; plants with strong, woody stem (breaks with an audible snap); most **fascicles with numerous (> five) branches**; most commonly in cedar swamps . . . . . .*S. wulfianum*

rough carpet, sturdy plants standing individually (above); with large spherical capitulum on top of a strong, woody stem (left); fascicle with numerous (> five) branches (below, four pendent in center and four spreading branches)



9b. Capitula hemi-spherical or flat; plants forming a more uniform, **smooth carpet** or **straggling plants in wetter microhabitats**; plants with weaker stems, supporting each other or straggling; fascicles with fewer than six branches . . . . . 10.

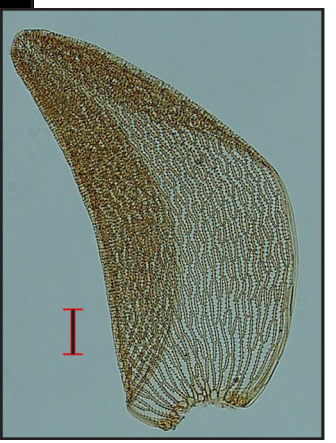


plants forming a smooth carpet (above) or straggling in wetter microhabitats (below)

10a. Branches in capitulum **twisted and curved**, branch leaves often **curved-secund**; plants in intermediate fens, in nearly aquatic habitats (floating mats, small clones just emergent) . . . . . *S. subsecundum*

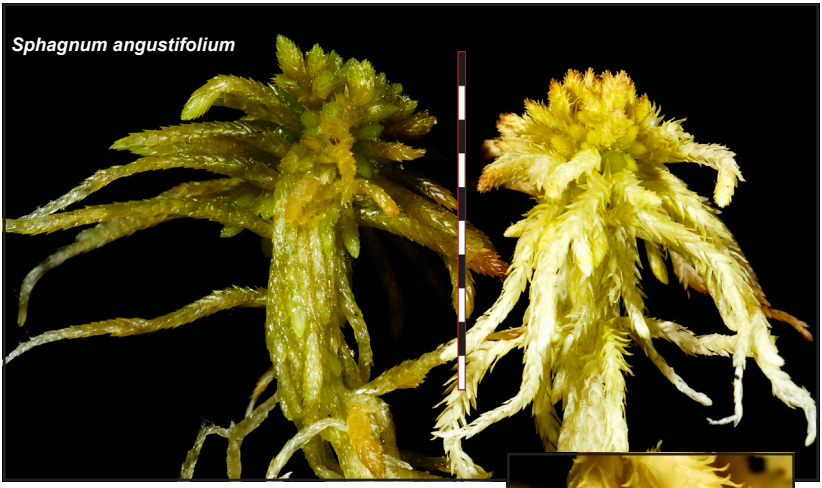
Sphagnum subsecundum

twisted and curved branches in capitulum (above and left); curved-secund branch leaf (below)



10b. Branches not twisted, branch leaves straight (wet or dry), **squarrose-recurved** (wet or dry), or **wavy-recurved** (only when dry) . . . . . .11.

squarrose-recurved branch leaves



straight (left, when wet), wavy-recurved branch leaves (right and inset, when dry)

11a. Branch leaves with upper part **squarrose-recurved** but with the base clasping; plants large, **pale- or yellow-green**; commonly found in minerotrophic alder swamps, shrubby lagg areas, and wet meadows . . . . . *S. squarrosum*

squarrose-recurved branch leaves; plants in pale- or yellow-green carpets (below)

11b. Branch leaves straight (wet or dry), or wavy-recurved, but only when dry (squeeze water out of some branches between thumb and forefinger); plants smaller, pale-green to yellow-brown, sometimes with a very slight tinge of red at the base of the branches; often growing in more oligotrophic or open peatland areas, but not exclusively . . . . . 12.

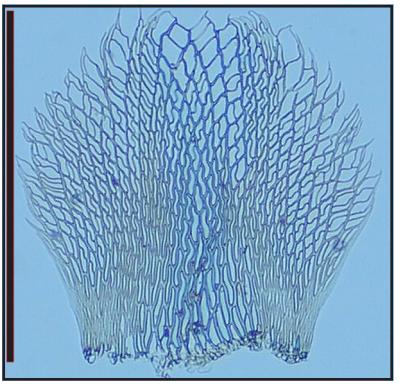
12a. Capitulum with **visible terminal bud** formed by enrolled stem leaves; branch-leaf margins straight when dry . . . . . 13.

visible terminal buds

12b. Terminal bud not easily discernible among the other branches in the capitulum; branch-leaf margins wavy-recurved when dry (use 20x handlens) . . . . . 15.

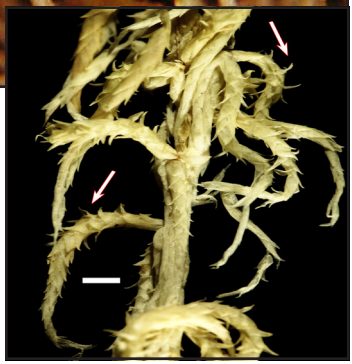
13a. Stem leaf **spatulate**, margin and apex fibrillose; in forested and alder swamps and in ecotones, forming **smaller hummocks** . . . . . *S. fimbriatum*

small hummock (above) spatulate and fibrillose stem-leaves (a crown of stem leaves at the tip of the stem as seen with the handlens on left, a single leaf under the compound microscope on right)



13b. Stem leaf lingulate-oblong, only apex fibrillose . . . . . 14.

14a. Plants usually **brown**, stem dark; **some branch leaves on lower fascicles squarrose-recurved** (most obvious when dry); in forested swamps or along lake edges, forming large carpets . . . . . *S. teres*



plants frequently brown in open microhabitat (above); lower branch leaves often squarrose-recurved when dry (right, dry)

14b. Plants always **green**, stem green; all branch leaves **straight**, even on older portions of plant; most often on paludifying forest floor . . . . . *S. girgensohnii*

green plants (above)

branches with straight leaves (white arrow), single pendent branches (blue arrows), and obvious terminal bud (red arrow)

15a. Young **pendent branches in pairs** among arms of capitulum; plants in shaded habitats green or **yellow-green**; in more exposed situations yellow; growing in hollows in bogs and poor fens, forested or open, but usually not submerged (most common *Sphagnum* species in Minnesota) . . . . . *S. angustifolium*

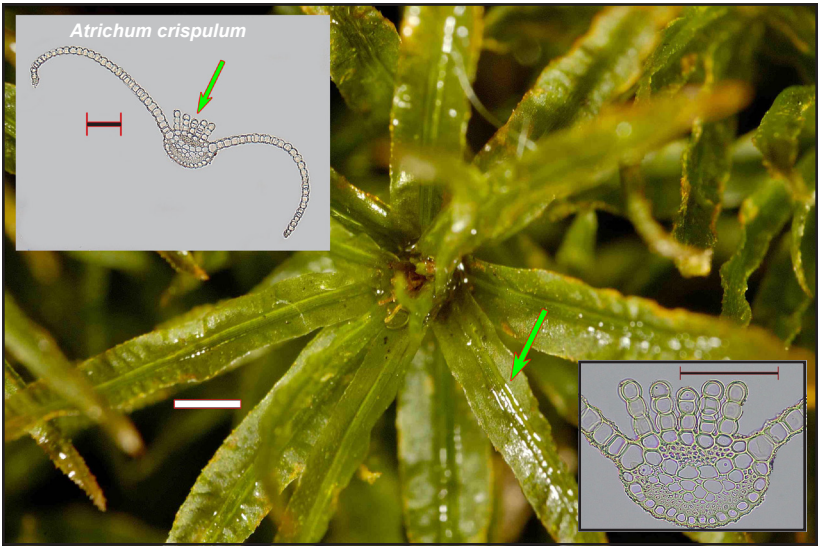
plants most commonly yellow-green (above); young pendent branches in pairs, stacked between the arms of the capitulum (right, arrow); mature spreading branches with pinkish tint at the base

15b. Young **pendent branches single or not differentiated from spreading branches**; plants **dark brown**; in very wet depressions or pools in open poor fens, often forming floating carpets . . . . . *S. majus*

plants frequently dark-brown (above); pendent branches single (not obviously in pairs or highly differentiated (right)

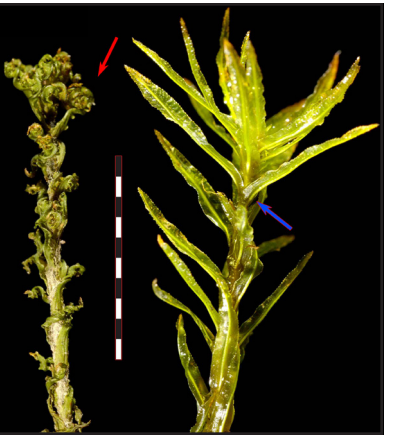
Illustrated Key to Polytrichales

1a. Costa narrow with **few adaxial lamellae**; leaves strongly **crisped** when dry. . . . . *Atrichum crispulum*

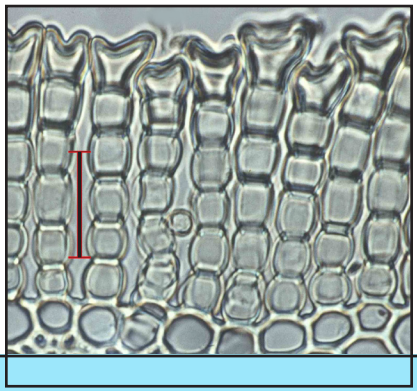


few adaxial lamellae (at arrow; inset tr.s. through costa))

mixture of dry plants with crisped leaves and of plants, still sufficiently wet, with expanded leaves (left); crisped (red arrow) versus wet gametophore (blue arrow) leaves without sheathing base (below)

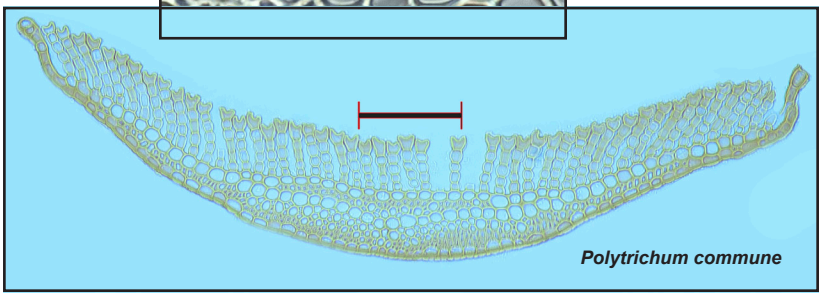


1b. Costa very wide (leaf lamina not obvious), **many adaxial lamellae**; leaves not crisped when dry . . . . 2.

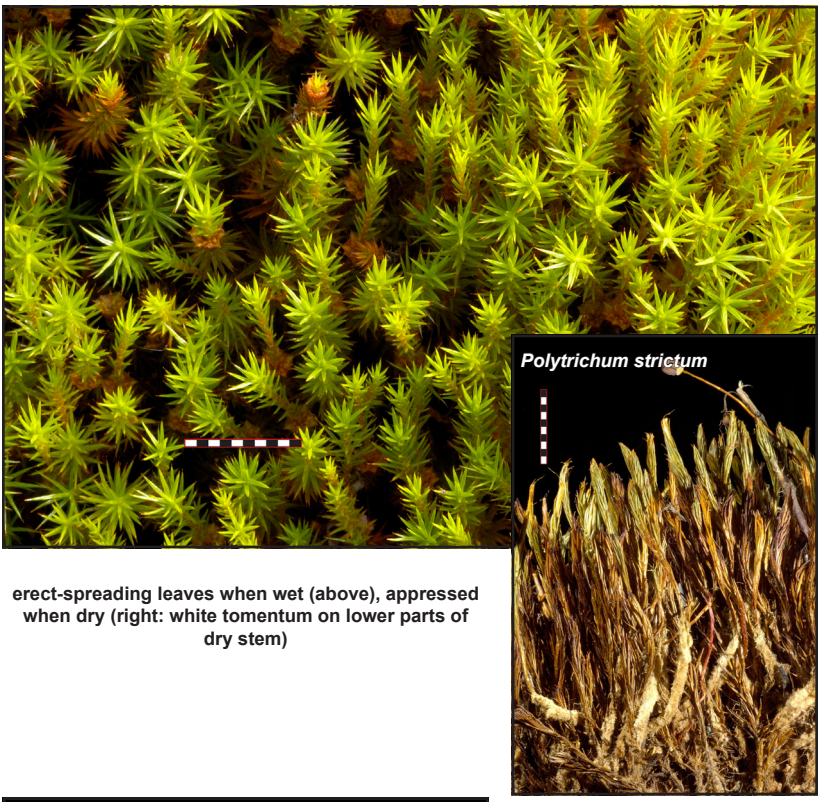


above: adaxial lamellae (red arrow: visible as faint lines on top of very wide costa)

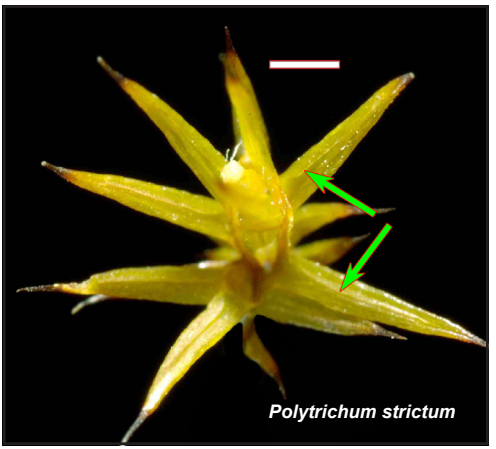
below: position on costa in tr.s. of leaf; inset detail



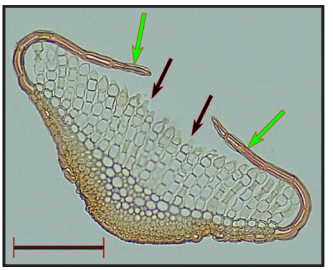
2a. When dry leaves **appressed** (folded against the stem), when wet **erect-spreading**, standing out straight; **leaf laminae enrolled** over the lamellae; lower part of stem covered with **white tomentum** (when water is squeezed out); in *Sphagnum* habitats, usually on high hummocks in bogs [if not among *Sphagnum*, mind the look-alike *P. juniperinum*, usually with less tomentum development]. . . *Polytrichum strictum*



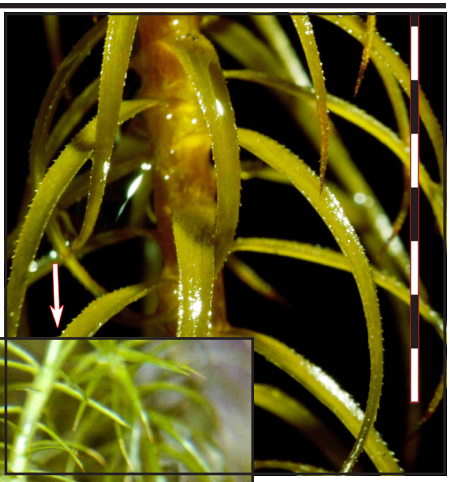
erect-spreading leaves when wet (above), appressed when dry (right: white tomentum on lower parts of dry stem)



enrolled leaf laminae indicated by green arrows (inset transverse section through leaf, lamellae indicated by black arrows)



2b. Leaves less closely appressed when dry, when wet **spreading-recurved**; leaf border serrate and **lamellae exposed**; very large plant, without white tomentum on stem; often in more shaded habitats, along mire margins rather than in the open center . . . . . *P. commune*



spreading-recurved leaves (below) with exposed lamellae and serrated leaf border (right)

Illustrated Key to *Dicranum*

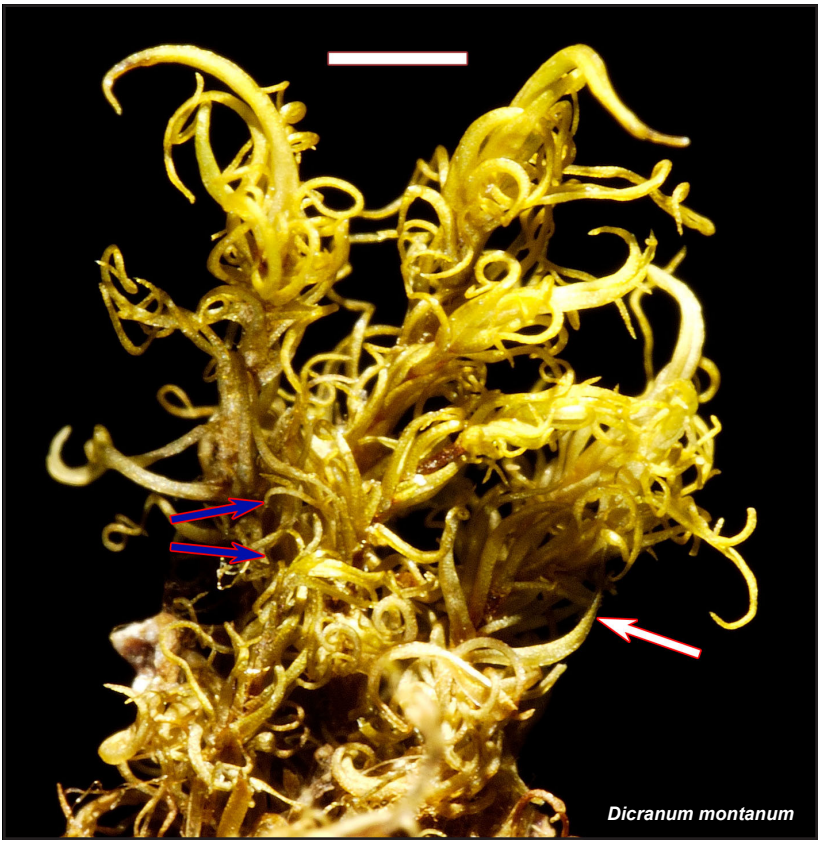
1a. Plants growing in **short turfs**, up to 2 cm in height, densely packed and velvety green; mostly growing on bark . . . . . 2.

1b. Plants growing in **tall turfs**, often over 5 cm in height, easier to separate and green to golden-green; mostly growing on coniferous forest floor or on exposed and drier peat in peatlands . . . . . 4.

short turf

tall turf

2a. Plants very small and leaves strongly curled when dry, often with even smaller **brood plants**, similarly curled, attached, or the entire patch consisting of these small brood plants; on dead wood and bark at the base of trees in quite xerophytic microhabitats . . . . . *Dicranum montanum*

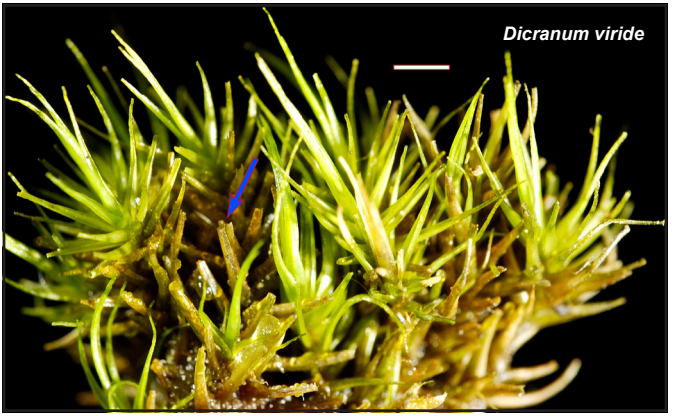


brood plants (blue arrows); papillose leaf tip (white arrow)

2b. Plants larger, leaves not strongly curled when dry, broken leaf tips or flagelliform branches acting as propagula . . . . . 3.

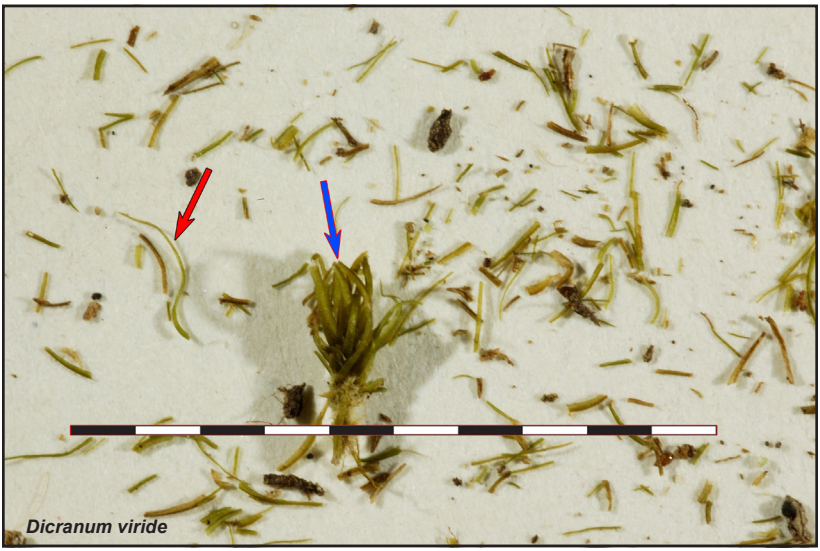
3a. **Leaf tips very fragile (propaguliferous)**: when a small patch is tapped upside down against the palm of hand, the leaf tips remain on the skin and most **leaves appear broken**; usually **dark green and matte turfs**, most leaves **stiffly erect**; usually on bark [have specimen checked if collecting along the North Shore: there is a look-alike, the rare *D. fragilifolium*] . . . . . *D. viride*

dark green and matte turf



fragile (propaguliferous) leaf tips

stiffly erect, often broken leaves, in turf with lighter hue

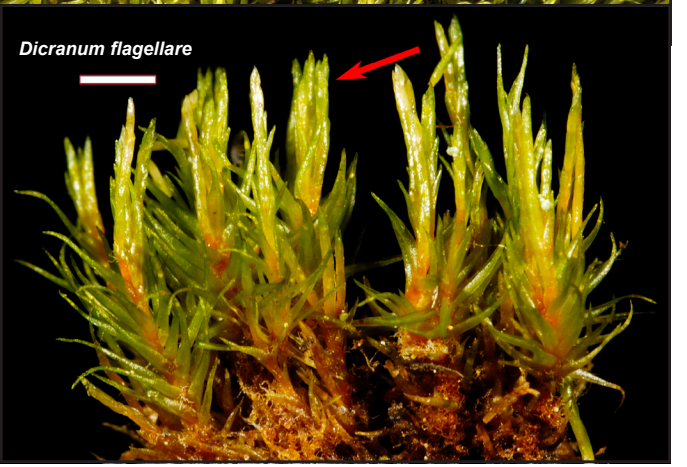


broken leaf tips after tapping turf upside-down on card

3b. Leaf tips not fragile, but clusters of straight branches with minute leaves (**flagelliform branches**) among the regular plants; usually lighter green or yellow-green, glossy turfs, most leaves falcate to falcate-secund; on dead wood and bark, sometimes on dry peat or rotten wood underneath trees. *D. flagellare*

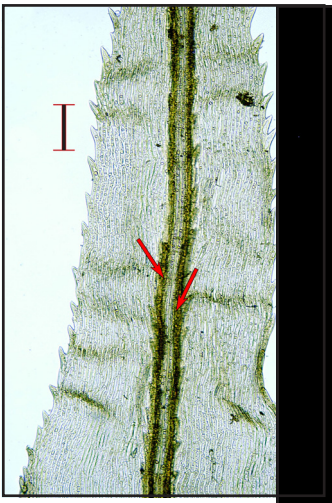
short turf consisting of nearly all flagelliform branches (left)

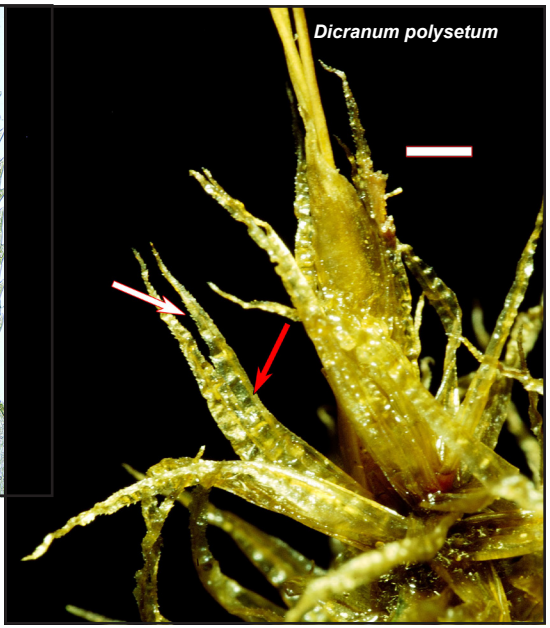
close- up of short turf with well-developed leaves and clusters of flagelliform branches hidden among them (below, arrows)



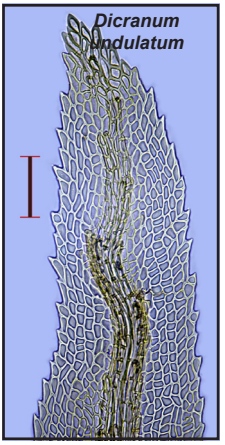
flagelliform branches

4a. Glossy plants with **serrated leaf margins** (use 20x handlens) . . . . . 5.
4b. Matte plants with **denticulate leaf margins** . . . . . 6.



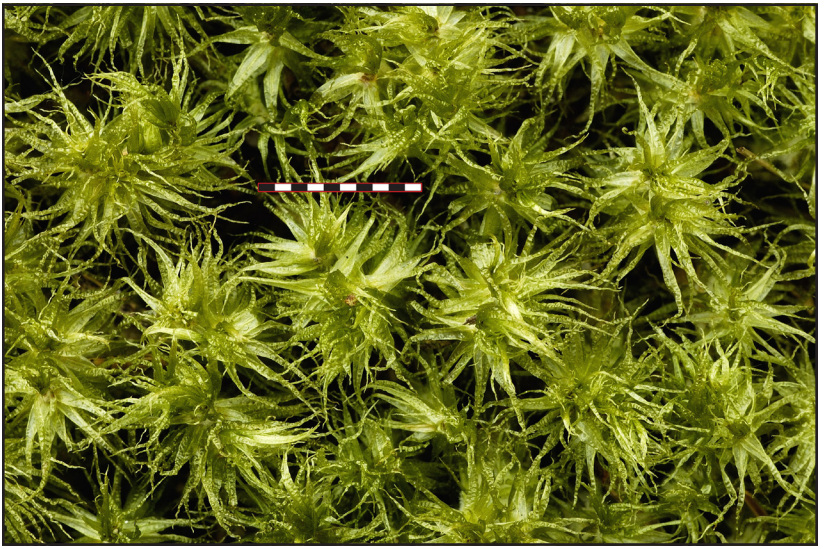


plants glossy; leaf margins sharply serrate (sawlike teeth, white arrow) and back of costa with two toothed lamellae (red arrows)

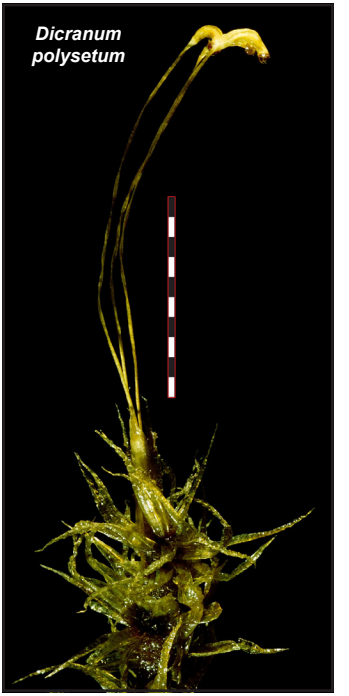


plants matte; leaf margins denticulate (small teeth formed by only part of the marginal cells) and back of costa without lamellae but sometimes toothed (above)

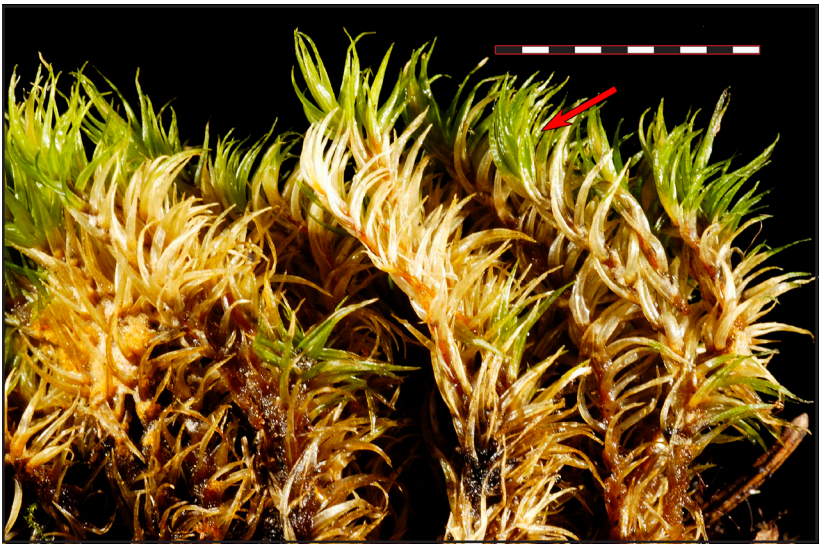
5a. Leaves strongly **undulate** and often straight (not curved or falcate), **highly glossy**; the most recent annual increment of the stem covered with **white-greenish tomentum**; setae in bundles (**polysetous**); in dry to mesic coniferous forests and forested peatlands, sometimes on drier hummocks underneath small trees and shrubs in open peatlands . . . . . *D. polysetum*



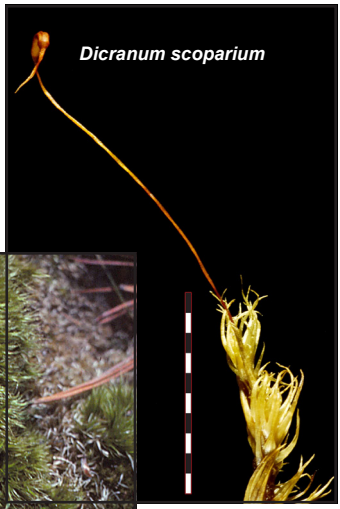
highly glossy plants with undulate leaves (above), white tomentum (below), and several setae originating from a single perichaetium (right)



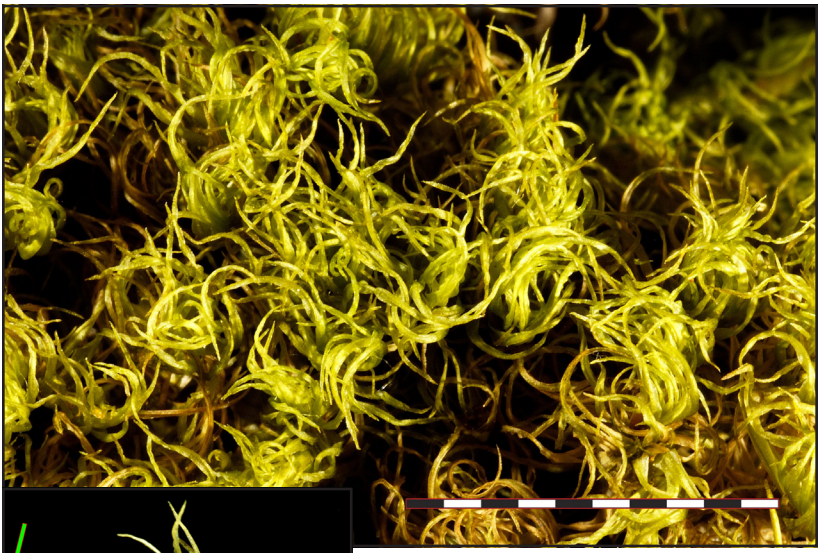
5b. Leaves sometimes slightly undulate and usually **curved-secund**, sometimes falcate-secund, moderately glossy; stem usually covered with **brownish tomentum**; **setae singly**; most commonly on coniferous forest floor, more rarely in peatlands . . . . . *D. scoparium*

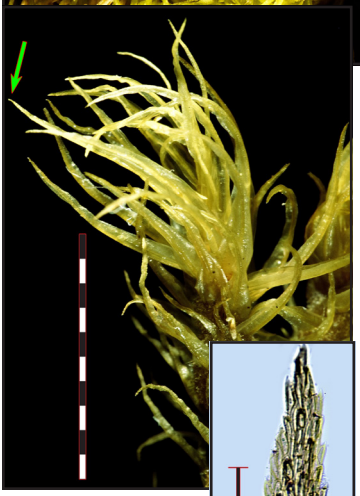


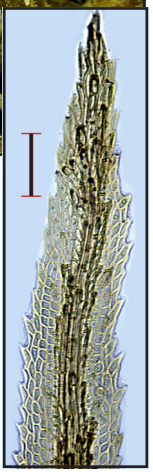
plants with curved-secund and only slightly undulate leaves and with usually brown tomentum (below); and a single seta originating from the perichaetium (right)



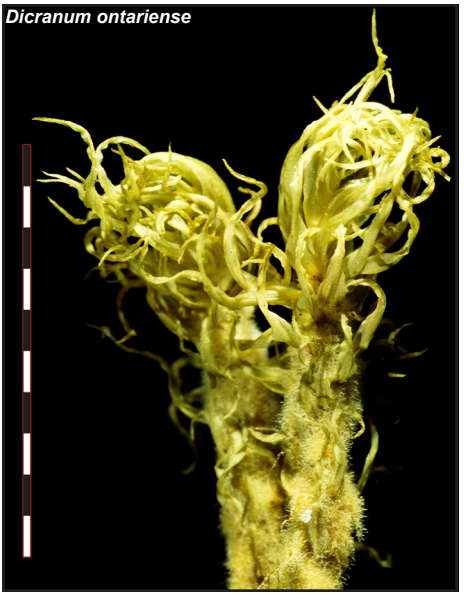
6a. When dry leaves are **strongly curled**; **leaf tips sharply acute**; in more open turfs, usually in forested peatlands and on forest floors . . . . . *D. ontariense*



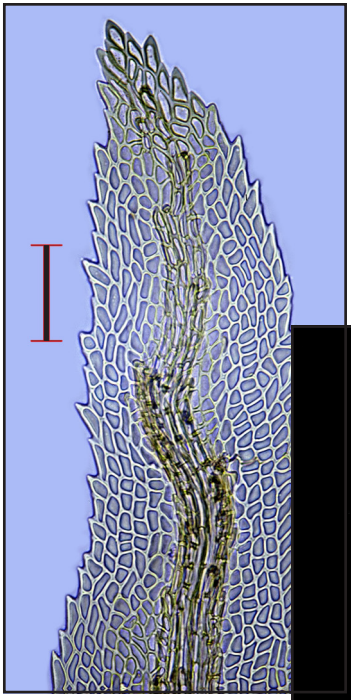




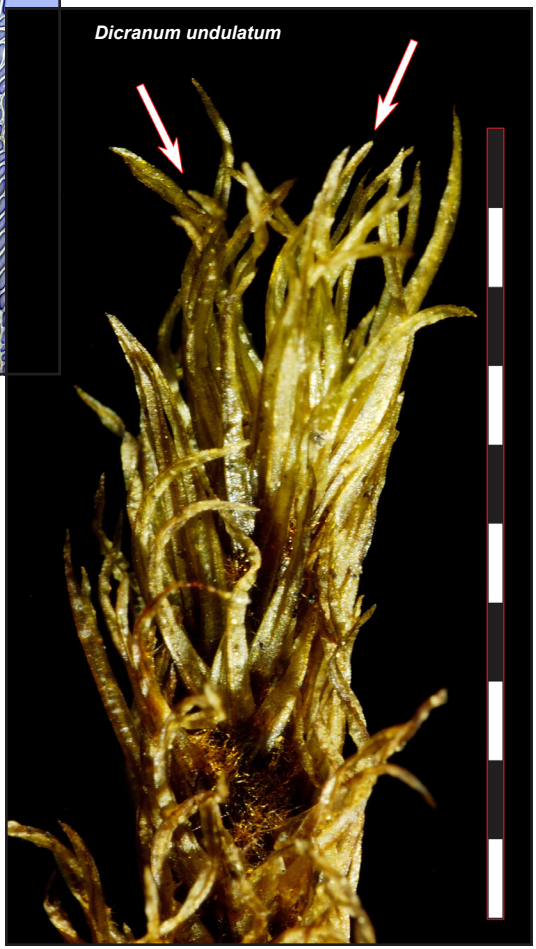
plants with dry leaves strongly curled (far right and top) and with their apices sharply acute (right and above)



6b. When dry leaves are erect-appressed, only **slightly twisted or contorted**; **leaf apex somewhat blunt**; in dense turfs on drier hummocks, mostly in open peatlands . . . . . *D. undulatum*



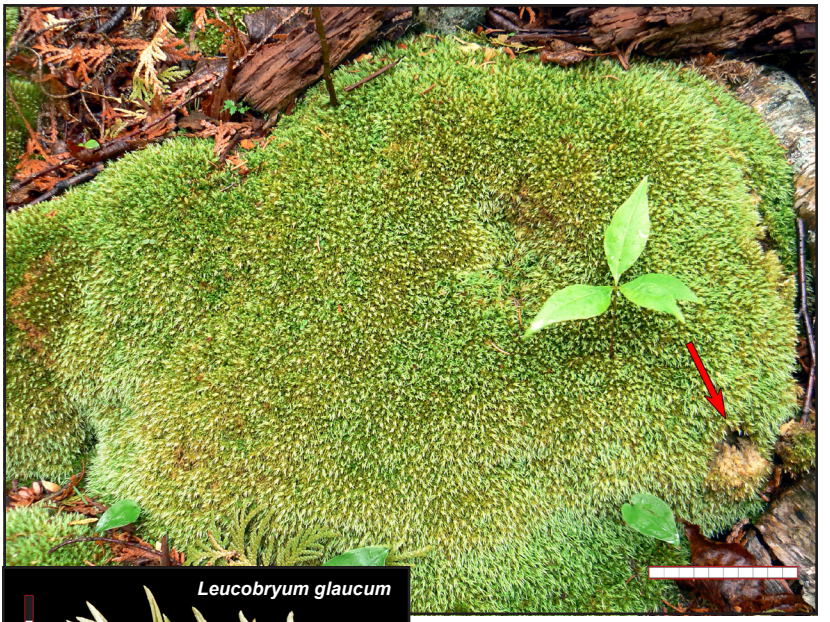
when dry leaves erect-appressed (below) and apices relatively blunt (left) compared with those of *D. ontariense*

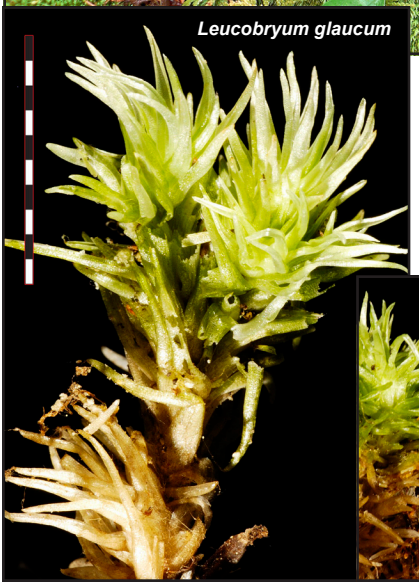


Illustrated Key to Other Acrocarps

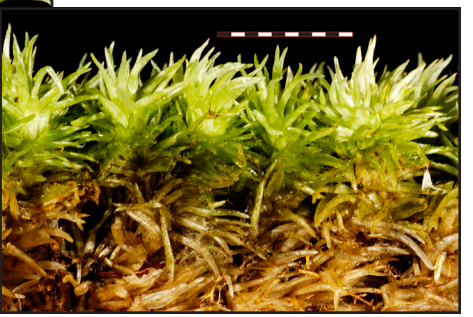
1a. Plants **pale-green** or **whitish-silvery**. . . . . 2.
1b. Plants not pale-green or whitish-silvery . . . . . 3.

2a. Larger plants (> 2 cm, often a lot taller) in **large, pale-green and brittle cushions**; on coniferous-forest floor . . . . . *Leucobryum glaucum*





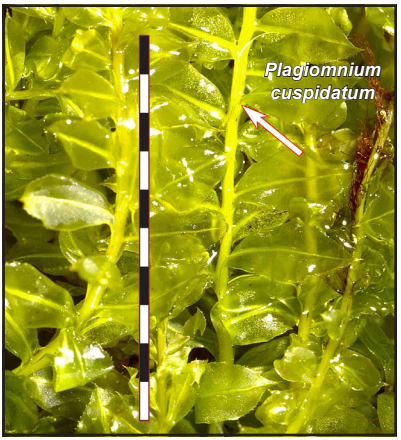
whitish-green large cushions, individual plants fleshy and brittle, easily damaged by trampling (red arrow above)



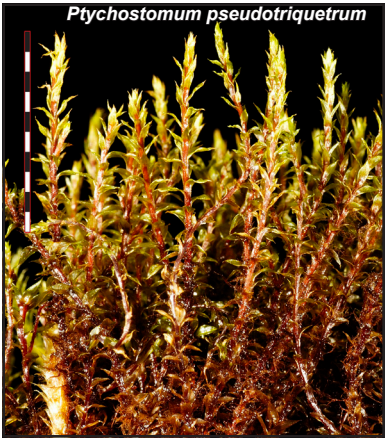
2b. Smaller plants (usually < 1 cm tall, often a lot shorter) in small, silvery turfs; upper half of leaf **hyaline**, giving the plants the **silvery aspect;** usually on mineral substrate in disturbed habitats (ruderal) . . . . . *Bryum argenteum*

hyaline-tipped leaves giving plants a silvery aspect

3a. Leaves **translucent** with cells easily visible with a 20x handlens, and **widely elliptic**, **obovate**, or orbicular, with a distinctly **narrowed insertion** on stem, also distinctly bordered. . . . . 4.
3b. Leaves **opaque or transparent** with usually small cells, and oblong-ovate, ovate, oblong-obovate, **ovate-lanceolate** or **lanceolate** but towards the insertion only **slightly narrowed**, if at all, bordered or not 6.

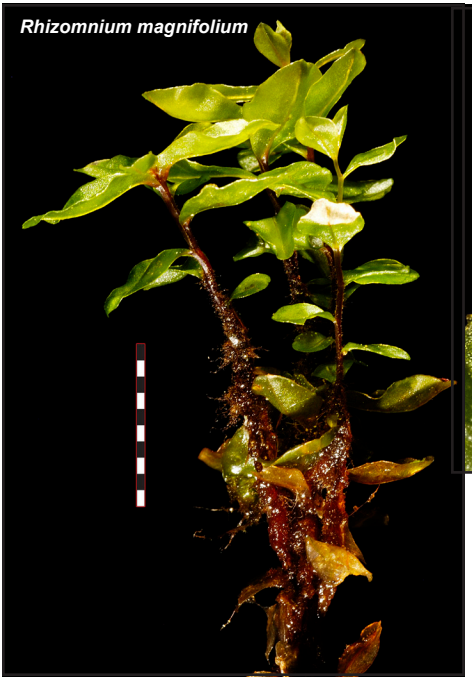


translucent leaves, widely elliptic, orbicular, or obovate with strongly constricted, narrow insertion on stems; cells large



transparent or opaque leaves, ovate-lanceolate or lanceolate with basal part only slightly narrowed towards the stems; cells small

4a. **Stems**, both fertile and sterile, **always upright** with leaves spirally inserted; **leaves up to 12 mm long**; leaf margin always **entire** (without teeth); **rhizoids well developed** on stems; in depressions in swamps, usually in quite pure populations and very obvious because of the large leaves . . . . . *Rhizomnium magnifolium*

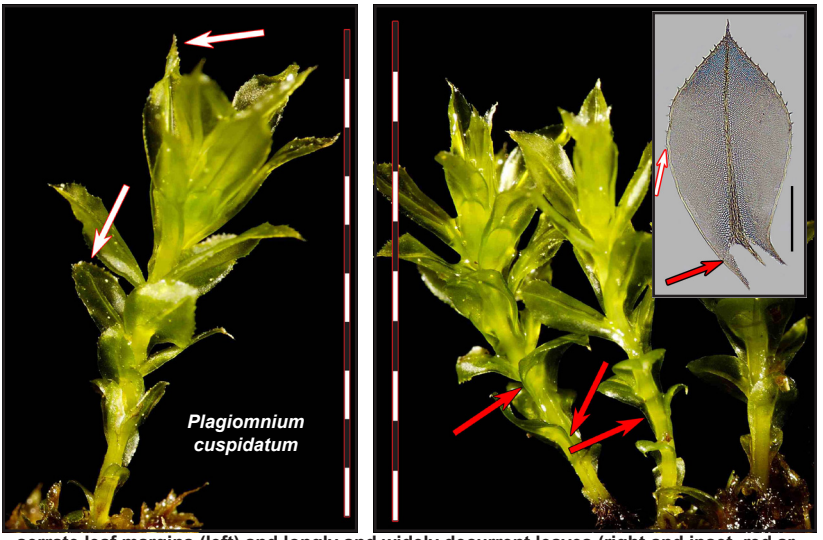


large entire leaves; rhizoids abundant on both sterile and fertile upright stems

4b. Sterile stems often arching (similar to strawberry stolons) over the substrate (**prostrate**) with **complanate** leaves; leaves smaller and frequently with teeth along the margin (**serrate**); rhizoids usually less well-developed on upright fertile stems. . . . . 5.

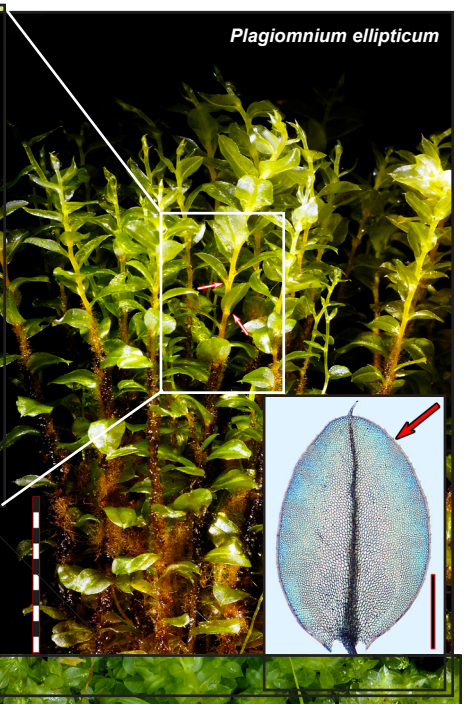
5a. Leaf insertion **widely and longly decurrent** along the stem; **leaf serration only along the upper half of the obovate leaves** (use 20x handlens); frequent both in wet or dry mesohabitat but always in their drier, often shaded microhabitats . . . . . *Plagiomnium cuspidatum*

prostrate stems with complanate leaves



serrate leaf margins (left) and longly and widely decurrent leaves (right and inset, red arrows); marginal teeth only along upper half of obovate leaf (white arrows, and inset)

5b. Leaf insertion **narrowly or non-decurrent**; **some of the elliptic leaves with few or no marginal teeth, those with teeth are serrate all the way to the base** (use 20x handlens); very common in wetlands, rich fens (a calcareous-fen indicator in MN), and swamps . . . . . *Plagiomnium ellipticum*



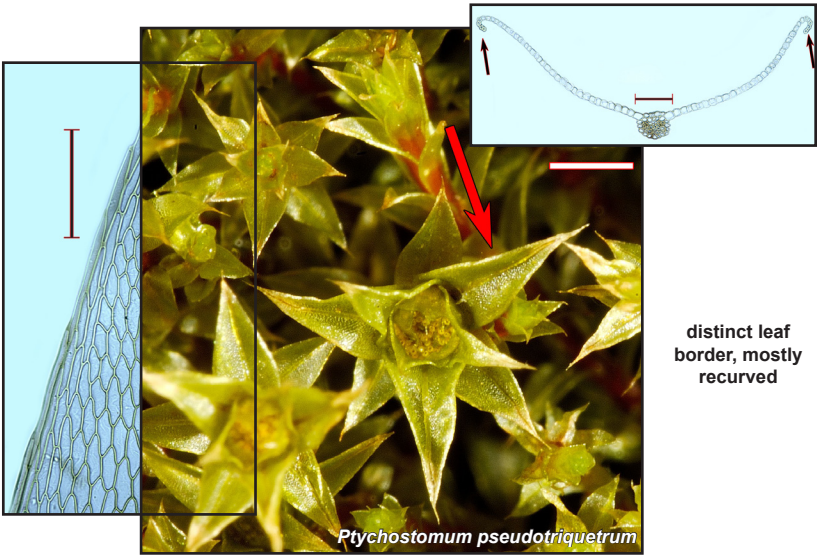
non-decurrent or shortly and narrowly decurrent leaves (above and inset), small teeth along entire margin (inset); sterile stems prostrate

OTHER ACROCARPS

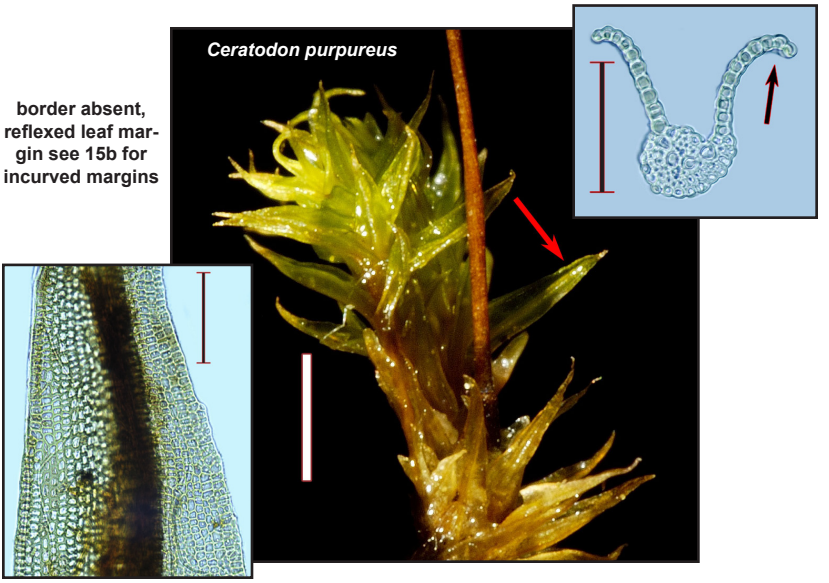
The next dichotomy is hard to use in the field with only a handlens as tool, even a 20x. A true border consists of marginal cells quite different from those of the lamina. However, when margins with undifferentiated cells are curved or rolled, it is hard to distinguish them in the field from a true border. If your specimen can not be convincingly IDed as one of the two *Bryum* species below (dichotomy 7) try the species starting at 8.

6a. Transparent leaves with a **border** (marginal cells different from those of the rest of the lamina), and margins often entirely **recurved**; capsules symmetrical, large, pear-shaped and pendant . . . . . 7.

6b. Opaque or transparent leaves with **margins** without differentiated cells, plane or recurved usually at the most in the lower 3/4, loosely **reflexed** or **incurved**; capsule otherwise . . . . . 8.

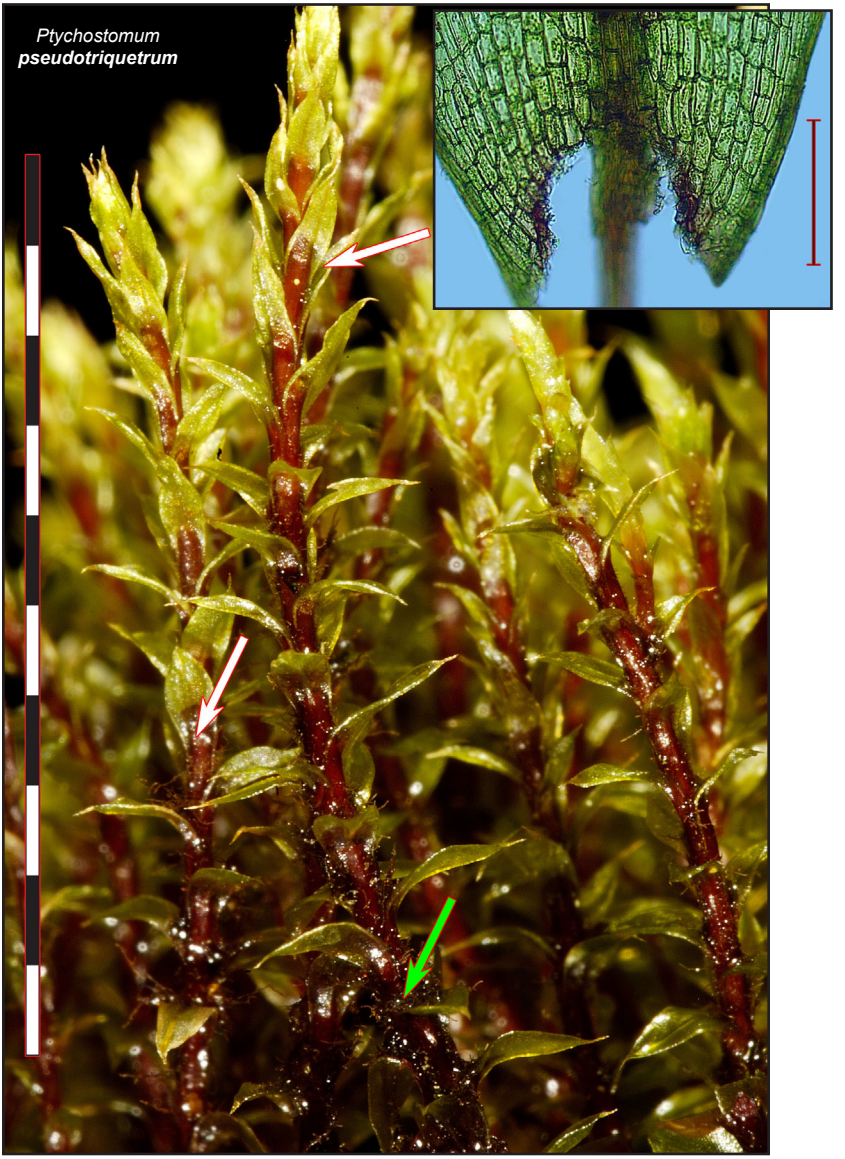


distinct leaf border, mostly recurved



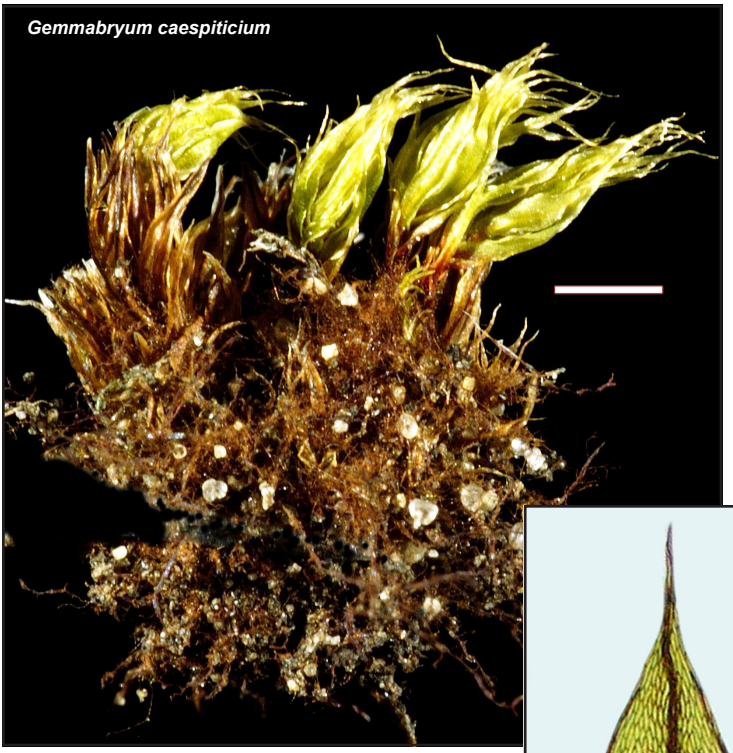
border absent, reflexed leaf margin see 15b for incurved margins

7a. Larger plants with obviously **widely decurrent** leaves easily visible because of **long internodes**; stems often with **propaguliferous rhizoids** along most of their length; commonly mixed among other bryophytes in circumneutral peatlands and rich fens (a calcareous-fen indicator in MN) . . . . . *Ptychostomum pseudotriquetrum*



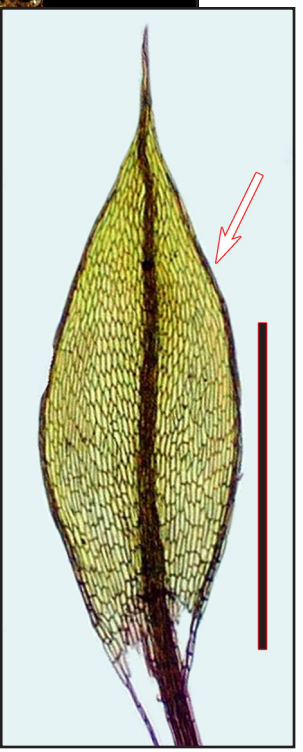
widely decurrent leaves (white arrows and inset) easily visible because of elongated internodes; propaguliferous rhizoids (green arrow)

7b. Smaller plants with leaves often tufted (**comose**), not obviously and only **narrowly decurrent**; stems with **abundant rhizoids only at the base**; growing on all kinds of substrates in disturbed habitats (ruderal) [many look-alikes!] . . . . . *Gemmabryum caespiticium*

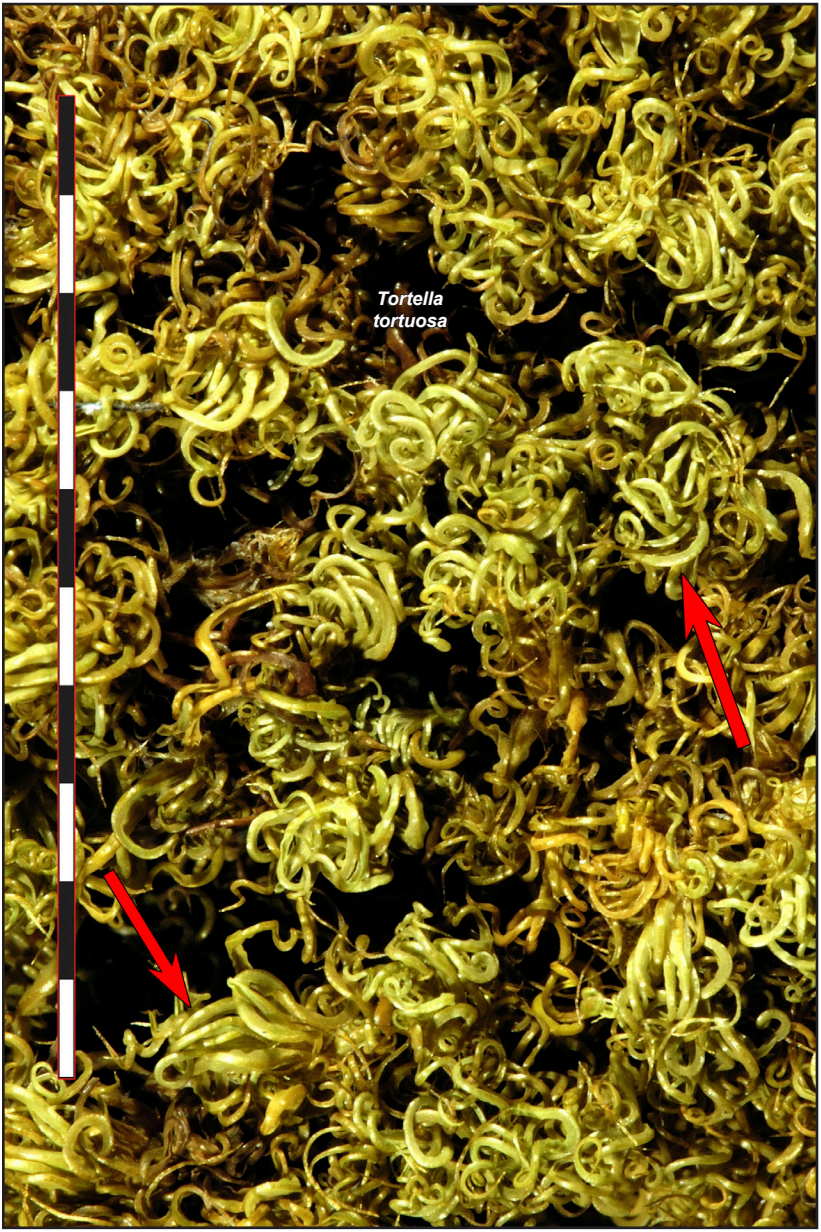


comose plants with abundant rhizoids only at the base

leaf border distinct and leaf narrowly decurrent only



8a. Leaves **strongly crisped** when dry with the **back of the costae shiny yellow**; on dry calcareous soil and rocks, usually quite exposed, sometimes in cedar swamps in dry microhabitats . . . . . *Tortella tortuosa*



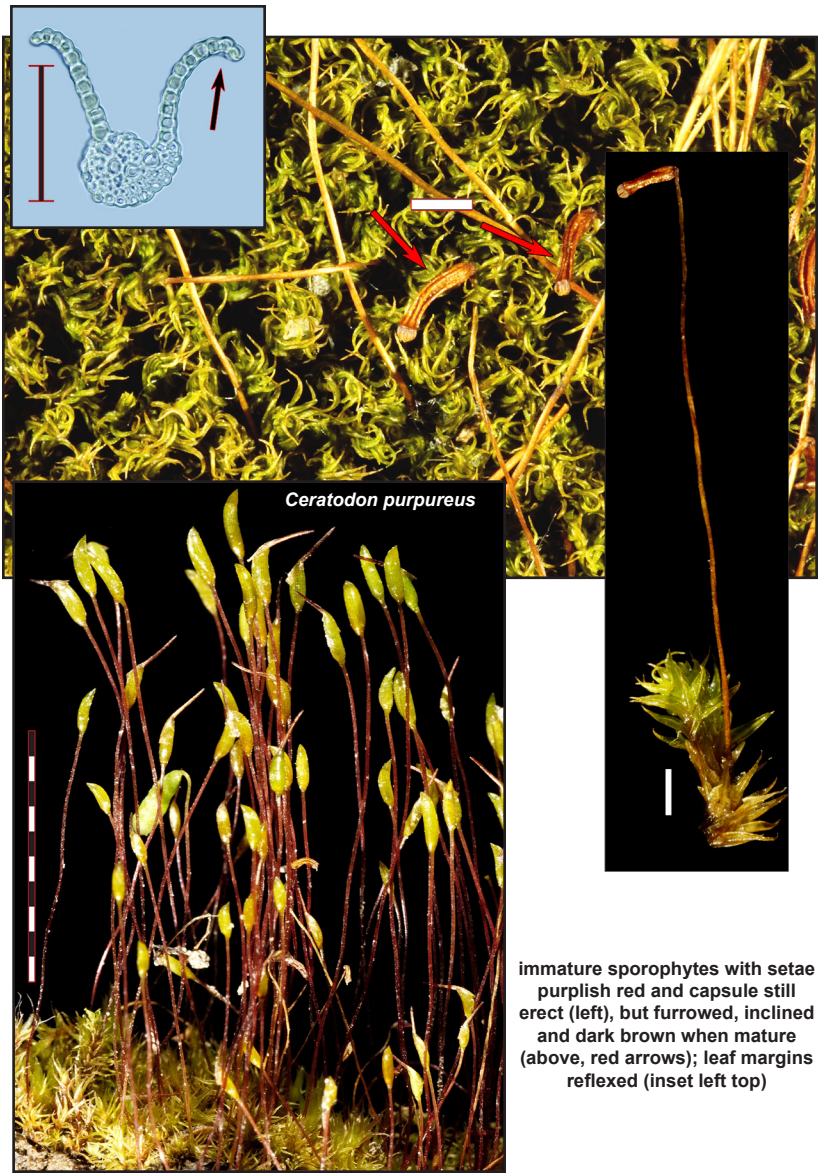
back of costa shiny yellow on strongly crisped leaves when plants are dry

8b. Leaves frequently somewhat contorted or twisted when dry but the costae not obviously shiny as above . . . . . 9.

9a. Part of the patches nearly always with **obvious and numerous sporophytes**; species often growing in **disturbed mesohabitat (ruderal)** . . . . . 10.
9b. Sporophytes, when present, less obvious; species in natural mesohabitat . . . . . 11.

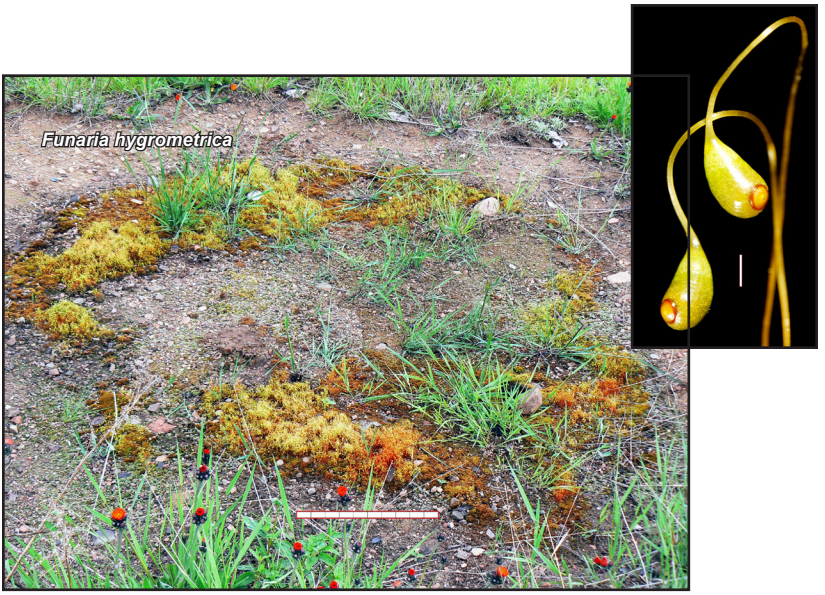
patches prolifically producing sporophytes, often in ruderal mesohabitat

10a. Plants in dense, extensive turfs; sporophytes with straight setae, when **immature purplish red and capsules erect**; **mature capsules glossy brown, furrowed** and **inclined**; leaves narrowly lanceolate [very variable in its gametophytic features, both macroscopically and microscopically, always check out this extremely common species first before considering other species. Most characteristic, in addition to the sporophytes, are the small square cells and the **recurved/reflexed** margins] . . . . *Ceratodon purpureus*

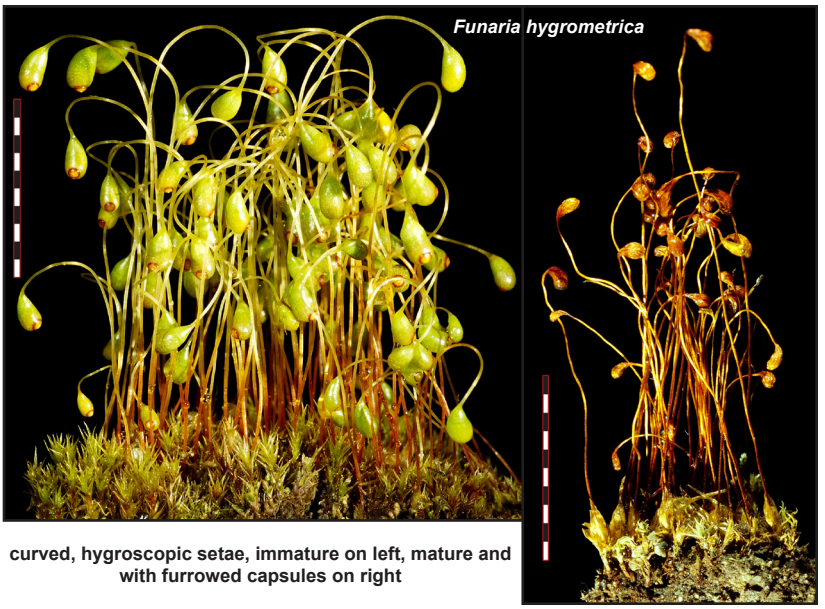


immature sporophytes with setae purplish red and capsule still erect (left), but furrowed, inclined and dark brown when mature (above, red arrows); leaf margins reflexed (inset left top)

10b. Individual plants usually in **loose turfs**; sporophytes with **capsules furrowed when mature but strongly asymmetric and elevated by very tall, curved and hygroscopic setae**; leaves ovate to obovate; often in ruderal habitats on loose unconsolidated mineral sediment, soon after fire or surrounding **old fire pits** . . . . . *Funaria hygrometrica*

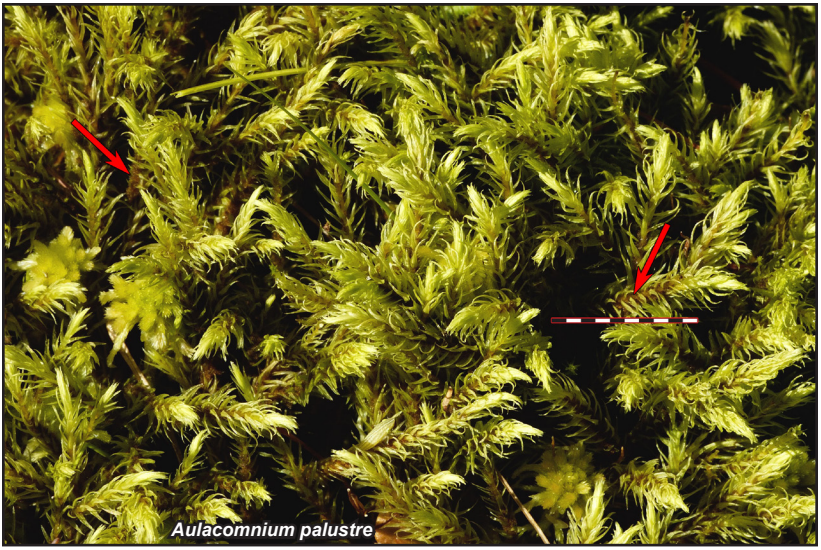


loose turfs surrounding old fire pit; asymmetric peristomate capsules



curved, hygroscopic setae, immature on left, mature and with furrowed capsules on right

11a. Plants usually growing on organic soil, peat, or among *Sphagnum* on hummocks, **light-green when actively growing**, later in season turning dark-green; long stems covered by **brown tomentum**; in bogs and poor to intermediate fens, mostly with *Sphagnum*, on the top and sides of drier hummocks . . . . . *Aulacomnium palustre*



light-green aspect of actively growing plants, stems covered with brown tomentum

brown tomentum

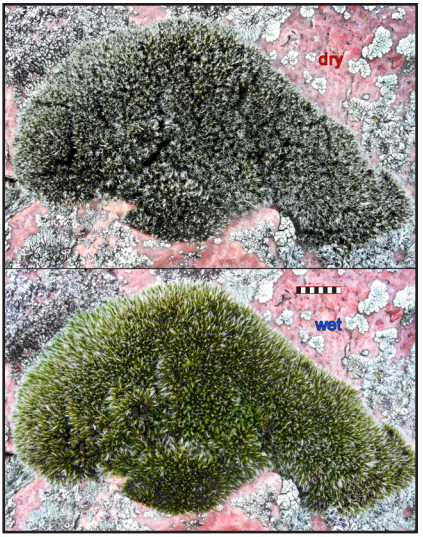
11b. Plants growing on mineral soil or rock . . . . . 12.

12a. Upper leaves with excurrent costae, forming distinct hairpoints . . . . . 13.
12b. Upper leaves without hairpoints, but sometimes with a hyaline apiculus . . . . . 14.

13a. Plants large, often > 5 cm tall, brownish-green to brick red-brown; leaves with **long hyaline hairpoints with reddish base**, **twisted around the stem when dry, when wetted quickly changing from enrolled-twisted to strongly squarrose-recurved**; often on unconsolidated sand near lake shores . . . . . *Syntrichia ruralis*

hyaline hairpoints with red base; leaves enrolled-twisted when plants are dry and strongly squarrose-recurved when wet

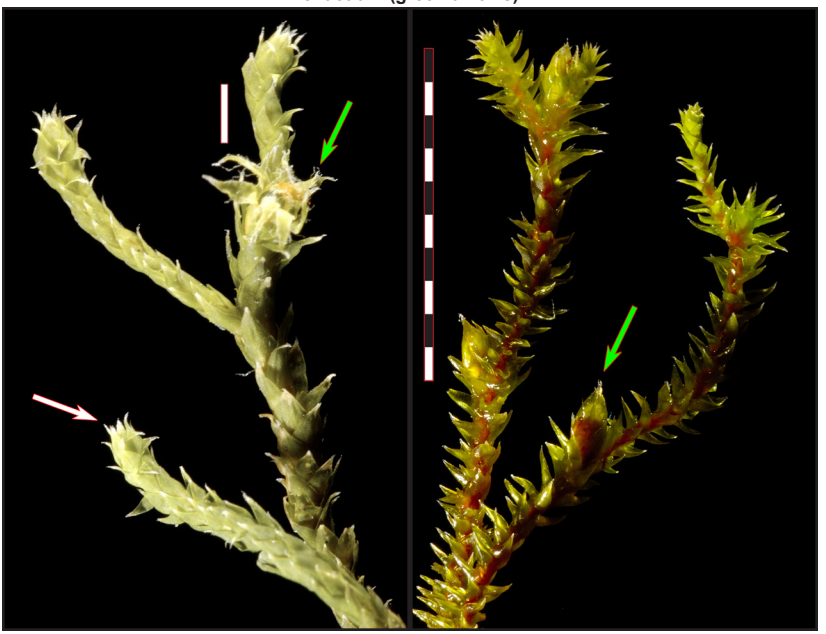
13b. Plants smaller, < 2 cm tall, green when wet, gray to near black when dry except for the **long hyaline hairpoints** of the upper leaves; leaves not contorted when dry, nor suddenly squarrose-recurved when wetted; growing on exposed rocks or thin dry soil over rocks . . . . . *Grimmia laevigata*



long hyaline hairpoints (red arrow)

14a. Plants in **somewhat flattened and rigid patches** [because of this mat-like habit the specimen might have keyed out inadvertently under 'Ecostate Pleurocarps on Bark, Wood, or Rock'], grey when dry but turning bright green when wetted; leaves **appressed** when dry, **spreading** when wet, **ecostate**, upper parts hyaline; **capsules hidden** among longer **perichaetial leaves with a distinct ciliated and hyaline fringe**; growing on exposed or sheltered rocks, well attached . . . . . *Hedwigia ciliata*

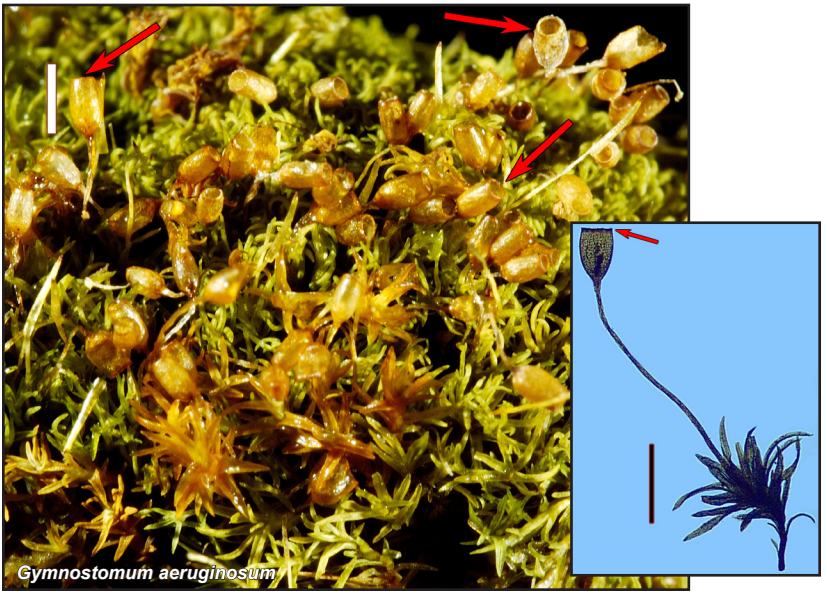
mat-like patch (above); ecostate leaves appressed when dry (below, left) spreading when wet (below, right), with hyaline tips (white arrow) and capsule inserted within ciliate perichaetium (green arrows)



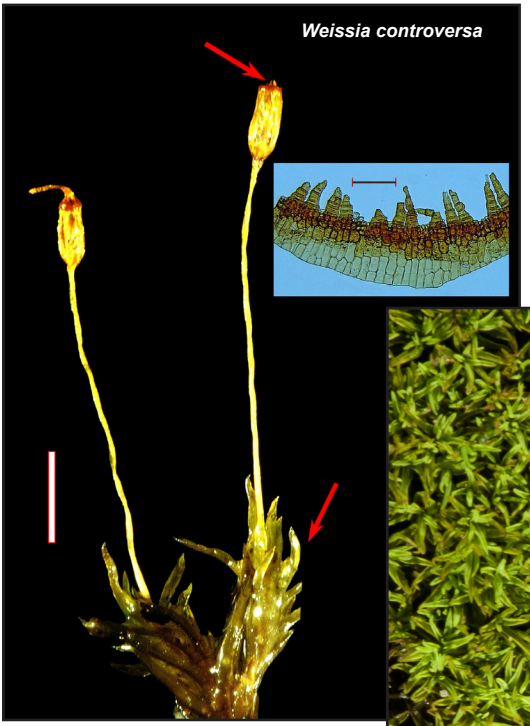
14b. Plants in small or large cushions or turfs, pale-green or dark-green to yellow-brown, without sudden color change when wetted; leaves incurved to strongly crisped when dry, erect-spreading when wet, costate, upper part green; capsule exserted on **yellow setae** 15

15a. Plants in dense, and often very **large, merging cushions or tall turfs**; leaf margins plane; **capsules without peristomes**; on wet boulders and seeping calcareous cliffs . . . . . *Gymnostomum aeruginosum*

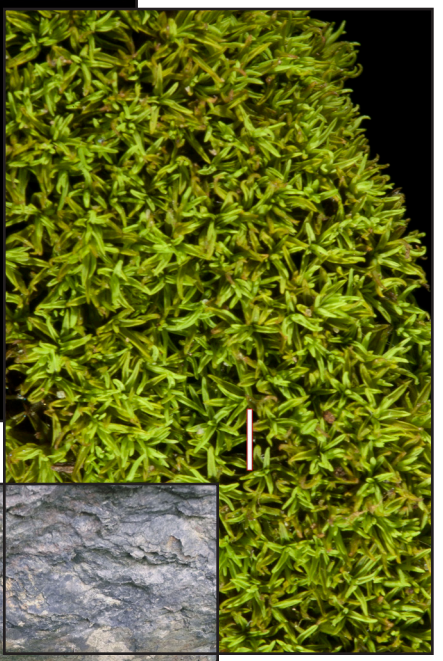
large cushions on wet rocks (above);
small erect capsules on yellow setae without peristomes (below)



15b. Plants in small turfs; leaf margins incurved; **capsules with peristomes;** on soil and rock in usually disturbed mesohabitat. . . . . *Weissia controversa*



capsules erect and setae yellow; leaf margins incurved (inset)



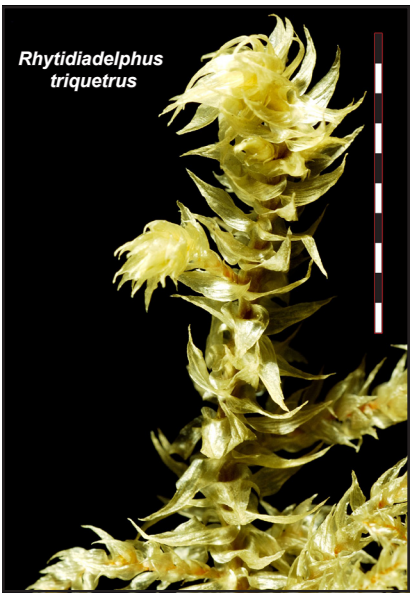
above: leaf margins distinctly incurved

left: small turfs

NOTES:

Illustrated Key to Feather Mosses

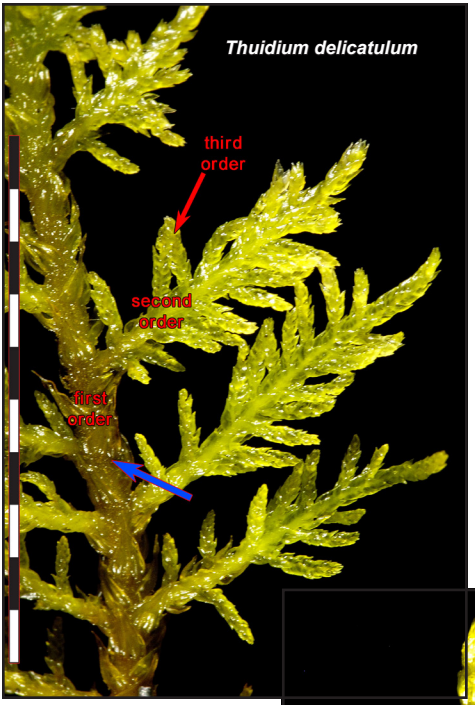
1a. Coarse plants with stiff stems ('pipe-cleaner moss'), leaves large, **triangular and plicate** (with longitudinal folds); in drier microhabitats on the forest floor . . . . . *Rhytidiadelphus triquetrus*



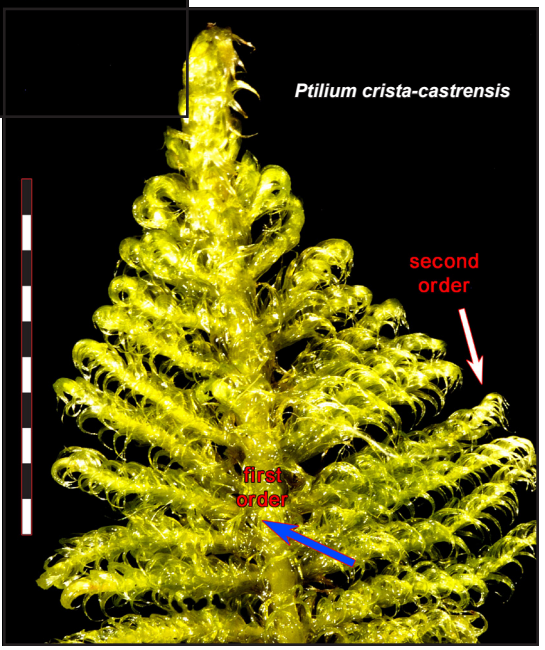
stiff, pipe-cleaner aspect with triangular, plicate leaves

1b. Less coarse plants, leaves much smaller; usually mesic to wet microhabitats . . . . . 2.

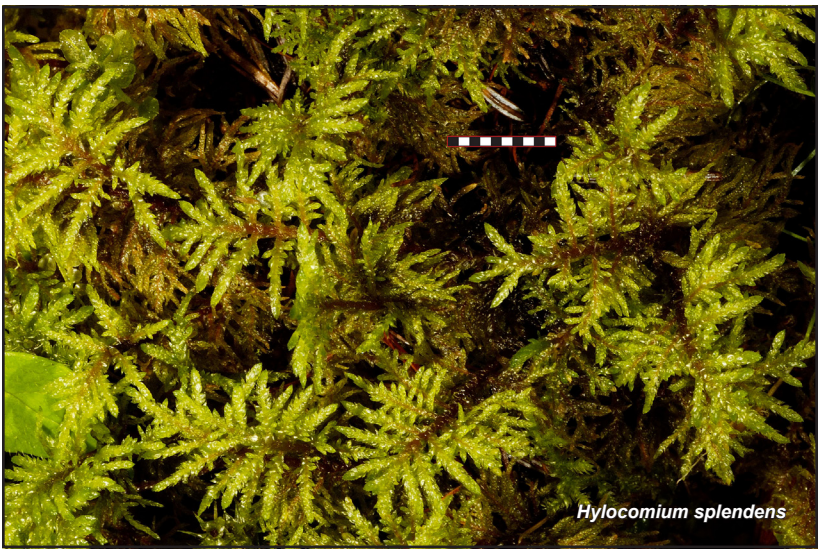
2a. Plants with annual segments **bi(tri)-pinnately** branched . . . . . 3.
2b. Plants with annual segments irregularly or **uni-pinnately** branched . . . . . 5.



annual segment bi(tri)-pinnately (left) versus uni-pinnately branched (below)



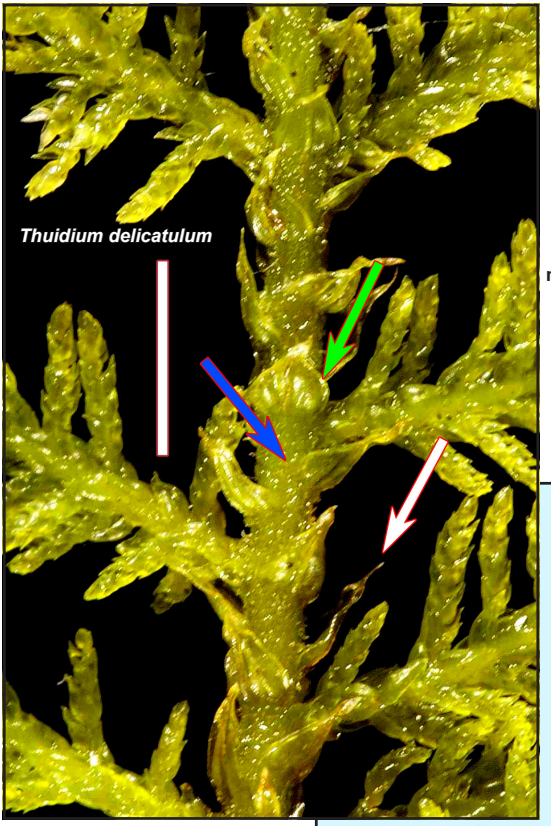
3a. Plants somewhat glossy, with **annual steplike fronds**; in large wefts in dry to mesic microhabitats under coniferous forest canopy . . . . . *Hylocomium splendens*



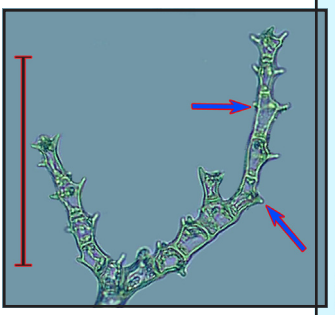
wefts (above) with annual step-like fronds (below)

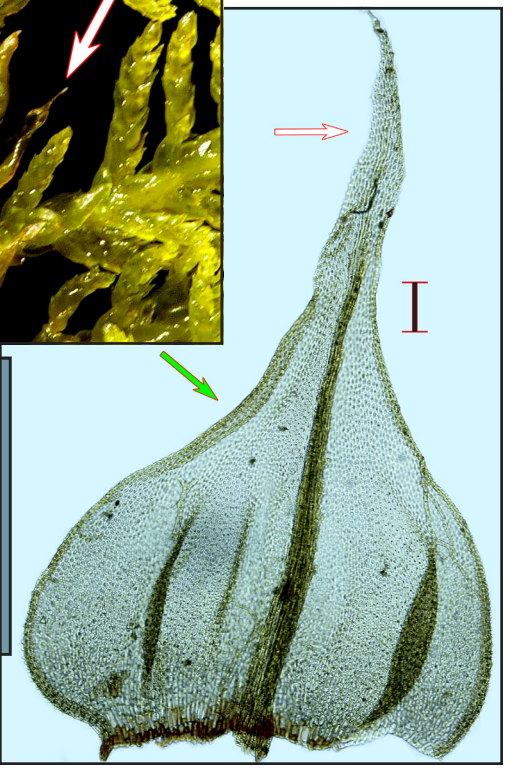
3b. Plants matte, without such obviously annual fronds . . . . . 4.

4a. Stem leaves with recurved margins and costae ending well below **narrowly acuminate and mostly straight apices** . . . . . *Thuidium delicatulum*



stem leaf with straight and narrowly acuminate apex (white arrows) and recurved margins (green arrows), and median papillae on paraphyllia (blue arrows)

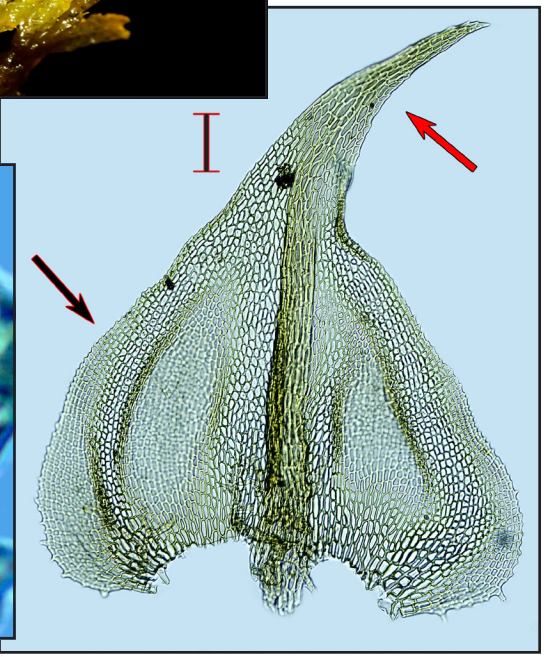




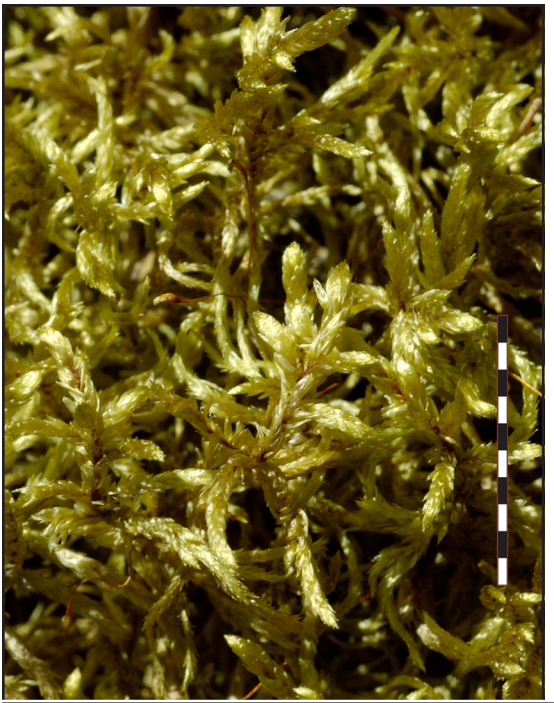
4b. Stem leaves with plane margins and costae percurrent into strongly **recurved apices**; both *Thuidium* species are found on the forest floor, most commonly of swamps, and they can grow together in mixed populations; *T. recognitum* might be a slightly more xerophytic . . . . . *Thuidium recognitum*

Taxonomic note: as the structure of the stem leaves is quite difficult to observe in the field, the only reliable character to differentiate the two species of *Thuidium* above are the papillae on the paraphyllia covering the stem and branches (see microphotographs below) for which a microscope preparation and compound scope are needed. *Thuidium delicatulum* has many papillae that are located near in the **middle of the cells**, while those of *T. recognitum* are always at the **distal tip of the cells**.

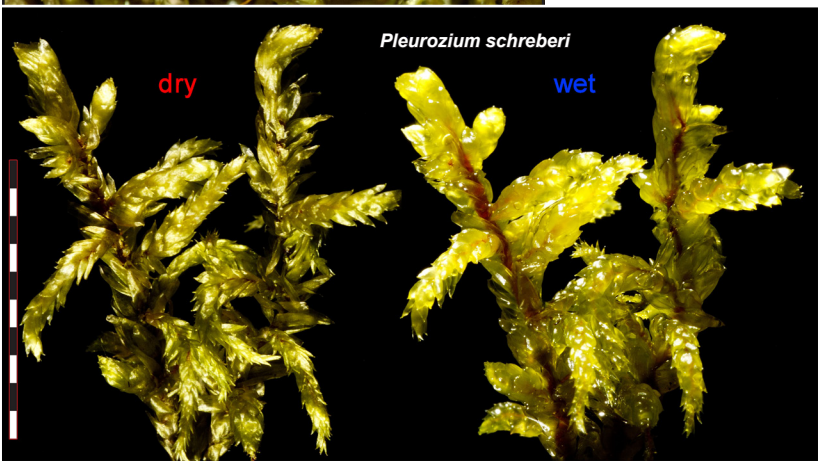
stem leaf with recurved apex (red arrow), plane margins (black arrow), and distal papillae on paraphyllia (white arrows)



5a. Plants **irregularly or semi uni-pinnately branched**, when dry normally very **glossy**, the nearly **straight** and **concave** branch leaves becoming translucent only when wet, and the main branch or stem shows then distinctly red; MN's most common moss, on both wet to mesic forest floors and in also in the drier parts of all forested peatlands; sometimes even in more exposed situations on rocky barrens or forest-road banks somewhat away from tree canopy . . . . . *Pleurozium schreberi*



semi uni-pinnate branching and leaves nearly straight and concave



glossy when dry, red stem obvious when wet

5b. Plants truly **feather**-like in aspect because of very **regularly uni-pinnate** branching; stems not red; stem and branch leaves strongly **circinate** (curved in a circle) and **plicate** (with longitudinal folds); usually as small patches in mesic to wet microhabitats . . . . . *Ptilium crista-castrensis*

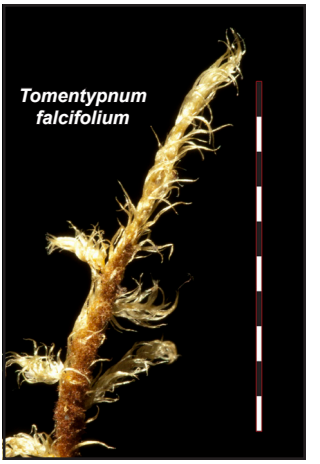
leaves circinate and plicate (right) and plants regularly uni-pinnately branched (below)

NOTES:

Illustrated Key to Costate Wetland Pleurocarps

1a. Plants with **brown tomentum** along the stem, mainly on the underside . . . . . 2.
1b. Plants without tomentum (but with or without paraphyllia, see 4a) . . . . . 3.

2a. Leaves **straight**, erect; in rich fens, forming often large and tall, pure hummocks. . . . . *Tomentypnum nitens*
2b. Leaves falcate-secund; in poor fens, frequently growing as separate stems within small *Sphagnum* hummocks. . . . . *Tomentypnum falcifolium*

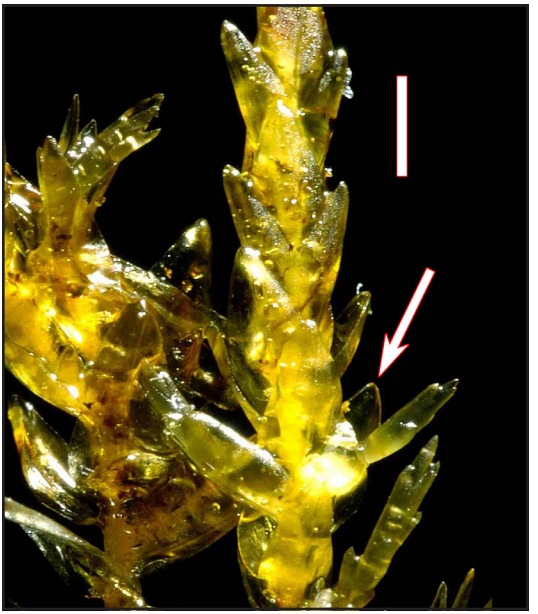


above: brown tomentum (felt-like covering of abundant rhizoids) on underside of stem (brown even when the plants are dry) and strongly plicate (longitudinal folded) leaves

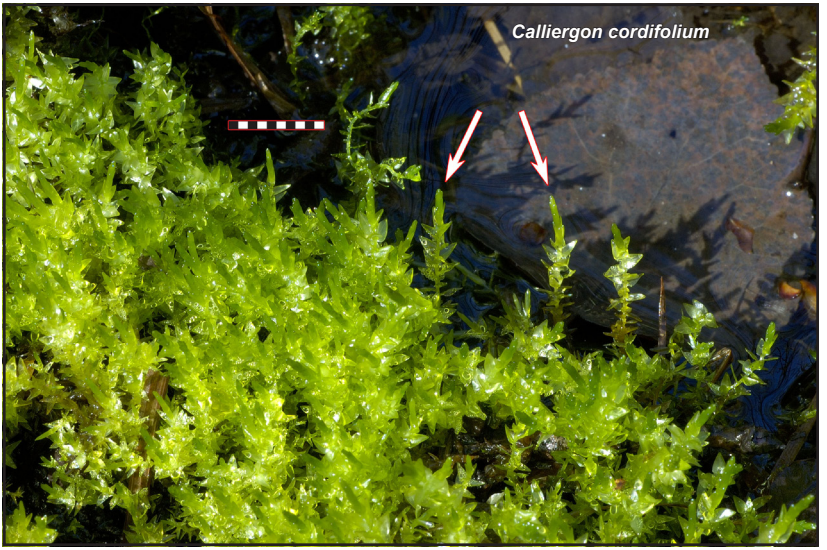
plant with straight leaves (below right) (those of *T. falcifolium* are quite a bit more curved, above right)

Note: Several of the following species have modifications growing in either semi- or fully aquatic microhabitats. These can look very similar to each other. Critical species identification has to rely thus on quite technical characters which you can only observe with a stereo- and compound microscope. However, the character states in the following key are suitable to differentiate at least the most typical emergent modifications.

3a. Leaves **rounded-obtuse**; uppermost leaves **enrolled** so that the **branch tips look pointed**, lower stem leaves large, spreading, and distant; large plants with straggly branching and most commonly in water-filled depressions in cedar swamps . . . . . *Calliergon cordifolium*

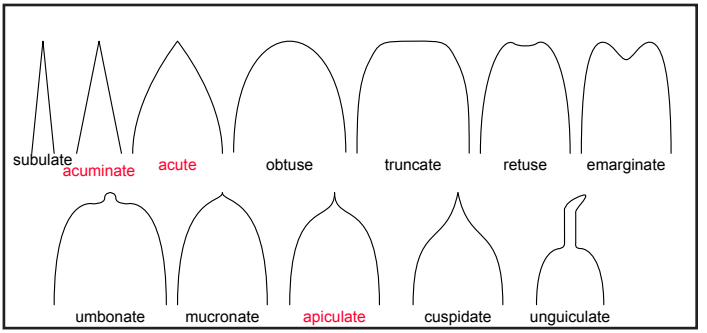


pointed branch tips with enrolled, rounded-obtuse leaves



3b. Leaves sharply **apiculate, acuminate,** or **acute** . . . . . 4.

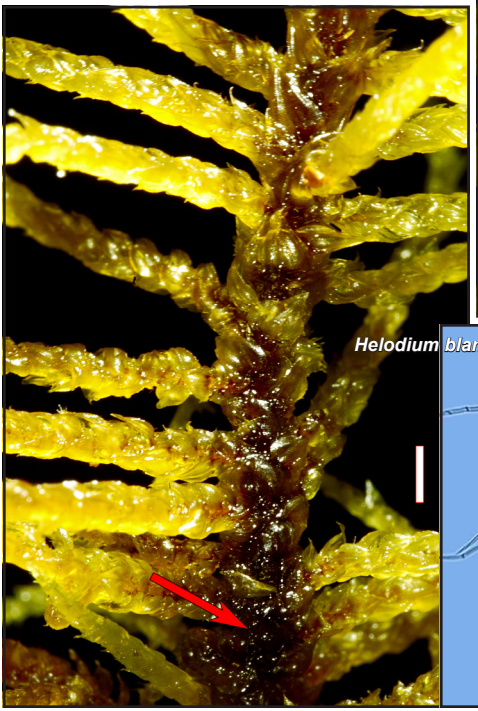
4a. Stems with many **paraphyllia**; in calcareous and rich fens as wefts forming low hummocks, or in swamps in shaded habitats among other bryophytes. . . . . *Helodium blandowii*



bryophyte leaf-apex shapes (above)

paraphyllia (small thread- or leaf-like appendages: they appear only dark on the wet stem (below), because they are translucent: when dry (right) they are yellow-green, similarly as the leaves

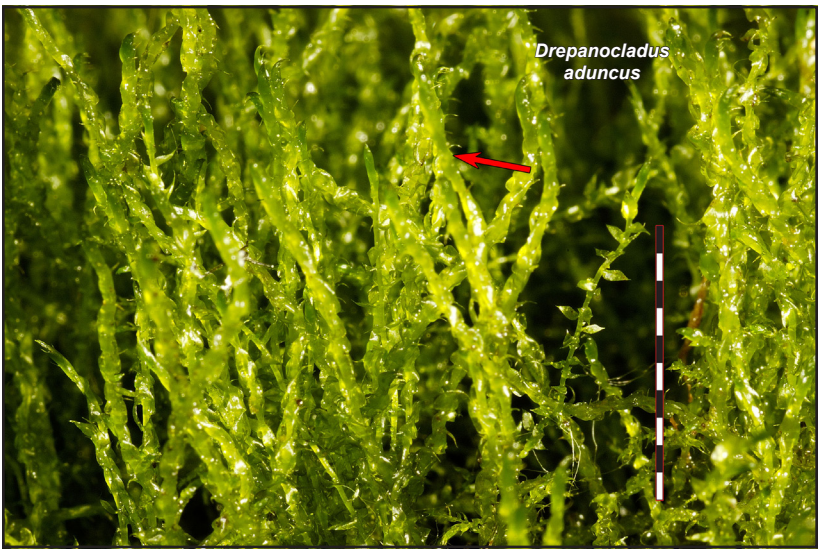
microscopic image of paraphyllium (below right)



4b. Stems without paraphyllia . . . . . 5.

5a. Leaves **distant and straight** (internodes often visible between the leaves), costa often reaching the apex (study this carefully with your 20x handlens) . . . . . 6.
5b. Leaves usually covering stem, more **appressed**, straight, **curved** or falcate, costa usually not reaching the apex . . . . . 7.

distant, straight leaves



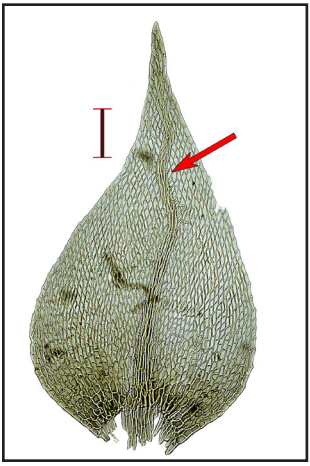
appressed, curved leaves

COSTATE WETLAND PLEUROCARPS

Taxonomic note: the following two entities are apparently positioned along a continuous scale of structural variation: presently all specimens are considered to belong to the highly polymorphic species *Hygroamblystegium varium*. However, as most Minnesota specimens are easily separated based on both structure and ecology from each other, their separation in upheld here: the more narrowly defined traditional species concept *H. varium* as keyed out here under 6a will be considered *H. varium* mod. *'varium'*, those keyed out under 6b as *H. varium* mod. *'tenax'*.

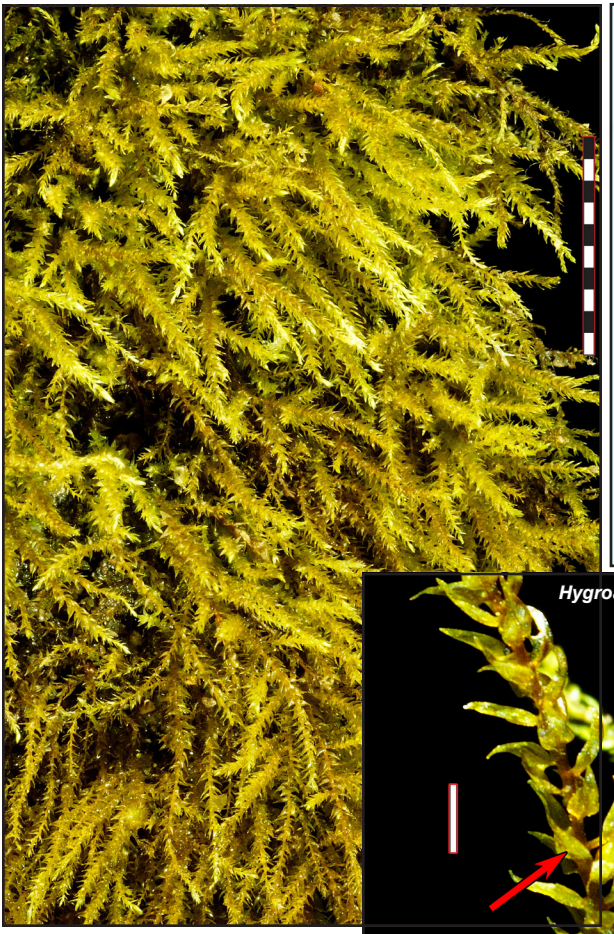
6a. **Soft plants**; **leaves green, with a weak but nearly percurrent costa, which is curved above**; commonly **with sporophytes**; usually growing on bark elevated above water-filled depressions, in many microhabitats of mesic and transitional forests, swamps, and rich fens
. . . . . *Hygroamblystegium varium mod.'varium'*

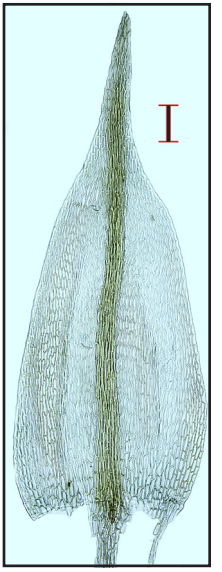
soft plants, irregularly branched, with sporophytes

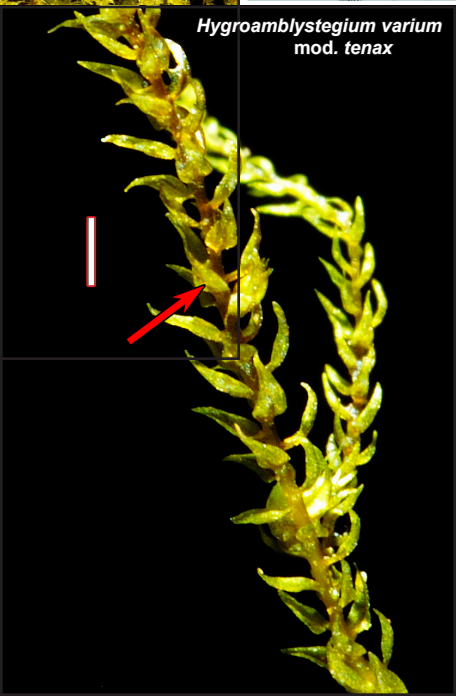


leaves with a green, weak costa, but nearly percurrent (ending in the apex of the leaf) and curved above

6b. **Stiff plants; leaves with a dark-colored, stout and straight costa**; sporophytes rare; in seepage and running water, attached to rocks or logs . . . . . *Hygroamblystegium varium* mod. *'tenax'*



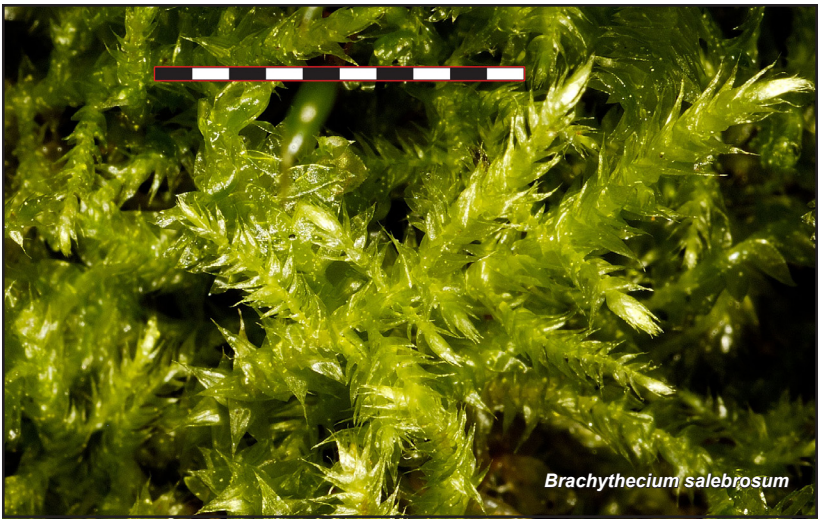




stiff plants (above)

stout costa, dark-colored (top right and right)

7a. Leaves **straight** . . . . . 8.
7b. Leaves curved, **falcate-secund** to **circinate**; [nearly all of the species with falcate leaves have also atypical, orthophyllous (straight-leaved) modifications: the most common one is *Drepanocladus aduncus*; for the other species the orthophyllous forms are usually found only in aquatic microhabitats] . . . . 10.

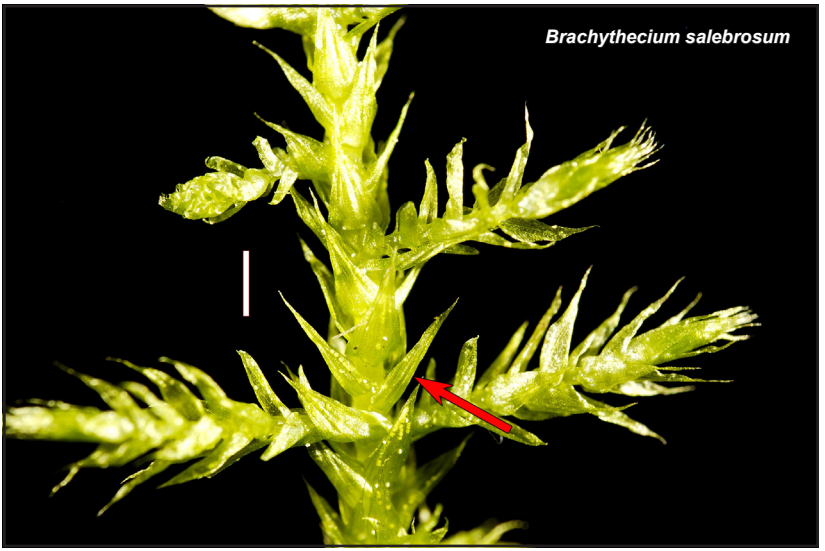


straight leaves

leaves falcate-secund (sickle shaped and curved towards one direction) to circinate (curved in a circle)

8a. Leaves distinctly **plicate**, narrowly lanceolate; **plants distinctly glossy and light yellow-green**; usually found in shaded microhabitats but rarely in very wet spots . . . . . *Brachythecium salebrosum*

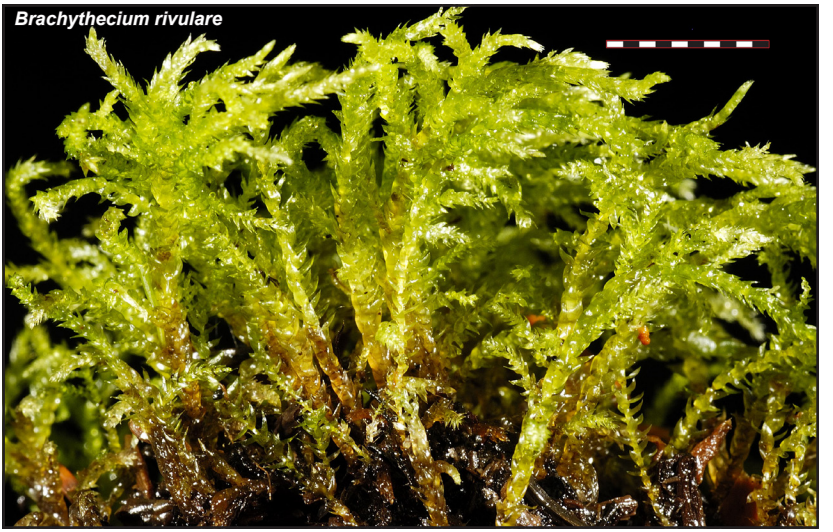
plants distinctly glossy and light yellow-green



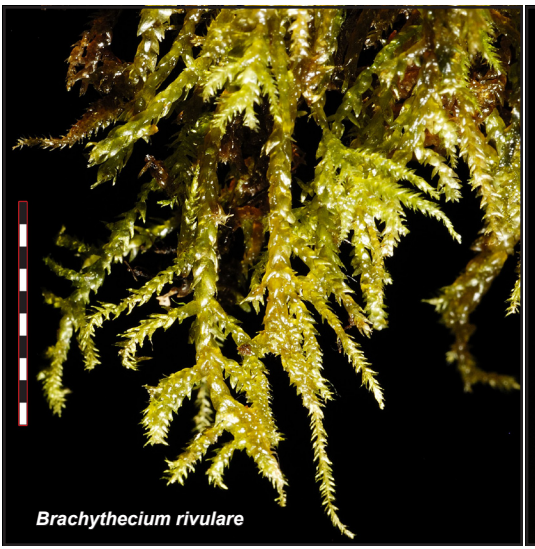
plicate leaves (with longitudinal folds)

8b. Leaves smooth, more ovate-lanceolate, apex often apiculate; plants moderately glossy to matte, darker . . . . . 9.

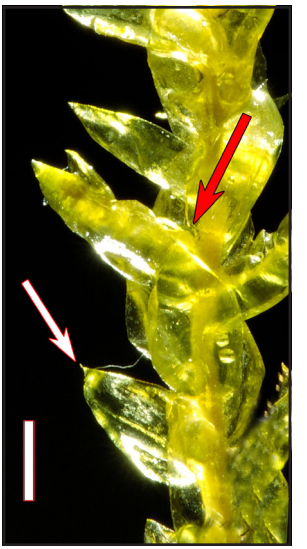
9a. Leaves, when typical, **apiculate**; plants somewhat glossy; usually in rich fens and in small seeps, as exposed patches with a **subdendroid growth form**, or draping downward in slowly flowing water on cliffs in a **fan-like pendant growth form** . . . . . *Brachythecium rivulare*



subdendroid (nearly dendroid or tree-like) growth form



pendant (drooping and fan-like) growth form



apiculate leaves, large alar cells

9b. Leaves ovate-lanceolate, never apiculate; plants matte; in shaded but unforested minerotrophic mesohabitats, **hidden underneath large amounts of vascular-plant litter** (wet meadows, etc.), also in ditches, lakes, and small pools (plants extremely variable, often in a straggly untidy growth form, also extremely common, certainly when there is some disturbance) . . . . . **orthophyllous** modification of *Drepanocladus aduncus* (see below for regular curved-leaved modification)

typical untidy aspect of patch underneath thatch in wet meadows, stems with orthophyllous leaves (straight leafed)

often with numerous sporophytes

COSTATE WETLAND PLEUROCARPS

10a. Populations usually semi-terrestrial, emergent in rich fens or minerotrophic wetlands . . . . . 11.
10b. Populations usually aquatic, floating along lake margins or in poor-fen pools . . . . . 12.

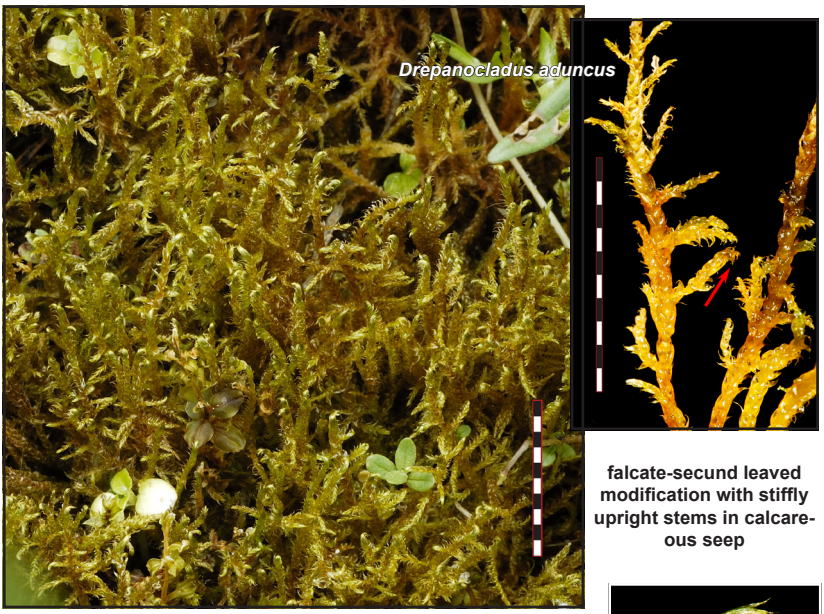
11a. Leaves strongly **falcate-secund** to **circinate**; plants **yellow-brown** to **reddish-brown, turgid** looking; plants in exposed patches in depressions and **along pool margins in calcareous and rich fens** (calcareous-fen indicator), often associated with marl formation and with *Scorpidium scorpioides* . . . . . *Scorpidium cossonii*

Scorpidium cossonii

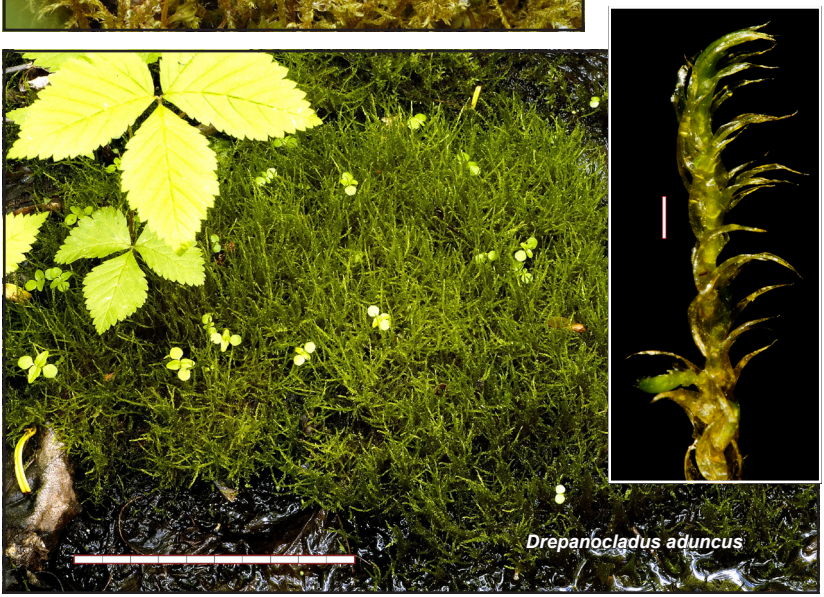
semi-terrestrial populations of turgid (swollen) stems along the edge of extreme rich-fen pools, yellow to reddish-brown (above)

leaves strongly falcate-secund (sickle shaped and curved towards one side) to circinate (curved around in nearly a full circle) (right)

11b. Leaves **curved** to **falcate-secund**; plants green or yellow-green without a swollen aspect; plants often hidden under graminoid thatch in all wetland and peatland types except poor fens and bogs, extremely common and very variable; in open, highly calcareous seeps, the species forms dense patches of stiffly upright stems, but then check also *Cratoneuron filicinum* . . . . . **curved-leaved modification** of *Drepanocladus aduncus*



falcate-secund leaved modification with stiffly upright stems in calcareous seep



curved-leaved modification in shaded mesohabitat

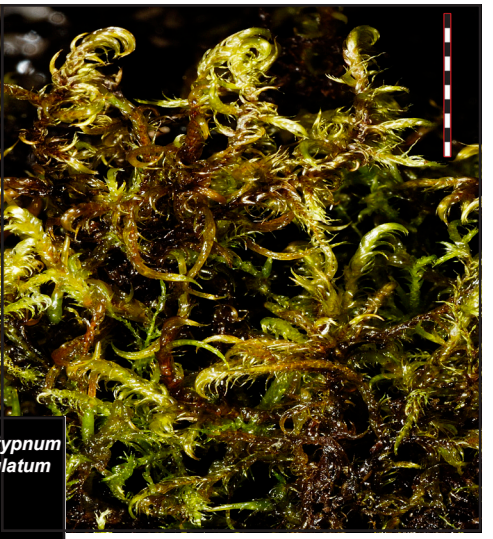
Illustrated Key

Costate Wetland Pleurocarps

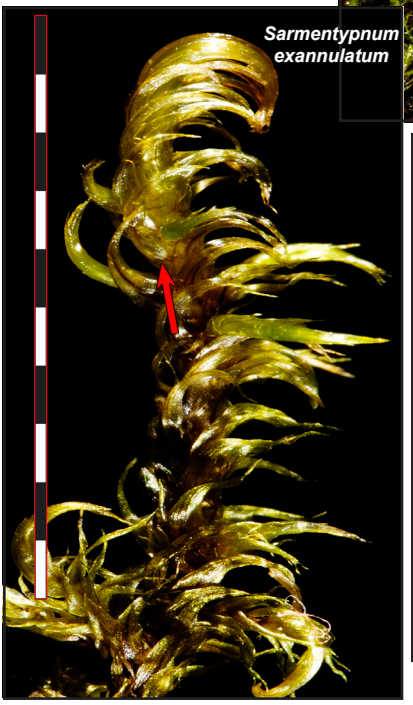
Taxonomic note: the following two species are extremes along a continuous scale of variation, which also includes several other, far more rare species in MN, with very similar habitat preferences and phenotypic aspect.

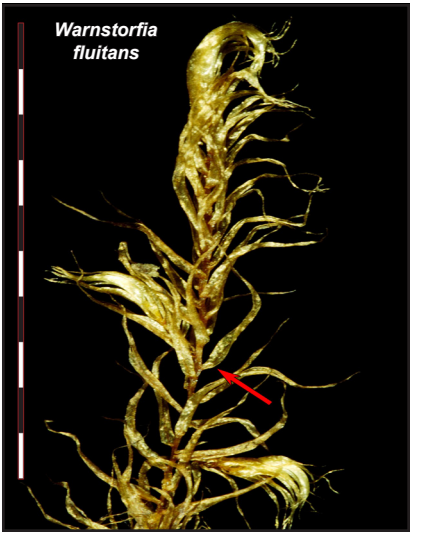
12a. **Costa long** and stout, reaching beyond midpoint of leaf and sometimes percurrent, alar cells in a very well-defined group; **leaf insertion wide**, not much contracted from the maximal width of the leaf; plants usually growing in lakes, submerged or floating, in minerotrophic conditions . . . . . *Sarmentypnum exannulatum*

12b. **Costa short**, only reaching half-way up the leaf; alar cells less obvious; **leaf insertion** contracted, **narrow**; plants usually growing in peatlands, often quite acidophilous and associated with *Sphagnum* . . . . . *Warnstorfia fluitans*



costa long, leaf insertion wide



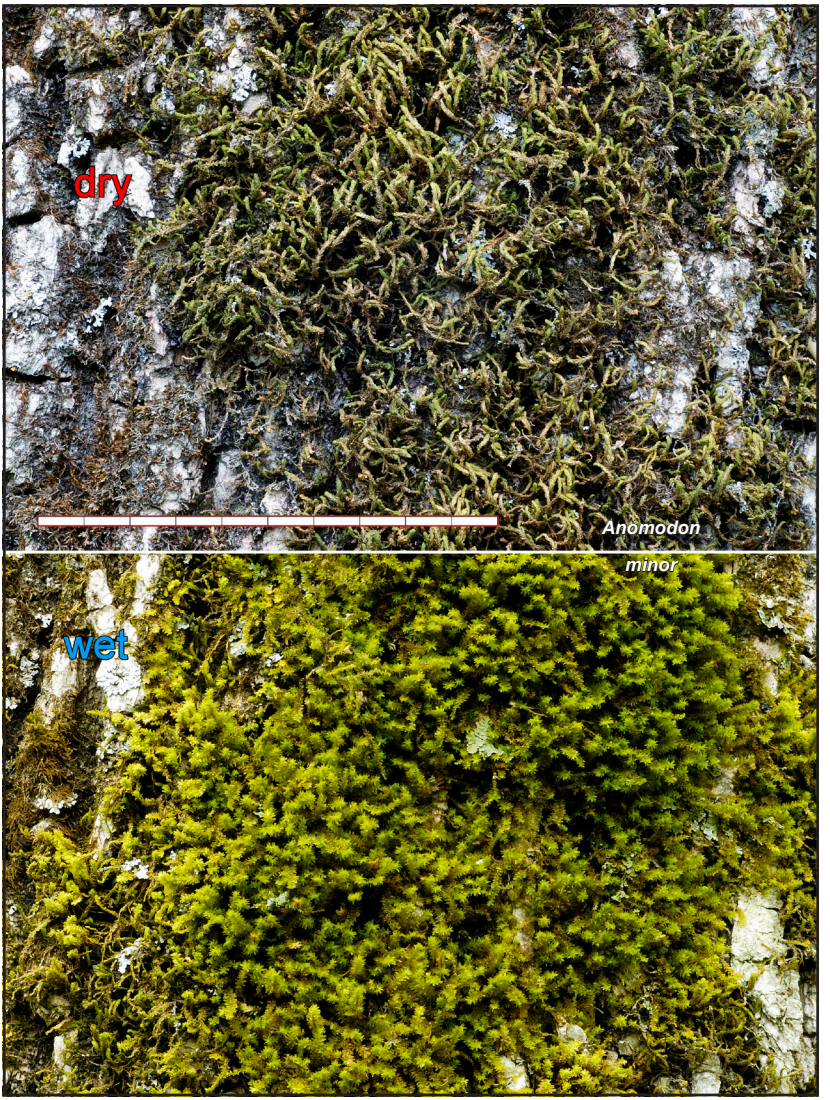


costa short, leaf insertion narrow

Illustrated Key to Costate Upland Pleurocarps

1a. Plants matte and dull green when dry, **strongly altered when wetted**; usually growing on the bark of the trunk of hardwood trees, often way above the soil surface, less commonly on exposed rocks and boulders . . . . . 2.

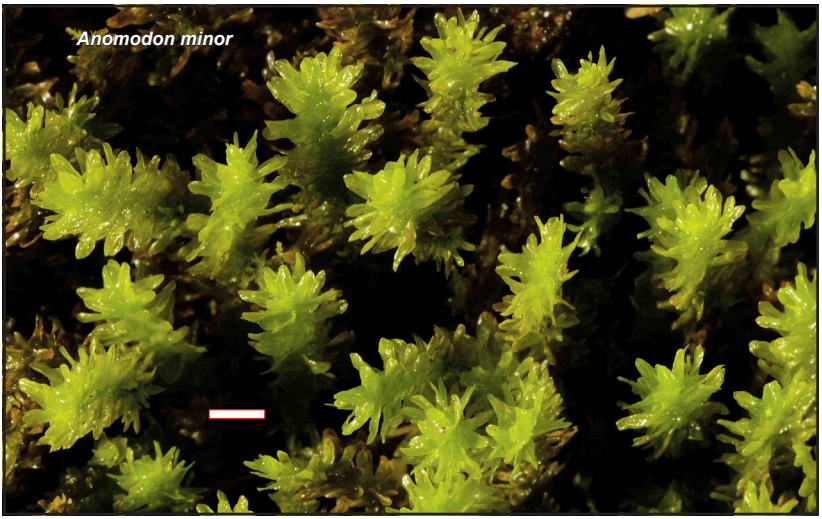
1b. Plants with some luster or glossy, less obviously altered when wetted; usually growing on cliffs, soil, rocks, and fallen logs or rotting stumps, or partly creeping up the base of hardwood trees . . . . . 6.



altered when wetted: dry (top) versus wet (bottom)
(both pictures are of exactly the same area of a patch and at the same scale, but several of the peripheral plants have expanded beyond the frame)

2a. Leaves **homomallous** or **subsecund** (turned in one direction) when wet and branches appearing flattened or **complanate** . . . . . 3.

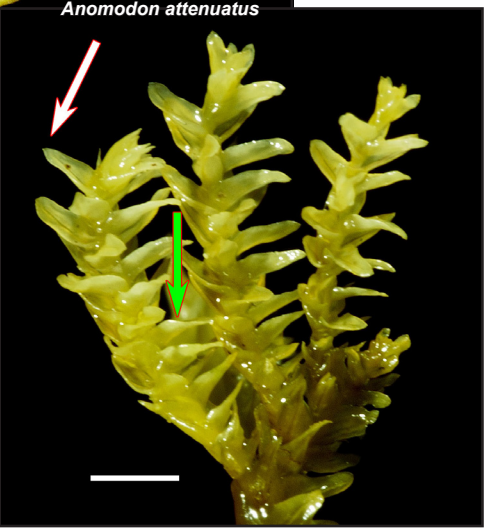
2b. Leaves **heteromallous** (pointing in all directions) and branches thus appearing **rounded** or sometimes even terete (with leaves strongly appressed) . . . . . 4.



homomallous leaves forming complanate branches

heteromallous leaves forming rounded branches

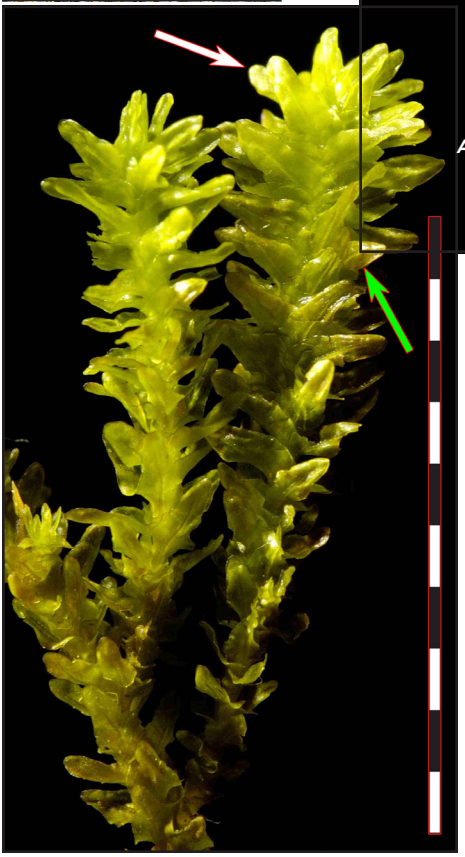
3a. Plants with regular branches with large leaves but others also extending farther as narrow flagella with very small leaves (**flagelliform branches**), or with these attenuated branches mixed among the regular ones; leaves **distinctly shouldered** with narrow, **apiculate** apices; on hardwood bark, or cliffs and boulders . . . . . *Anomodon attenuatus*



flagelliform branch (dry, above);

apiculate apex (white arrow) and distinct shoulders (green arrow) (wet, right)

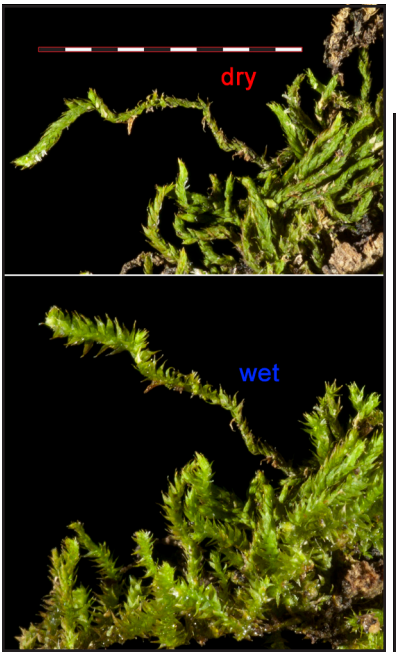
3b. Plants without attenuated flagelliform branches, all similar; leaves with wide, **obtuse** apices and **without distinct shoulders**; on hardwood bark, rarely on calcareous rocks . . . . . *Anomodon minor*



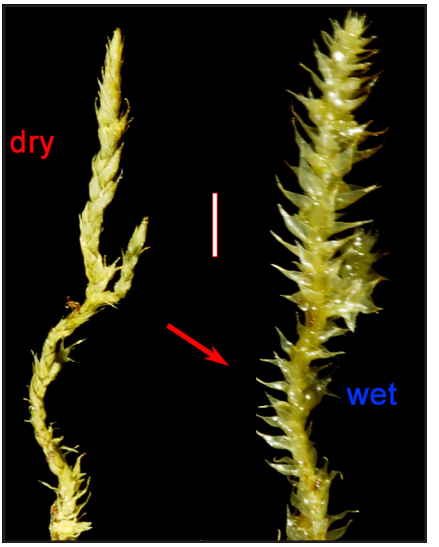
all branches similar (dry, right);

obtuse apex (white arrow) and shoulders not distinct (green arrow) (wet, below)

4a. Leaves **tightly appressed when dry**, suddenly springing out to **spreading** and even squarrose **when wetted**, with long and **narrow, acuminate apices**; on the trunk of trees, often along roadsides . . . . . *Lindbergia brachyptera*



tightly appressed leaves when dry, spreading-squarrose when wet; with narrow acuminate apices

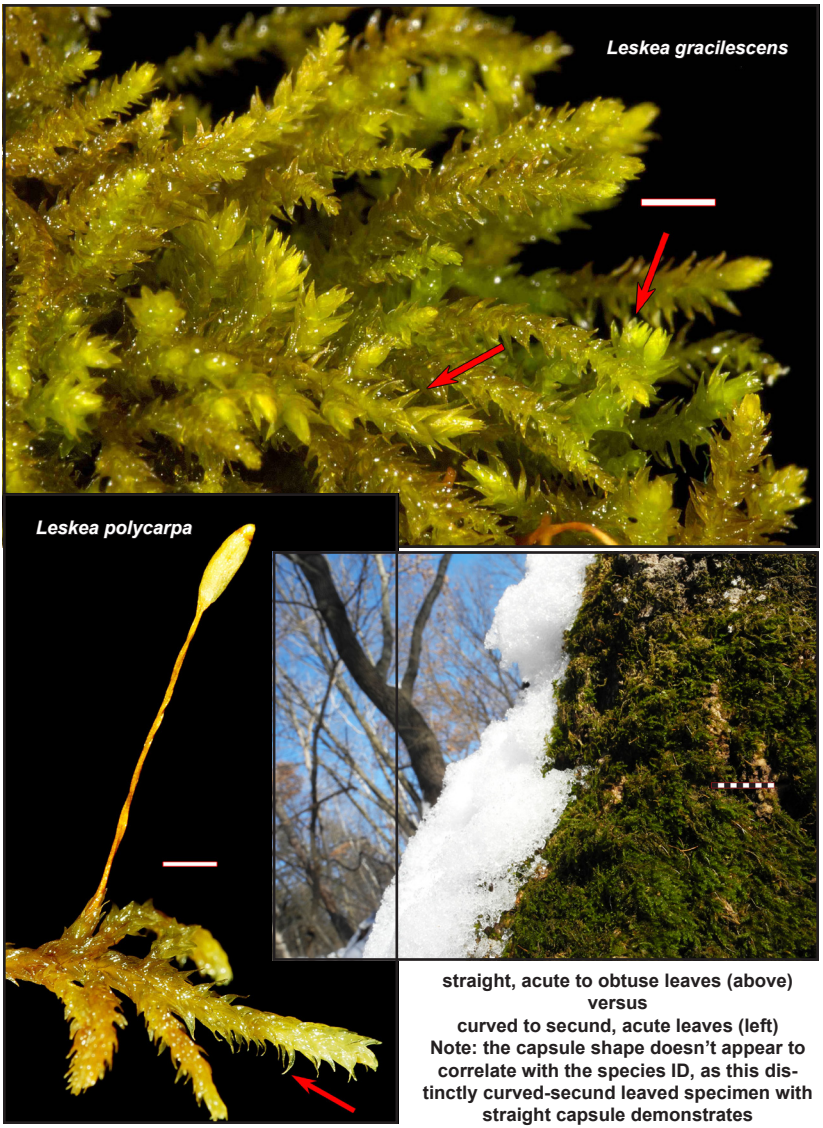


4b. Leaves less obviously responding to wetting, with short acute apices; frequently found as epiphytes on bark of living trees in floodplain forests above the high spring-flood water line . . . . . 5.

Taxonomic note: the following two species are very close, and I have not been able to separate them satisfactory among the MN collections, even with mature capsules or when using critical microscopic characters listed in other keys.

5a. Leaves not longer than wide, **straight**; capsules usually erect (?). . . . . *Leskea gracilescens*

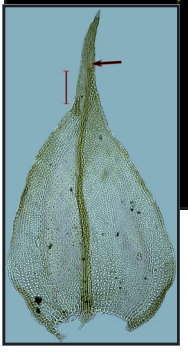
5b. Leaves longer than wide, **curved to secund at the branch tips**; capsules usually curved (?). . . . . *Leskea polycarpa*

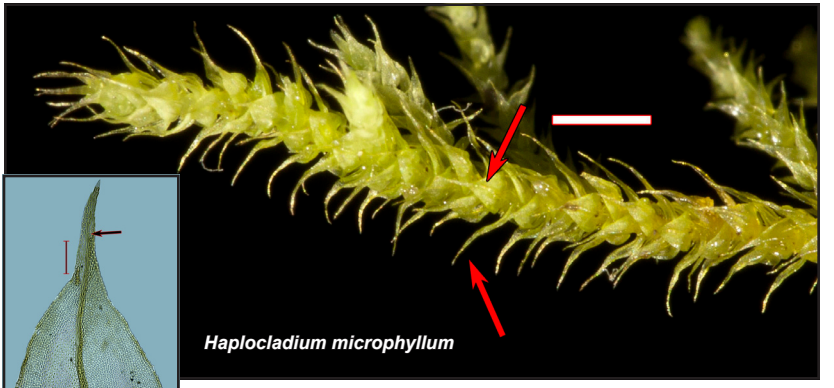


straight, acute to obtuse leaves (above) versus curved to secund, acute leaves (left) Note: the capsule shape doesn't appear to correlate with the species ID, as this distinctly curved-secund leaved specimen with straight capsule demonstrates

6a. Leaves with **short costae** not reaching the leaf apex. . . . . 7.
6b. Leaves with obvious **percurrent to excurrent** costae . . . . . 8.

Short costae, not obvious macroscopically (inset: ending at arrow)

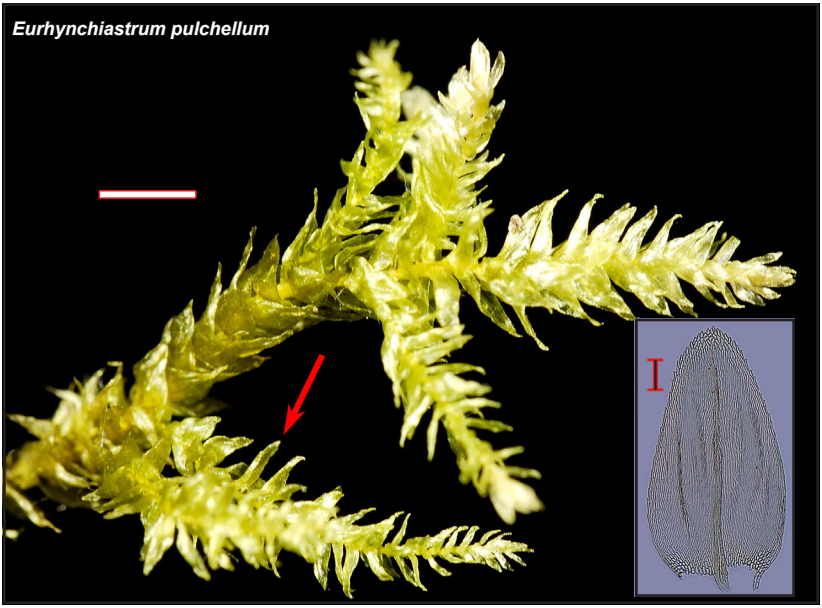




percurrent or excurrent costae (filling apical point)

7a. Branch leaves with **bluntly acute or narrowly rounded-obtuse apices**, **smooth**, **erect-spreading,** stem leaves acuminate; plants somewhat **matte**; usually found on the forest floor on humus or right at the base of trees and rotting stumps . . . . . *Eurhynchiastrum pulchellum*

erect-spreading leaves and somewhat matte plants, with many upright branches (arrow)



many smooth branch leaves with obtuse apices

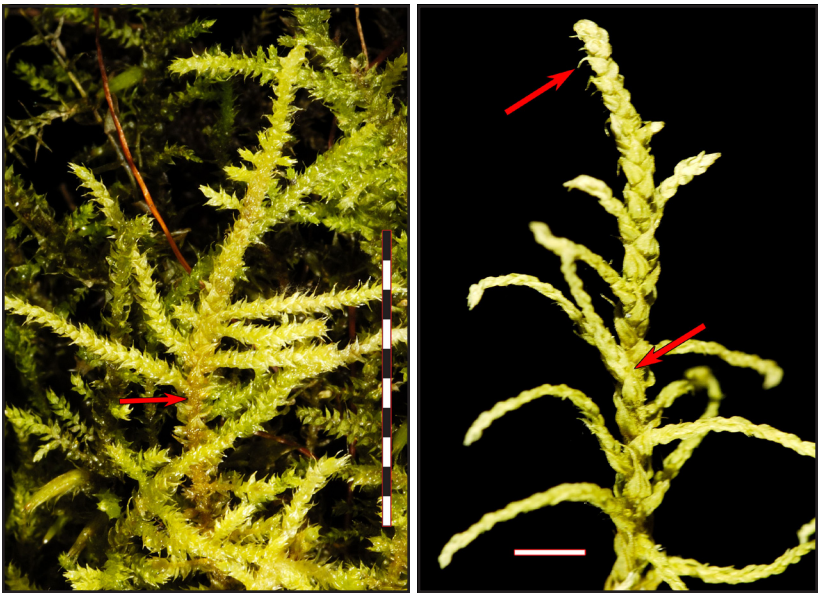
7b. All leaves sharply **acuminate**, somewhat to highly **plicate** and often strongly **appressed**; plants highly glossy; extremely common, on all kinds of substrates in mesic to dry microhabitats . . . . . *Brachythecium acuminatum*

highly glossy plants

acuminate, appressed, and plicate (arrows) leaves

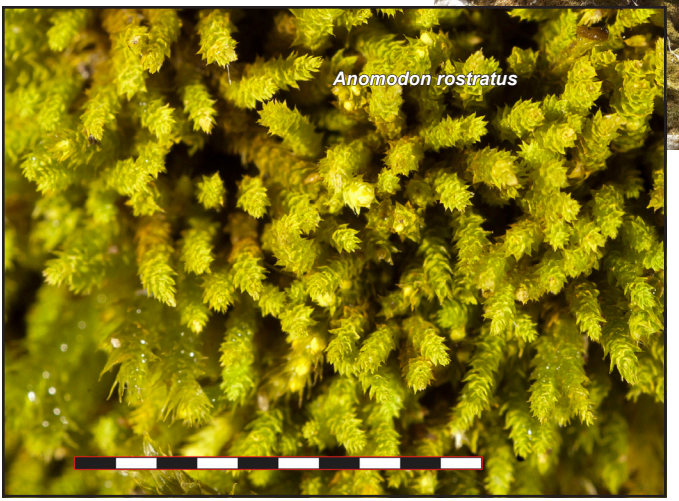
8a. Plants forming **extensive flat mats**, often uni-pinnately branched and most **branches growing flat along the substrate**; stems with **paraphyllia**; **percurrent costae** of the stem leaves of the same color as the leaves; in shaded mesic sites on soil, rock, bark, and rotten wood, often along the edges or even in the middle of trails . . . . . *Haplocladium microphyllum*

extensive flat mat with uni-pinnate branches growing flat along the substrate



single pinnately branched stem (left: wet, right: dry) with paraphyllia and excurrent costa with non-hyaline tips

8b. Plants forming bulging mats, irregularly branched and **branches curving upwards away from substrate**; stems without paraphyllia; leaves with **hyaline tips** formed by **excurrent costae**: usually on dry to mesic cliffs . . . . . *Anomodon rostratus*



smooth mat with upturned branches

up-curving branches and excurrent, hyaline-tipped costae (arrow)

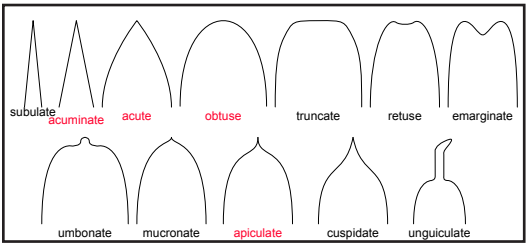
NOTES:

Illustrated Key to Ecostate Pleurocarps on Peat

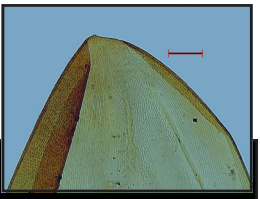
1a. Leaves ovate, at the end of the branches **enrolled**, either **obtuse** or with a very small apiculus (**apiculate**) 2.

1b. Leaves **acute** to narrowly **acuminate** . . . . . 3.

2a. Leaves straight, usually with an obtuse apex; stems with a slightly complanate (flattened) aspect; young branch tip forming **sharp point** with **enrolled leaves**; in extreme rich fens (calcareous-fen indicator in MN, but growing in grassy lawns in Europe as a ruderal species!) . . . . . *Calliergonella cuspidata*

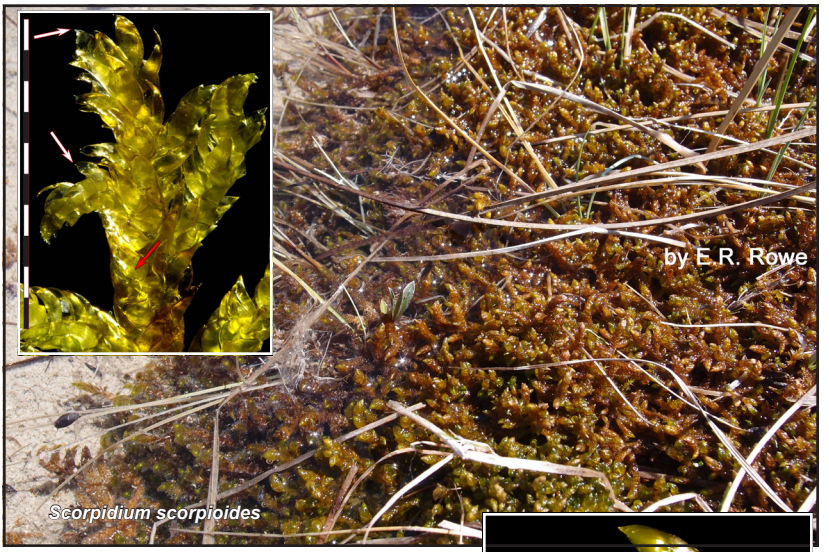


bryophyte leaf-apex shapes

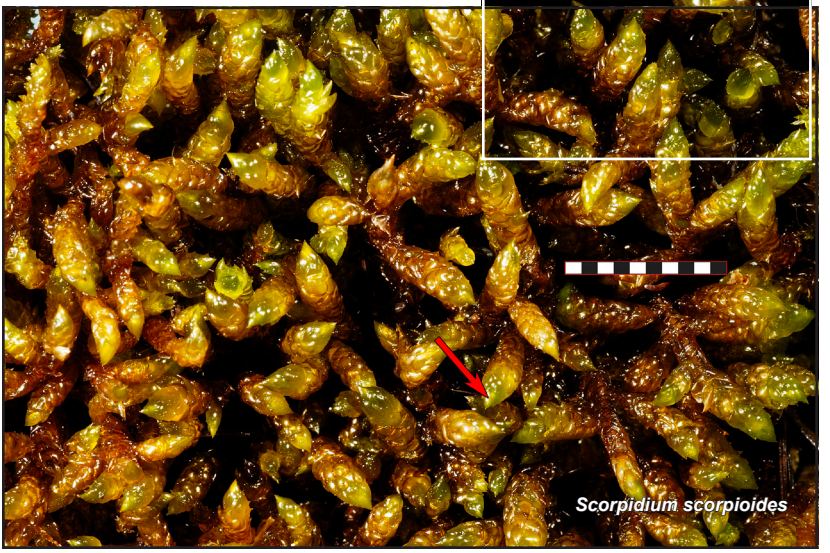


upper right: obtuse leaves and enrolled leaves forming sharp branch tips
left: flattened leaves give a somewhat complanate aspect to plants

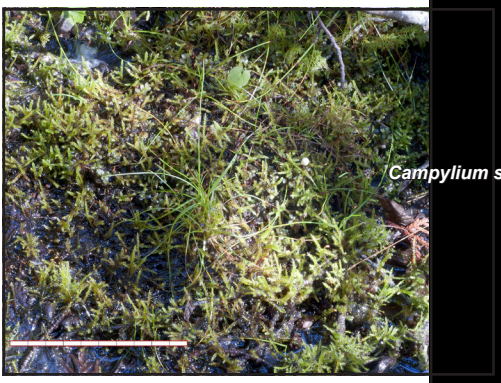
2b. Leaves **curved-secund** at the tip of branches and stems, usually with an **apiculate** apex; stems **rounded**; young branch with **hooked** tips formed by the **enrolled** leaves; plants often growing as separate, nearly unbranched, **worm-like** and black or **dark-reddish strands** in marl pools (calcareous-fen indicator in MN), or forming denser and greener clones on the edge of rich-fen pools, rarely floating in highly minerotrophic flark pools and lakes. . . . . *Scorpidium scorpioides*

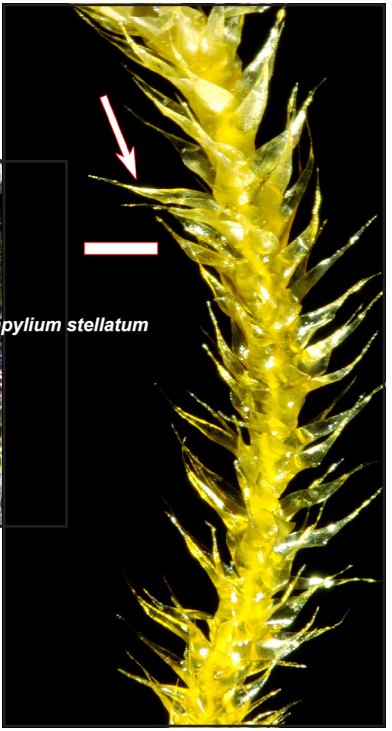


population along edge of rich-fen pool (above)
insets: apiculate,ecostate leaves (above) and hooked branch tips with enrolled leaves (middle)
large worm-like plants with distinct brown-reddish coloration and rounded, pointed branches (below)

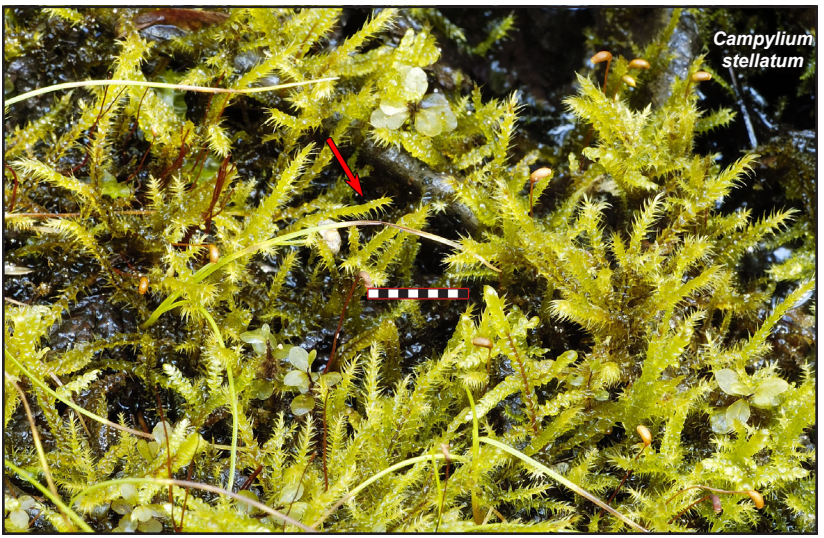


3a. Leaves **straight, stiffly erect-spreading**, upper part distinctly differentiated, **subulate**; plants growing in open rich fens (calcareous-fen indicator in MN) growing as small hummocks in drier microhabitats . . . . . *Campylium stellatum*



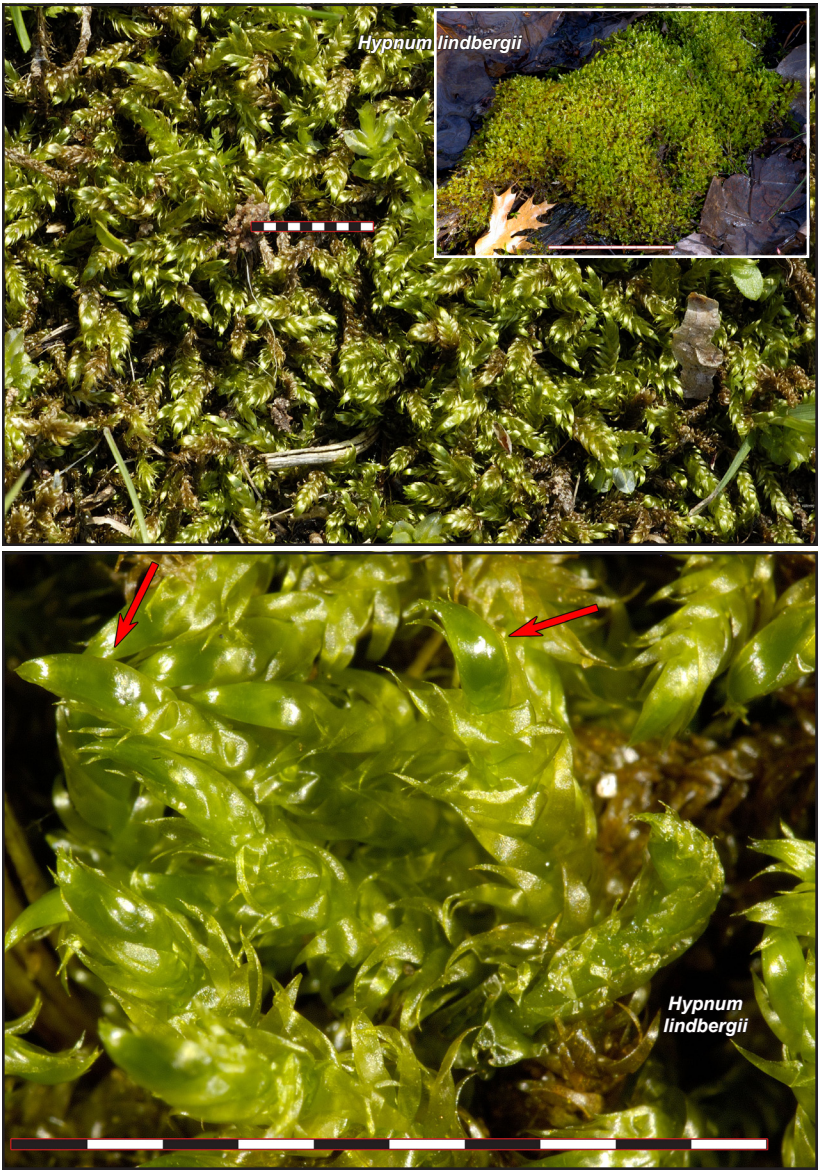


straight, stiffly erect-spreading, subulate leaves (distal half channeled)



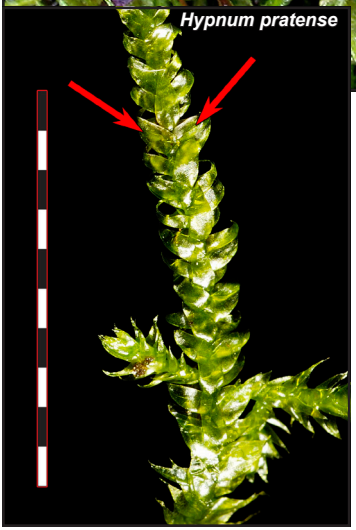
3b. Leaves always **curved- to falcate-secund**; upper part of leaf not abruptly differentiated from lower . . 4.

4a. Plants not complanate, leaves distinctly **falcate-secund** and **radially inserted**, not wrinkled; in wet depressions in swamps and rich fens . . . . . *Hypnum lindbergii*



falcate-secund leaves and
plants not complanate, with smooth leaves distinctly radially arranged

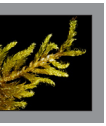
4b. Plants with a more **complanate** aspect, leaves rather curved than falcate and **decurved**, often wrinkled; usually on rotten wood in swamps, but also in rich fens, sometimes even mixed with *Hypnum lindbergii*, frequently has a very distinctive 'algal' smell . . . . . *Hypnum pratense*



plants with complanate aspect and somewhat wrinkled leaves (above)

decurved leaves (curved downward), distinctly arranged in two rows (left)

NOTES:



Illustrated Key to Ecostate Pleurocarps on Bark, Wood, or Rocks

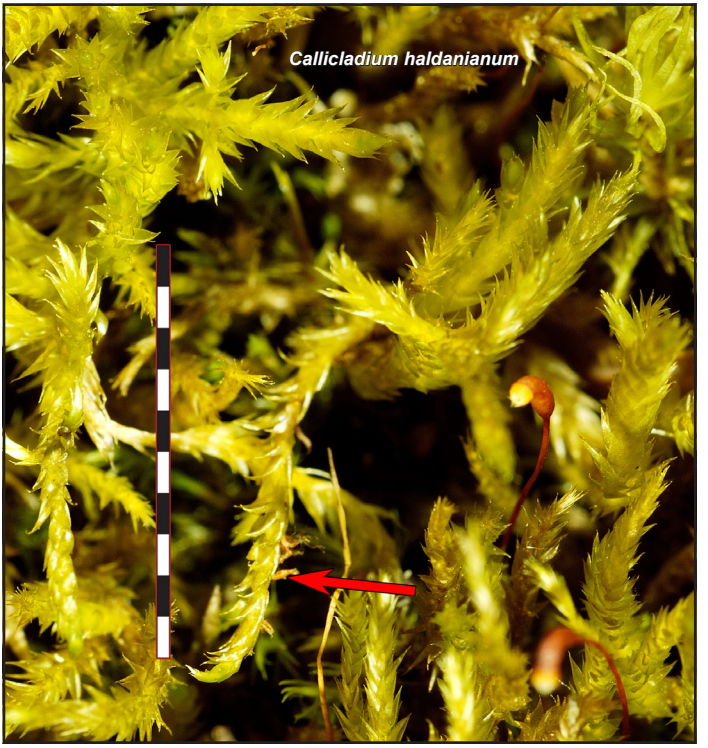
1a. Plants forming distinct **fans**; leaves **undulate**; on hardwood trees and cedars, rarely on rocks . . . . . *Neckera pennata*

fan growth form: downward growing branches on vertical bark, curling away from the substrate at their tip

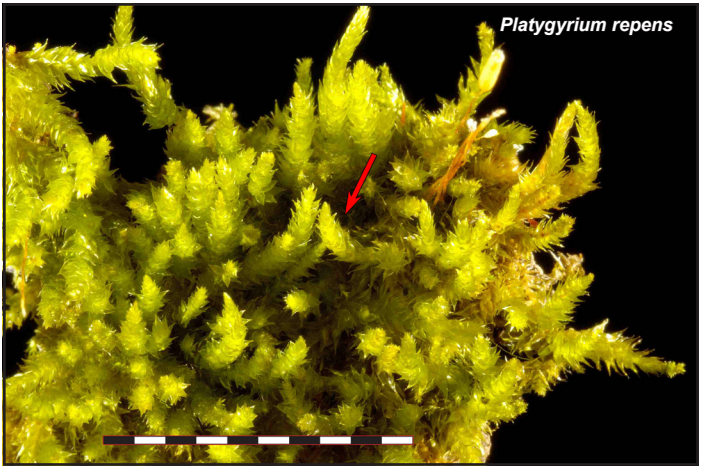
pendent branch with undulate leaves (transversely wavy)

1b. Plants forming mats; leaves not undulate . . . . . 2.

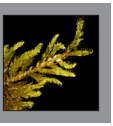
2a. Larger plants (leaves usually > 1 mm) with **somewhat flattened** to strongly complanate branches . . . . 3.
2b. Smaller plants (leaves usually < 1 mm) with **rounded branches**, often curved away from the substrate . . . . . 4.



somewhat flattened branches

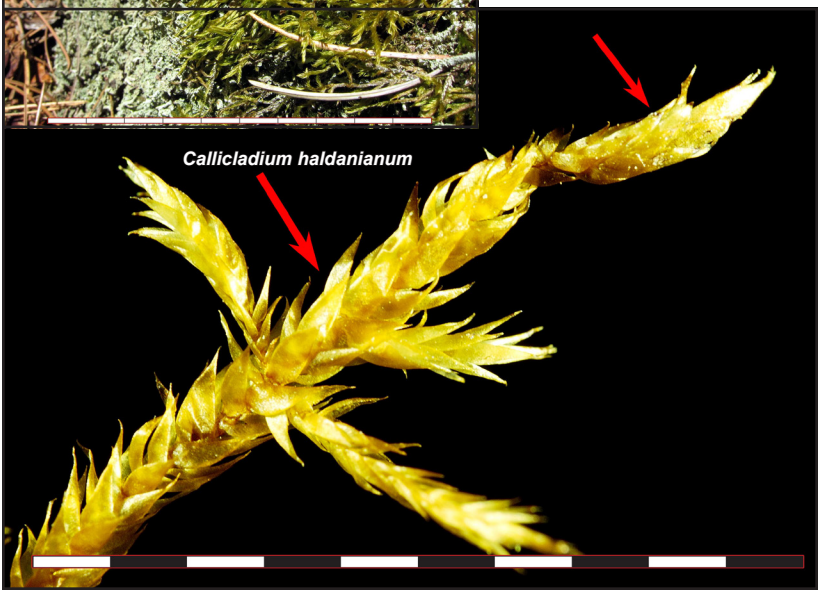


rounded branches

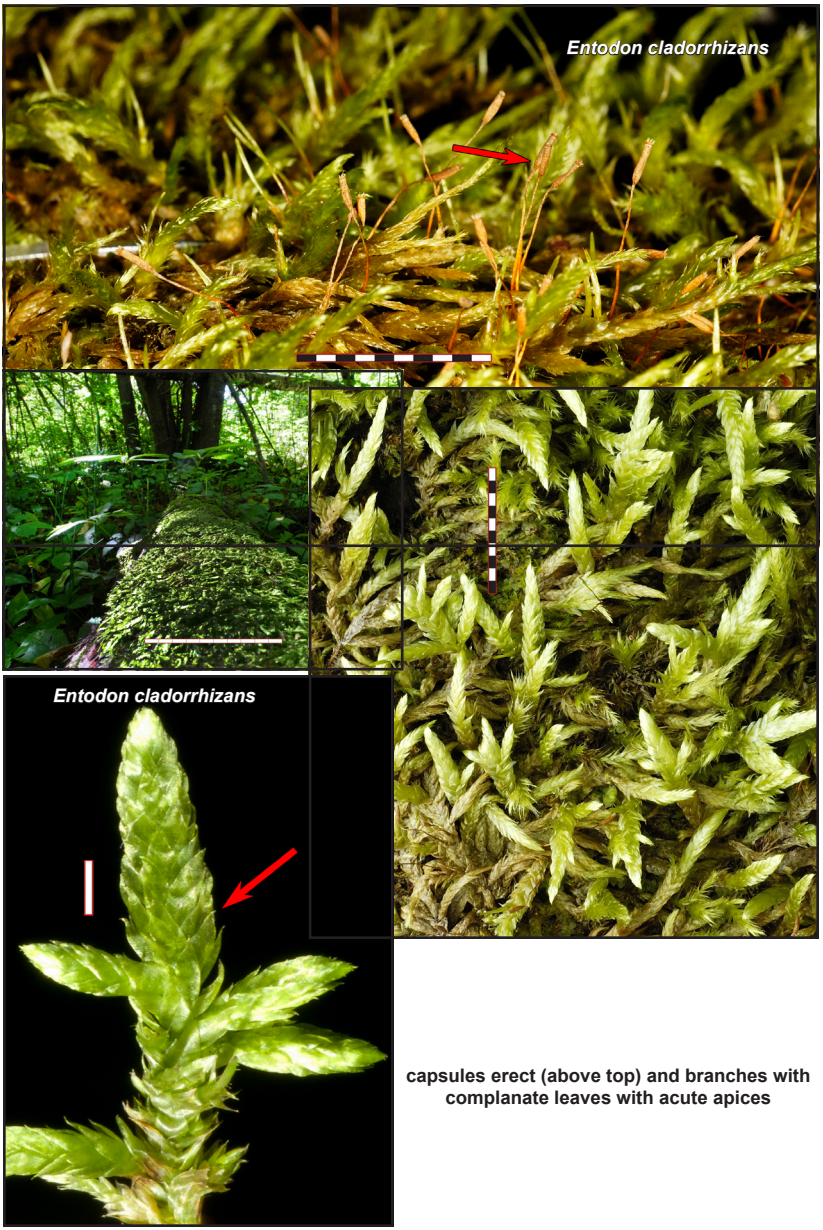


3a. Moderately shiny plants with narrowly ovate-lanceolate and curved leaves with **acuminate apices, branches (and uniquely also the leaves) curved upwards** away from the substrate (sword moss); capsules **curved** extremely common in all forested mesohabitats, nearly always growing on the base of conifers and hardwood trees but also found on all other substrates in mesic and wet mesohabitats . . . . . *Callicladium haldanianum*

capsules curved and both branches and acuminate, highly glossy, leaves turned up

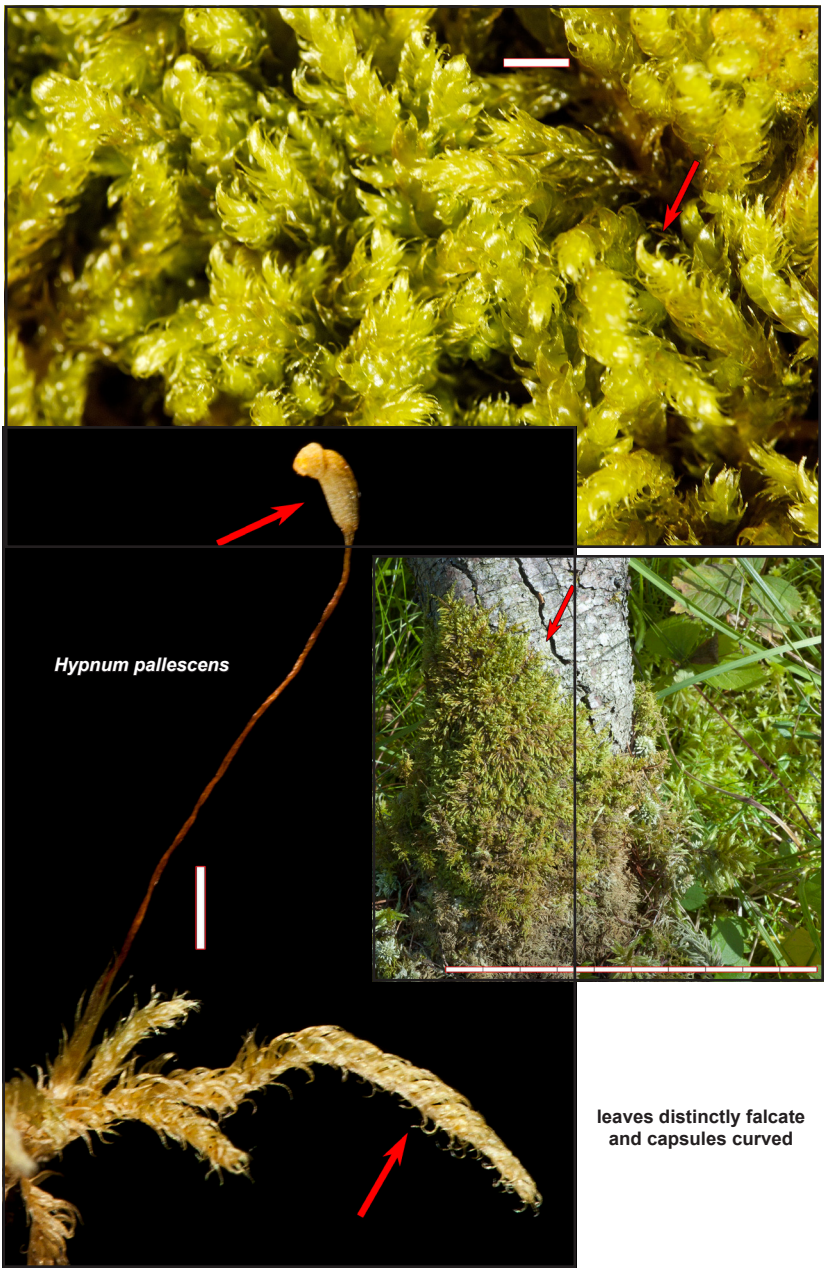


3b. Very glossy plants with wide ovate-lanceolate and **straight** or slightly curved downward **leaves with acute apices, complanate** on branches appressed to the substrate; capsules **erect**; mostly on rotten wood in mesic forests, sometimes on soil or rocks . . . . . *Entodon cladorrhizans*



capsules erect (above top) and branches with complanate leaves with acute apices

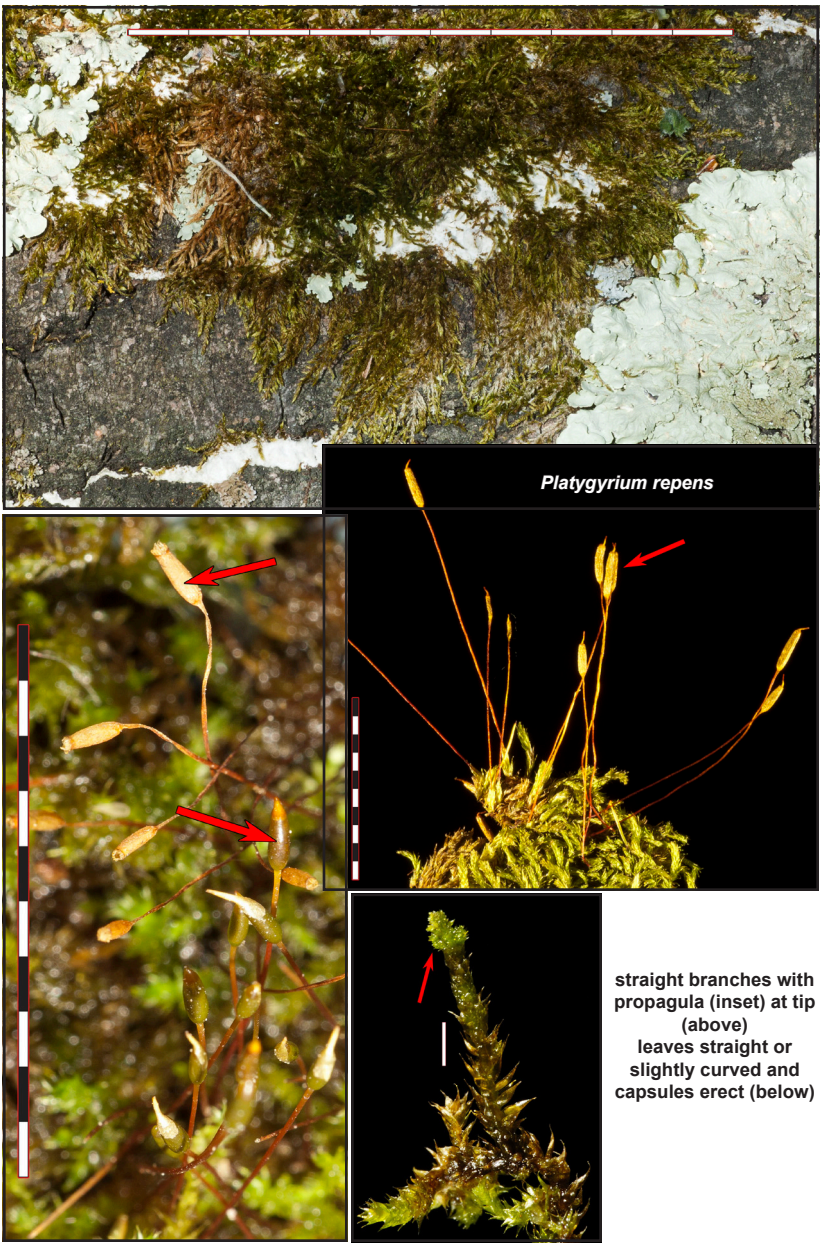
4a. Leaves distinctly **falcate**; capsules curved; on bark in dry-mesic forests, also commonly on rocks . . . . . *Hypnum pallescens*



leaves distinctly falcate and capsules curved

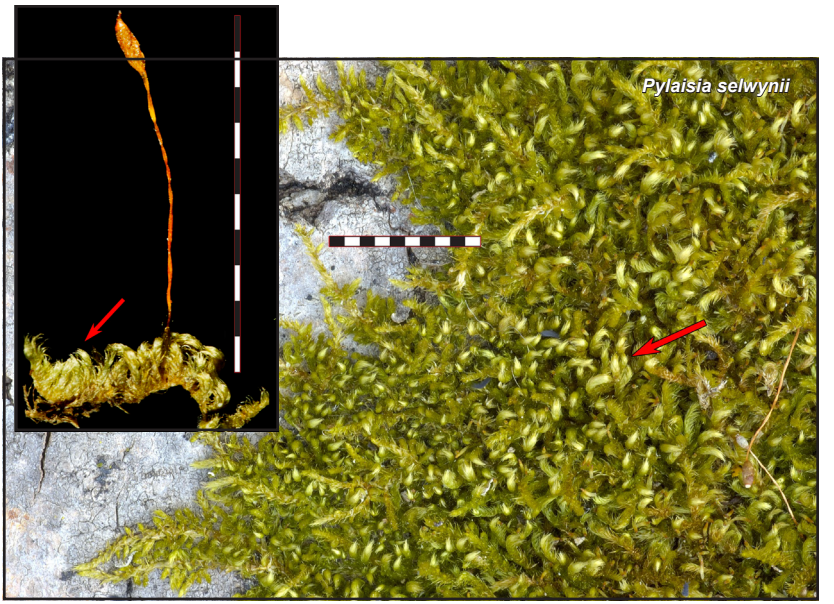
4b. Leaves **straight or curved**; capsules **erect** . . . . . 5.

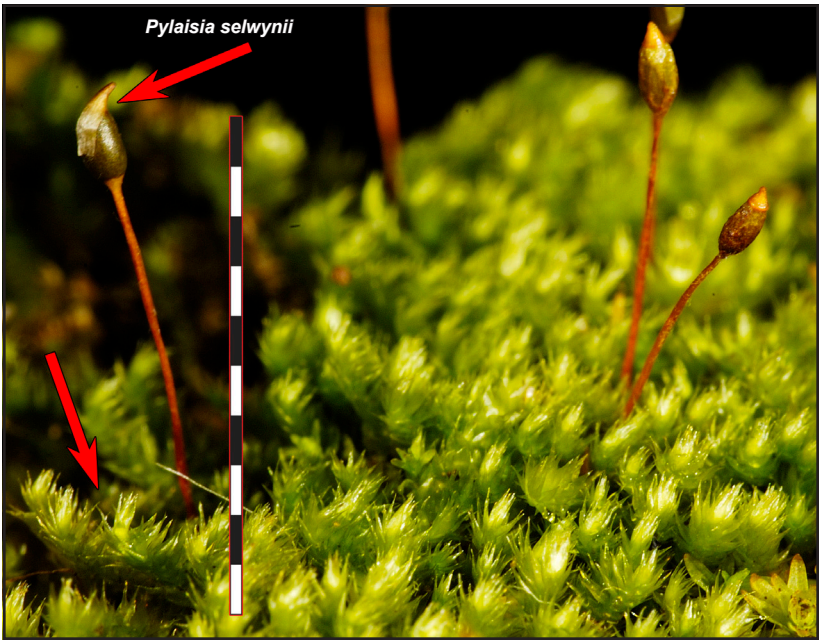
5a. Dark-green to golden-brown plants with **clusters of propagula** near the tip of **straight** or only slightly curved **branches**; most common on fallen, rotten logs. . . . . *Platygyrium repens*



straight branches with propagula (inset) at tip (above)
leaves straight or slightly curved and capsules erect (below)

5b. Bright yellow-green glossy plants with **upcurved and curly branches** without propagula; mostly on bark of hardwood tree trunks . . . . . *Pylaisia selwynii*





upcurved and curly branches (dry above, wet below) and capsules erect

NOTES:

Keys (text only)

Main Key

1a. Plants **thalloid** . . . . . THALLOID LIVERWORTS
1b. Plants **leafy** . . . . . 2.

2a. Leaves without a **costa** (= medial nerve), often irregularly shaped, **lobed**, or **ciliate**, always inserted in two or three longitudinal rows; the leaves that form the third, ventral row (**underleaves**), if present, are smaller and quite different in shape from the dorsal ones . . . . . LEAFY LIVERWORTS
2b. Leaves with or without a **costa**, unlobed and mostly longitudinally symmetric, **spirally** (= helically) inserted, or rarely **distichously** (= strictly in two rows), but then with costae. . . . . 3. Mosses

3a. Plants with branches in bundles ('**fascicles**') spirally arranged around the stem and usually clustered in a dense head ('**capitulum**') at the tip; color pale green in shade but in exposed habitats plants often pigmented with **yellow-brown**, **brown**, **yellow**, or **red** . . . . . *SPHAGNUM*
3b. Plants unbranched, or if branched, branches not clustered in fascicles or capitula; plants with younger leaves mostly yellow-green to dark green, without dense reddish pigments . . . . . True Mosses 4.

4a. Leaves **distichously** inserted, of the ***Fissidens*** type (leaves alternate, in two opposite rows, giving the plants the aspect of small fern fronds, with an apical and abaxial lamina and two adaxial vaginant laminae, forming a boat-shaped structure inserted on the stem); in dark-green turfs in rich fens and along the edge of pools and creeks . . . . . *Fissidens adianthoides*
4b. Leaves spirally inserted along stems and branches (even when plants have a **complanate** (= flattened) aspect, the leaf insertions are still helically arranged around the stem) . . . . . 5.

5a. Plants terrestrial, growing upright as a **cushion** or **turf** (see table below), stems without branches, or if branched, by stem-like **innovations** from below (but also check *Hedwigia ciliata*) . . . . . 6.
5b. Plants **dendroid** or growing as a **mat** or **weft** (see table below), frequently profusely branched with distinct 2nd order branches, theses either **irregularly, sub-pinnately**, or **pinnately** arranged, or if poorly branched, stems and branches growing closely along the substrate (also including aquatics) . . . . . Pleurocarps 8.

Growth-form table, specific only for the species further covered below

Cushion	Rounded domes, shoots clearly radiating from central point of origin (never aquatic)
	Small cushion: radiating shoots short, a few cm at most
	Large cushion: radiating shoots often one to several dm long
Turf	Parallel stems mostly growing vertically; branches, if present, are innovations, eventually becoming stems (never aquatic)
	Short turf: stems up to a few cm tall
	Tall turf: stems from several cm to up to several dm tall
Dendroid	Upright stems unbranched below, branches densely clustered above (never aquatic)
Mat	Many side branches of determinate growth on horizontal stems of indeterminate growth, usually firmly attached to substrate when terrestrial; but also includes aquatics* and fan-shaped clones
	Smooth mat: stems and branches growing appressed to the substrate, often attached to it by rhizoids
	Rough mat: main stems adhering to the substrate, but branches growing in oblique or vertical directions
Weft	Intertwining side branches on intertwining and straggling main stems, the entire clone very loosely attached to substrate (never aquatic)

* plants growing semi-terrestrially or aquatically have no obvious attachment to substrate, but still have evident branches in the older parts

6a. Leaves with few to many upright **adaxial lamellae** (low, upright cell plates implanted in longitudinal direction on a narrow or wide costa, visible as darker green lines from above, sometimes hidden below translucent **overfolding** leaf laminae) . . . . . **POLYTRICHALES**
6b. Costa without adaxial lamellae . . . . . Acrocarps 7.

7a. Most leaves **curved** to one side to strongly **falcate-secund** *when wet,* sometimes undulate . . . . . **DICRANUM**
7b. Most leaves straight or at the most somewhat wavy when wet, not distinctly undulate, but sometimes strongly **contorted** and **crisped** when dry . . . . . **OTHER ACROCARPS**

8a. Plants distinctly **dendroid**; in forested swamps, most commonly in cedar swamps *Climacium dendroides*
8b. Plants not obvious dendroid, either growing as mats or wefts . . . . . 9.

9a. **Wefts**: plants in thick, loose carpets, very loosely attached to substrate and thus easy removed, growing on the drier parts of the forest floor in mesic mesohabitats and swamps (not aquatic) . . . . . **FEATHER MOSSES**
9b. **Mats,** terrestrial or **epiphytic**, including **pendent fans on tree trunks**: plants not as easily removed from their substrate; or aquatics and **semi-aquatic mats** in open wetlands and in pools of swamps . . . . . Other Pleurocarps 10.

The next dichotomy is hard to use in the field with only a handlens as tool, except with a 20 x: try to strip a wet stem of most leaves and hold it up against the sky as background lighting. Using transmitted light, it should be possible to see if there is a single, thickened central vein in at least one of the remaining leaves — then the moss is costate. This costa doesn't always extends all the way to the tip of the leaf but might stop halfway or 3/4 up. Some ecostate leaves (leaves without costae) might actually have a short double costa, which starts immediately at the insertion of the leaf as two different, but short prongs, rarely reaching half-way up the leaf (see next page).

10a. Leaves **costate** . . . . . Costate Pleurocarps 11.
10b. Leaves **ecostate** (without a costa or with a short double costa, hardly visible with a handlens) . . . . . Ecostate Pleurocarps 12.

11a. Wetland plants (always growing close or at the surface water table in mires and swamps) . . . . . **COSTATE WETLAND PLEUROCARPS**
11b. Upland plants (sometimes found in swamps and on floodplains, but then as epiphytes or on logs, not at the water table or submerged) . . . . . **COSTATE UPLAND PLEUROCARPS**

12a. Translucent and extremely **complanate** (flattened) plants; leaves distinctly asymmetric ovate-lanceolate . . . . . *Plagiothecium denticulatum*
12b. Matte or glossy plants with branches with rounded or a less complanate aspect; leaves mostly symmetric . . . . . 13.

13a. Plants growing on peat in swamps and rich fens . . . . . **ECOSTATE PLEUROCARPS ON PEAT**
13b. Plants growing as epiphytes on bark of living trees in forested mires or in swamps, or on bark, rotten wood, and rocks in forested upland mesohabitats (also check out *Hedwigia ciliata* in 'Other Acrocarps', which grows on rocks and boulders, is ecostate, and has a somewhat mat-like habit; however, it is still considered an acrocarp) . . . **ECOSTATE PLEUROCARPS ON BARK, WOOD, OR ROCK**

Key to Thalloid Liverworts

1a. Thallus **thick and often > 1 cm wide**, surface **opaque**, **ventral** and dorsal side looking distinctly **different**, on ventral side with **scales** sprouting a dense mat of **rhizoids** . . . . . 2.
1b. Thallus more **translucent** and **narrower**, ventral and dorsal side much less strongly differentiated, rhizoids rare or absent (specimens with abundant rhizoids belong to species not covered in this guide) . 3.

2a. Dorsal side of thallus patterned with **large** hexagonal areas (**areolae**) **CLEARLY visible** to the naked eye; plant, when crushed, with a distinct aromatic smell like citrus; thallus without gemmae cups; in wet forests, swamps, and on moist cliffs . . . . . *Conocephalum salebrosum*
2b. Dorsal side of thallus with **areolae barely** visible, only obvious with a handlens; plants not aromatic; dorsal thallus surface often with **gemmae cups**; in similar habitats as *Conocephalum*, but also in disturbed ones such as on recently burned forest floor . . . . . *Marchantia polymorpha*

3a. Thallus > 3 mm wide, at the most 1 cm, smooth, fleshy and greasy looking when wet, filmy when dry, **irregularly branched**; in calcareous and rich fens and on beaches . . . . . *Aneura pinguis*
3b. Thallus < 1 mm wide, **regularly dichotomously branched,** sometimes forming rosettes, the more common **aquatic modification** forming tangled mats; floating in pools and lakes, sometimes stranded and thallus then shorter and wider . . . . . *Riccia fluitans*
(*R. rhenana* is a slightly larger and diploid form of *Riccia fluitans* and might also occur frequently)

Key to Leafy Liverworts

The leafy liverworts are a numerous and complex group; proper identification is usually only possible by studying small microscopic structures. Most species have many look-alikes, but the ones listed here are all very common.

1a. Leaves with marginal **cilia**, giving the plants a fuzzy look under the handlens plants in tightly adhering mats on the lower bark of conifers, also frequently on dead wood . . . . . *Ptilidium pulcherrimum*
1b. Leaves without cilia . . . . . 2.

2a. Leaves unlobed and **simple**, but margins often **reflexed** and appearing folded (very obvious when dry), with serrated margins in well-developed plants; often in cedar swamps forming substantial flat patches in drier microhabitats or along the edges of pools. . . . . *Plagiochila asplenioides*
2b. Leaves with a more complex leaf shape (with large teeth, or retuse, lobed, or complicate-bilobed, see descriptions below) . . . . . 3.

3a. Leaves **complicate-bilobed**: with large dorsal lobe and a smaller ventral lobe hidden underneath which is transformed into a small water sac or **lobule**; on bark of both hardwood and cedar trees . . . . . *Frullania eboracensis*
3b. Leaves not complicate-bilobed . . . . . 4.

4a. Leaves with three, bluntly acute, **apical teeth**, but basically unlobed; plants with obvious stolons (narrow, thread-like branches with minute leaves) growing downward; in drier transitional forests often forming hemi-spherical small hummocks on the forest floor . . . . . *Bazzania trilobata*
4b. Leaves **bilobed** and/or **retuse** (obscurely lobed or merely notched); plants without obvious stolons (species with leaves with more than 2 lobes are not covered in this field guide and need microscopic examination for proper identification) . . . . . 5.

5a. **Bilobed** leaves, sharp-tipped on the younger branches, and with two rounded lobes or merely **retuse** leaves on the more mature branches; leaf insertion highly **oblique**, nearly parallel with the branch; on dead wood in shaded and humid microhabitats . . . . . *Lophocolea heterophylla*
(Other look-alike, entirely bilobed or entirely retuse species occur, but this one is the most common and the only one with sharply-tipped, round-lobed, and retuse leaves on branches of the same patch; others need careful observation of gametangial or microscopic structures for proper identification)
5b. All leaves similar, distinctly **bilobed** with **rounded tips**; leaf insertion nearly **transverse**; forming smooth, often blackish, mats on mud bottoms in bogs and poor fens or scattered among Sphagnum plants . . . . . *Cladopodiella fluitans*

Key to *Sphagnum*

Note: *Sphagnum* identification relies mainly on technical characters, best studied with stereo- and compound microscope. However, of the 25-30 species occurring in Minnesota, half might be identified with more or less reliability in the field. These species are presented in the key below. Those species names printed in blue font have very similar look-alikes (but with much rarer occurrence), and need to be confirmed when critical identification is necessary. Study only medium-sized branches and their leaves near the center of the capitulum.

1a. Branch leaves with **cucullate** (hood-shaped) apex, not pointed, apex rough at the back (abaxial side) . . 2.
1b. Branch leaves **pointed** (sometimes truncate and inrolled, appearing rounded), apex smooth at back . . . 4.

2a. Commonly with **red pigment**, if not visible in the branch leaves, **at least in the translucent stem**; forming low hummocks in bogs and poor fens, as well as in forested and open habitats . . . . . *S. magellanicum*
2b. Without red pigment, green, yellow-green, or light to dark brown . . . . . 3.

3a. Very **light-green** to yellowish-brown, loose plants, often with **long narrowly-pointed pendent branches**; in shaded alkaline habitats such as tamarack, alder, and cedar swamps, usually forming small hummocks . . . . . *S. centrale*
3b. **Brown compact carpets**, plants usually with short, **stubby branches**; often in exposed habitats, forming extensive wet lawns in poor fens . . . . . *S. papillosum*

4a. Plants red or splotched red-green (deep-shade specimens might be evenly green, and will need to be identified using structural characters) . . . . . 5.
4b. Plants without significant red pigment . . . . . 8.

The following four species are quite difficult to differentiate in the field. The only reliable characters are either microscopic, or the stem-leaf shape. Even the latter is not easily to study in the field, but with a bit of practice and a 20x handlens it might be possible to differentiate these four very common species. They can conveniently be grouped as 'small red section Acutifolia species'. These species are, however, distinctly different in their preferred habitat. There are also a number of much more rare, very similar look-alikes occurring in Minnesota, but all with a poorly documented record.

5a. Stem leaves **lingulate** with **rounded and notched** apex, or **short-triangular** . . . . . 6.
5b. Stem leaves **long-oblong** with **enrolled** or **pointed** apex . . . . . 7.

6a. **Terminal bud somewhat obvious**; stem leaf **lingulate** with **rounded** and often **notched** apex; branch leaves usually not obviously five-ranked; carpets usually **mottled green-red**; in poor to intermediate open or forested fens, growing in lawns or forming low hummocks . . . . . *S. russowii*
6b. **Terminal bud not differentiated**; stem leaf usually **short-triangular**; branch leaves usually strongly **five-ranked**; plants brownish green to red, and then **often with a bluish tint**; in highly minerotrophic forested peatlands . . . . . *S. warnstorfii*

7a. **Rounded capitulum**; branch leaves straight, not five-ranked; plants rarely solid red; usually in open or forested bogs and poor fens, forming low to high hummocks . . . . . *S. capillifolium*
7b. **Flat capitulum**; many branch leaves **slightly secund**, **somewhat five-ranked**; plants usually **solid red**; in open bogs and poor fens, forming extensive lawns and low hummocks . . . . . *S. rubellum*

8a. Plants **dull brown** to olive-green**, usually forming high hummocks**; if green, **stem still distinctly darkened**; **capitula** small, **densely packed**; in bogs and poor fens, usually in open areas . . . . . *S. fuscum*
8b. Plants not brown, or if brown, not forming high, densely compacted or tall hummocks . . . . . 9.

9a. Capitula **spherical**, plants individually elevated at different heights, forming a rough carpet that is obvious from a good distance, on fairly dry organic substrate; plants with strong, woody stem (breaks with an audible snap); most **fascicles with numerous (> five) branches**; most commonly in cedar swamps . . . . . *S. wulfianum*
9b. Capitula hemi-spherical or flat; plants forming a more uniform, **smooth carpet** or **straggling plants in wetter microhabitats**; plants with weaker stems, supporting each other or straggling; fascicles with fewer than six branches . . . . . 10.

10a. Branches in capitulum **twisted and curved**, branch leaves often **curved-secund**; plants in intermediate fens, in nearly aquatic habitats (floating mats, small clones just emergent) . . . . . *S. subsecundum*
10b. Branches not twisted, branch leaves straight (wet or dry), **squarrose-recurved** (wet or dry), or **wavy-recurved** (only when dry) . . . . . .11.

11a. Branch leaves with upper part **squarrose-recurved** but with the base clasping; plants large, **pale- or yellow-green**; commonly found in minerotrophic alder swamps, shrubby lagg areas, and wet meadows . . . . . *S. squarrosum*
11b. Branch leaves straight (wet or dry), or wavy-recurved, but only when dry (squeeze water out of some branches between thumb and forefinger); plants smaller, pale-green to yellow-brown, sometimes with a very slight tinge of red at the base of the branches; often growing in more oligotrophic or open peatland areas, but not exclusively . . . . . 12.

12a. Capitulum with **visible terminal bud** formed by enrolled stem leaves; branch-leaf margins straight when dry . . . . . 13.
12b. Terminal bud not easily discernible among the other branches in the capitulum; branch-leaf margins wavy-recurved when dry (use 20x handlens) . . . . . 15.

13a. Stem leaf **spatulate**, margin and apex fibrillose; in forested and alder swamps and in ecotones, forming **smaller hummocks** . . . . . *S. fimbriatum*
13b. Stem leaf lingulate-oblong, only apex fibrillose . . . . . 14.

14a. Plants usually **brown**, stem dark; **some branch leaves on lower fascicles squarrose-recurved** (most obvious when dry); in forested swamps or along lake edges, forming large carpets . . . . . *S. teres*
14b. Plants always **green**, stem green; all branch leaves **straight**, even on older portions of plant; most often on paludifying forest floor . . . . . *S. girgensohnii*

15a. Young **pendent branches in pairs** among arms of capitulum; plants in shaded habitats green or **yellow-green**; in more exposed situations yellow; growing in hollows in bogs and poor fens, forested or open, but usually not submerged (most common *Sphagnum* species in Minnesota) . . . . . *S. angustifolium*
15b. Young **pendent branches single or not differentiated from spreading branches**; plants **dark brown**; in very wet depressions or pools in open poor fens, often forming floating carpets . . . . . *S. majus*

Key to Polytrichales

1a. Costa narrow with **few adaxial lamellae**; leaves strongly **crisped** when dry . . . . . *Atrichum crispulum*
1b. Costa very wide (leaf lamina not obvious), **many adaxial lamellae**; leaves not crisped when dry . . . . 2.

2a. When dry leaves **appressed** (folded against the stem), when wet **erect-spreading**, standing out straight; **leaf laminae enrolled** over the lamellae; lower part of stem covered with **white tomentum** (when water is squeezed out); in *Sphagnum* habitats, usually on high hummocks in bogs [if not among *Sphagnum*, mind the look-alike *P. juniperinum,* usually with less tomentum development]. . . *Polytrichum strictum*
2b. Leaves less closely appressed when dry, when wet **spreading-recurved**; leaf border serrate and **lamellae exposed**; very large plant, without white tomentum on stem; often in more shaded habitats, along mire margins rather than in the open center . . . . . *P. commune*

Key to *Dicranum*

1a. Plants growing in **short turfs**, up to 2 cm in height, densely packed and velvety green; mostly growing on bark . . . . . 2.
1b. Plants growing in **tall turfs**, often over 5 cm in height, easier to separate and green to golden-green; mostly growing on coniferous forest floor or on exposed and drier peat in peatlands . . . . . 4.

2a. Plants very small and leaves strongly curled when dry, often with even smaller **brood plants**, similarly curled, attached, or the entire patch consisting of these small brood plants; on dead wood and bark at the base of trees in quite xerophytic microhabitats . . . . . *Dicranum montanum*
2b. Plants larger, leaves not strongly curled when dry, broken leaf tips or flagelliform branches acting as propagula . . . . . 3.

3a. **Leaf tips very fragile** (**propaguliferous**): when a small patch is tapped upside down against the palm of hand, the leaf tips remain on the skin and most **leaves appear broken**; usually **dark green and matte turfs**, most leaves **stiffly erect**; usually on bark [have specimen checked if collecting along the North Shore: there is a look-alike, the rare *D. fragilifolium*] . . . . . *D. viride*
3b. Leaf tips not fragile, but clusters of straight branches with minute leaves (**flagelliform branches**) among the regular plants; usually lighter green or yellow-green, glossy turfs, most leaves falcate to falcate-secund; on dead wood and bark, sometimes on dry peat or rotten wood underneath trees. *D. flagellare*

4a. Glossy plants with **serrated leaf margins** (use 20x handlens) . . . . . 5.
4b. Matte plants with **denticulate leaf margins** . . . . . 6.

5a. Leaves strongly **undulate** and often straight (not curved or falcate), **highly glossy**; the most recent annual increment of the stem covered with **white-greenish tomentum**; setae in bundles (**polysetous**); in dry to mesic coniferous forests and forested peatlands, sometimes on drier hummocks underneath small trees and shrubs in open peatlands . . . . . *D. polysetum*
5b. Leaves sometimes slightly undulate and usually **curved-secund**, sometimes falcate-secund, moderately glossy; stem usually covered with **brownish tomentum**; **setae singly**; most commonly on coniferous forest floor, more rarely in peatlands . . . . . *D. scoparium*

6a. When dry leaves are **strongly curled**; **leaf tips sharply acute**; in more open turfs, usually in forested peatlands and on forest floors . . . . . *D. ontariense*
6b. When dry leaves are erect-appressed, only **slightly twisted or contorted**; **leaf apex somewhat blunt**; in dense turfs on drier hummocks, mostly in open peatlands . . . . . *D. undulatum*

Key to Other Acrocarps

1a. Plants **pale-green** or **whitish-silvery**. . . . . 2.
1b. Plants not pale-green or whitish-silvery . . . . . 3.

2a. Larger plants (> 2 cm, often a lot taller) in **large, pale-green, brittle and large cushions**; on coniferous-forest floor . . . . . *Leucobryum glaucum*
2b. Smaller plants (usually < 1 cm tall, often a lot shorter) in small, silvery turfs; upper half of leaf **hyaline**, giving the plants the **silvery aspect;** usually on mineral substrate in disturbed habitats (ruderal). . . . . *Bryum argenteum*

3a. Leaves **translucent** with cells easily visible with a 20x handlens, and **widely elliptic**, **obovate**, or orbicular, with a distinctly **narrowed insertion** on stem, also distinctly bordered. . . . . 4.
3b. Leaves **opaque or transparent** with usually small cells, and oblong-ovate, ovate, oblong-obovate, **ovate-lanceolate** or **lanceolate** but towards the insertion only **slightly narrowed**, if at all, bordered or not 6.

4a. **Stems**, both fertile and sterile, **always upright** with leaves spirally inserted; **leaves up to 12 mm long**; leaf margin always **entire** (without teeth); **rhizoids well developed** on stems; in depressions in swamps, usually in quite pure populations and very obvious because of the large leaves . . . . . *Rhizomnium magnifolium*
4b. Sterile stems often arching (similar to strawberry stolons) over the substrate (**prostrate**) with **complanate** leaves; leaves smaller and frequently with teeth along the margin (**serrate**); rhizoids usually less well-developed on upright fertile stems. . . . . 5.

5a. Leaf insertion **widely and longly decurrent** along the stem; **leaf serration only along the upper half of the obovate leaves** (use 20x handlens); frequent both in wet or dry mesohabitat but always in their drier, often shaded microhabitats . . . . . *Plagiomnium cuspidatum*
5b. Leaf insertion **narrowly or non-decurrent**; **some of the elliptic leaves with few or no marginal teeth, those with teeth are serrate all the way to the base** (use 20x handlens); very common in wetlands, rich fens (a calcareous-fen indicator in MN), and swamps . . . . . *Plagiomnium ellipticum*

The next dichotomy is hard to use in the field with only a handlens as tool, even a 20x. A true border consists of marginal cells quite different from those of the lamina. However, when margins with undifferentiated cells are curved or rolled, it is hard to distinguish them in the field from a true border. If your specimen can not be convincingly IDed as one of the two *Bryum* species below (dichotomy 7) try the species starting at 8.
6a. Transparent leaves with a **border** (marginal cells different from those of the rest of the lamina), and margins often entirely **recurved**; capsules symmetrical, large, pear-shaped and pendant . . . . . 7.
6b. Opaque or transparent leaves with **margins** without differentiated cells, plane or recurved usually at the most in the lower 3/4, loosely **reflexed** or **incurved**; capsule otherwise . . . . . 8.

7a. Larger plants with obviously **widely decurrent** leaves easily visible because of **long internodes**; stems often with **propaguliferous rhizoids** along most of their length; commonly mixed among other bryophytes in circumneutral peatlands and rich fens (a calcareous-fen indicator in MN) . . . . . *Ptychostomum pseudotriquetrum*
7b. Smaller plants with leaves often tufted (**comose**), not obviously and only **narrowly decurrent**; stems with **abundant rhizoids only at the base**; growing on all kinds of substrates in disturbed habitats (ruderal) [many look-alikes!] . . . . . *Gemmabryum caespiticium*

8a. Leaves **strongly crisped** when dry with the **back of the costae shiny yellow**; on dry calcareous soil and rocks, usually quite exposed, sometimes in cedar swamps in dry microhabitats . . . . . *Tortella tortuosa*
8b. Leaves frequently somewhat contorted or twisted when dry but the costae not obviously shiny as above . . . . . 9.

9a. Part of the patches nearly always with **obvious and numerous sporophytes**; species often growing in **disturbed mesohabitat (ruderal)** . . . . . 10.
9b. Sporophytes, when present, less obvious; species in natural mesohabitat . . . . . 11.

10a. Plants in dense, extensive turfs; sporophytes with straight setae, when **immature purplish red and capsules erect**; **mature capsules glossy brown, furrowed** and **inclined**; leaves narrowly lanceolate [very variable in its gametophytic features, both macroscopically and microscopically, always check out this extremely common species first before considering other species. Most characteristic, in addition to the sporophytes, are the small square cells and the **recurved/reflexed** margins] . . . . . *Ceratodon purpureus*

10b. Individual plants usually in **loose turfs**; sporophytes with **capsules furrowed when mature but strongly asymmetric and elevated by very tall, curved and hygroscopic setae**; leaves ovate to obovate; often in ruderal habitats on loose unconsolidated mineral sediment, soon after fire or surrounding **old fire pits** . . . . . *Funaria hygrometrica*

11a. Plants usually growing on organic soil, peat, or among *Sphagnum* on hummocks, **light-green when actively growing**, later in season turning dark-green; long stems covered by **brown tomentum**; in bogs and poor to intermediate fens, mostly with *Sphagnum*, on the top and sides of drier hummocks . . . . . *Aulacomnium palustre*

11b. Plants growing on mineral soil or rock . . . . . 12.

12a. Upper leaves with excurrent costae, forming distinct hairpoints . . . . . 13.

12b. Upper leaves without hairpoints, but sometimes with a hyaline apiculus . . . . . 14.

13a. Plants large, often as > 5 cm tall turf, brownish-green to brick red-brown; leaves with **long hyaline hairpoints with reddish base**, **twisted around the stem when dry, when wetted quickly changing from enrolled-twisted to strongly squarrose-recurved**; often on unconsolidated sand near lake shores . . . . . *Syntrichia ruralis*

13b. Plants smaller, < 2 cm tall, green when wet, gray to near black when dry except for the **long hyaline hairpoints** of the upper leaves; leaves not contorted when dry, nor suddenly squarrose-recurved when wetted; growing on exposed rocks or thin dry soil over rocks . . . . . *Grimmia laevigata*

14a. Plants in **somewhat flattened and rigid patches** [because of this mat-like habit the specimen might have keyed out inadvertently under 'Ecostate Pleurocarps on Bark, Wood, or Rock'], grey when dry but turning bright green when wetted; leaves **appressed** when dry, **spreading** when wet, **ecostate**, upper parts hyaline; **capsules hidden** among longer **perichaetial leaves with a distinct ciliated and hyaline fringe**; growing on exposed or sheltered rocks, well attached . . . . . *Hedwigia ciliata*

14b. Plants in dense or open turfs, pale-green or dark-green to yellow-brown, without sudden color change when wetted; leaves incurved to strongly crisped when dry, erect-spreading when wet, costate, upper part green; capsule exserted on **yellow setae** 15

15a. Plants in dense, and often very **large, merging, often domed, tall cushions**; leaf margins plane; **capsules without peristomes**; on wet boulders and seeping calcareous cliffs . . . . . *Gymnostomum aeruginosum*

15b. Plants in short turfs often of scattered plants; leaf margins incurved; **capsules with peristomes;** on soil and rock in usually disturbed mesohabitat. . . . . *Weissia controversa*

Key to Feather Mosses

1a. Coarse plants with stiff stems ('pipe-cleaner moss'), leaves large, **triangular and plicate** (with longitudinal folds); in drier microhabitats on the forest floor . . . . . *Rhytidiadelphus triquetrus*
1b. Less coarse plants, leaves much smaller; usually mesic to wet microhabitats . . . . . 2.

2a. Plants with annual segments **multi-pinnately** branched . . . . . 3.
2b. Plants with annual segments irregularly or **uni-pinnately** branched . . . . . 5.

3a. Plants somewhat glossy, with **annual steplike fronds**; in large wefts in dry to mesic microhabitats under coniferous forest canopy . . . . . *Hylocomium splendens*
3b. Plants matte, without such obviously annual fronds . . . . . 4.

4a. Stem leaves with recurved margins and costae ending well below **narrowly acuminate and mostly straight apices** . . . . . *Thuidium delicatulum*
4b. Stem leaves with plane margins and costae percurrent into strongly **recurved apices**; both *Thuidium* species are found on the forest floor, most commonly of swamps, and they can grow together in mixed populations; *T. recognitum* might be a slightly more xerophytic . . . . . *Thuidium recognitum*

Taxonomic note: as the structure of the stem leaves is quite difficult to observe in the field, the only reliable character to differentiate the two species of *Thuidium* above are the papillae on the paraphyllia covering the stem and branches (see microphotographs below) for which a microscope preparation and compound scope are needed. *Thuidium delicatulum* has many papillae that are located near in the **middle of the cells**, while those of *T. recognitum* are always at the **distal tip of the cells**.

5a. Plants **irregularly or semi uni-pinnately branched**, when dry normally very **glossy**, the nearly **straight** and **concave** branch leaves becoming translucent only when wet, and the main branch or stem shows then distinctly red; MN's most common moss, on both wet to mesic forest floors and in also in the drier parts of all forested peatlands; sometimes even in more exposed situations on rocky barrens or forest-road banks somewhat away from tree canopy . . . . . *Pleurozium schreberi*
5b. Plants truly **feather**-like in aspect because of very **regularly uni-pinnate** branching; stems not red; stem and branch leaves strongly **circinate** (curved in a circle) and **plicate** (with longitudinal folds); usually as small patches in mesic to wet microhabitats . . . . . *Ptilium crista-castrensis*

Key to Costate Wetland Pleurocarps

1a. Plants with **brown tomentum** along the stem, mainly on the underside . . . . . 2.
1b. Plants without tomentum (but with or without paraphyllia, see 4a) . . . . . 3.

2a. Leaves **straight**, erect; in rich fens, forming often large and tall, pure hummocks. . . . . *Tomentypnum nitens*
2b. Leaves falcate-secund; in poor fens, frequently growing as separate stems within small *Sphagnum* hummocks. . . . . *Tomentypnum falcifolium*

Note: Several of the following species have modifications growing in either semi- or fully aquatic microhabitats. These can look very similar to each other. Critical species identification has to rely thus on quite technical characters which you can only observe with a stereo- and compound microscope. However, the character states in the following key are suitable to differentiate at least the most typical emergent modifications.

3a. Leaves **rounded-obtuse**; uppermost leaves **enrolled** so that the **branch tips look pointed**, lower stem leaves large, spreading, and distant; large plants with straggly branching and most commonly in water-filled depressions in cedar swamps . . . . . *Calliergon cordifolium*
3b. Leaves sharply **apiculate, acuminate,** or **acute** . . . . . 4.

4a. Stems with many **paraphyllia**; in calcareous and rich fens forming low hummocks, or in swamps in shaded habitats among other bryophytes. . . . . *Helodium blandowii*
4b. Stems without paraphyllia . . . . . 5.

5a. Leaves **distant and straight** (internodes often visible between the leaves), costa often reaching the apex (study this carefully with your 20x handlens) . . . . . 6.
5b. Leaves usually covering stem, more **appressed**, straight, **curved** or falcate, costa usually not reaching the apex . . . . . 7.

Taxonomic note: the following two entities are apparently positioned along a continuous scale of structural variation: presently all specimens are considered to belong to the highly polymorphic species *Hygroamblystegium varium*. However, as most Minnesota specimens are easily separated based on both structure and ecology from each other, their separation in upheld here: the more narrowly defined traditional species concept *H. varium* as keyed out here under 6a will be considered *H. varium* mod. *'varium'*, those keyed out under 6b as *H. varium* mod. *'tenax'*.

6a. **Soft plants**; **leaves green, with a weak but nearly percurrent costa, which is curved above**; commonly **with sporophytes**; usually growing on bark elevated above water-filled depressions, in many microhabitats of mesic and transitional forests, swamps, and rich fens . . . . . *Hygroamblystegium varium mod.'varium'*
6b. **Stiff plants; leaves with a dark-colored, stout and straight costa**; sporophytes rare; in seepage and running water, attached to rocks or logs . . . . . *Hygroamblystegium varium* mod. *'tenax'*

7a. Leaves **straight** . . . . . 8.
7b. Leaves curved, **falcate-secund** to **circinate**; [nearly all of the species with falcate leaves have also atypical, orthophyllous (straight-leaved) modifications: the most common one is *Drepanocladus aduncus*; for the other species the orthophyllous forms are usually found only in aquatic microhabitats] . . . . 10.

8a. Leaves distinctly **plicate**, narrowly lanceolate; **plants distinctly glossy and light yellow-green**; usually found in shaded microhabitats but rarely in very wet spots . . . . . *Brachythecium salebrosum*
8b. Leaves smooth, more ovate-lanceolate, apex often apiculate; plants moderately glossy to matte, darker . . . . . 9.

9a. Leaves, when typical, **apiculate**; plants somewhat glossy; usually in rich fens and in small seeps, as exposed patches with a **subdendroid growth form**, or draping downward in slowly flowing water on cliffs in a **fan-like pendant growth form** . . . . . *Brachythecium rivulare*
9b. Leaves ovate-lanceolate, never apiculate; plants matte; in shaded but unforested minerotrophic mesohabitats, **hidden underneath large amounts of vascular-plant litter** (wet meadows, etc.), also in ditches, lakes, and small pools (plants extremely variable, often in a straggly untidy growth form, also extremely common, certainly when there is some disturbance) . . . . . .

. . . . . **orthophyllous** modification of *Drepanocladus aduncus* (see below for regular curved-leaved modification)

10a. Populations usually semi-terrestrial, emergent in rich fens or minerotrophic wetlands . . . . . 11.
10b. Populations usually aquatic, floating along lake margins or in poor-fen pools . . . . . 12.

11a. Leaves strongly **falcate-secund** to **circinate**; plants **yellow-brown** to **reddish-brown, turgid** looking; plants in exposed patches in depressions and **along pool margins in calcareous and rich fens** (calcareous-fen indicator), often associated with marl formation and with *Scorpidium scorpioides* . . . . . *Scorpidium cossonii*
11b. Leaves **curved** to **falcate-secund**; plants green or yellow-green without a swollen aspect; plants often hidden under graminoid thatch in all wetland and peatland types except poor fens and bogs, extremely common and very variable; in open, highly calcareous seeps, the species forms dense patches of stiffly upright stems, but then check also *Cratoneuron filicinum* . . . . . **curved-leaved modification** of *Drepanocladus aduncus*

Taxonomic note: the following two species are extremes along a continuous scale of variation, which also includes several other, far more rare species in MN, with very similar habitat preferences and phenotypic aspect.

12a. **Costa long** and stout, reaching beyond midpoint of leaf and sometimes percurrent, alar cells in a very well-defined group; **leaf insertion wide**, not much contracted from the maximal width of the leaf; plants usually growing in lakes, submerged or floating, in minerotrophic conditions . . . . . *Sarmentypnum exannulatum*
12b. **Costa short**, only reaching half-way up the leaf; alar cells less obvious; **leaf insertion** contracted, **narrow**; plants usually growing in peatlands, often quite acidophilous and associated with *Sphagnum* . . . . . *Warnstorfia fluitans*

Key to Costate Upland Pleurocarps

1a. Plants matte and dull green when dry, **strongly altered when wetted**; usually growing on the bark of the trunk of hardwood trees, often way above the soil surface, less commonly on exposed rocks and boulders . . . . . 2.
1b. Plants with some luster or glossy, less obviously altered when wetted; usually growing on cliffs, soil, rocks, and fallen logs or rotting stumps, or partly creeping up the base of hardwood trees . . . . . 6.

2a. Leaves **homomallous** or **subsecund** (turned in one direction) when wet and branches appearing flattened or **complanate** . . . . . 3.
2b. Leaves **heteromallous** (pointing in all directions) and branches thus appearing **rounded** or sometimes even terete (with leaves strongly appressed) . . . . . 4.

3a. Plants with regular branches with large leaves but others also extending farther as narrow flagella with very small leaves (**flagelliform branches**), or with these attenuated branches mixed among the regular ones; leaves **distinctly shouldered** with narrow, **apiculate** apices; on hardwood bark, or cliffs and boulders *Anomodon attenuatus*
3b. Plants without attenuated flagelliform branches, all similar; leaves with wide, **obtuse** apices and **without distinct shoulders**; on hardwood bark, rarely on calcareous rocks . . . . . *Anomodon minor*

4a. Leaves **tightly appressed when dry**, suddenly springing out to **spreading** and even squarrose **when wetted**, with long and **narrow, acuminate apices**; on the trunk of trees, often along roadsides . . . . . *Lindbergia brachyptera*
4b. Leaves less obviously responding to wetting, with short acute apices; frequently found as epiphytes on bark of living trees in floodplain forests above the high spring-flood water line . . . . . 5.

Taxonomic note: the following two species are very close, and I have not been able to separate them satisfactory among the MN collections, even with mature capsules or when using critical microscopic characters listed in other keys.
5a. Leaves not longer than wide, **straight**; capsules usually erect (?). . . . . *Leskea gracilescens*
5b. Leaves longer than wide, **curved to secund at the branch tips**; capsules usually curved (?). . . . . *Leskea polycarpa*

6a. Leaves with **short costae** not reaching the leaf apex. . . . . 7.
6b. Leaves with obvious **percurrent to excurrent** costae . . . . . 8.

7a. Branch leaves with **bluntly acute or narrowly rounded-obtuse apices**, **smooth**, **erect-spreading,** stem leaves acuminate; plants somewhat **matte**; usually found on the forest floor on humus or right at the base of trees and rotting stumps . . . . . *Eurhynchiastrum pulchellum*
7b. All leaves sharply **acuminate**, somewhat to highly **plicate** and often strongly **appressed**; plants highly glossy; extremely common, on all kinds of substrates in mesic to dry microhabitats . . . . . *Brachythecium acuminatum*

8a. Plants forming **extensive smooth mats**, often uni-pinnately branched and most **branches growing flat along the substrate**; stems with **paraphyllia**; **percurrent costae** of the stem leaves of the same color as the leaves; in shaded mesic sites on soil, rock, bark, and rotten wood, often along the edges or even in the middle of trails . . . . . *Haplocladium microphyllum*
8b. Plants forming rough mats, irregularly branched and **branches curving upwards away from substrate**; stems without paraphyllia; leaves with **hyaline tips** formed by **excurrent costae**: usually on dry to mesic cliffs . . . . . *Anomodon rostratus*

Key to Ecostate Pleurocarps on Peat

1a. Leaves ovate, at the end of the branches **enrolled**, either **obtuse** or with a very small apiculus (**apiculate**) 2.
1b. Leaves **acute** to narrowly **acuminate** . . . . . 3.

2a. Leaves straight, usually with an obtuse apex; stems with a slightly complanate (flattened) aspect; young branch tip forming **sharp point** with **enrolled leaves**; in extreme rich fens (calcareous-fen indicator in MN, but growing in grassy lawns in Europe as a ruderal species!) . . . . . *Calliergonella cuspidata*
2b. Leaves **curved-secund** at the tip of branches and stems, usually with an **apiculate** apex; stems **rounded**; young branch with **hooked** tips formed by the **enrolled** leaves; plants often growing as separate, nearly unbranched, **worm-like** and black or **dark-reddish strands** in marl pools (calcareous-fen indicator in MN), or forming denser and greener clones on the edge of rich-fen pools, rarely floating in highly minerotrophic flark pools and lakes. . . . . *Scorpidium scorpioides*

3a. Leaves **straight, stiffly erect-spreading**, upper part distinctly differentiated, **subulate**; plants growing in open rich fens (calcareous-fen indicator in MN) growing as small hummocks in drier microhabitats . . . . . *Campylium stellatum*
3b. Leaves always **curved- to falcate-secund**; upper part of leaf not abruptly differentiated from lower . . 4.

4a. Plants not complanate, leaves distinctly **falcate-secund** and **radially inserted**, not wrinkled; in wet depressions in swamps and rich fens . . . . . *Hypnum lindbergii*
4b. Plants with a more **complanate** aspect, leaves rather curved than falcate and **decurved**, often wrinkled; usually on rotten wood in swamps, but also in rich fens, sometimes even mixed with *Hypnum lindbergii*, frequently has a very distinctive 'algal' smell . . . . . *Hypnum pratense*

Key to Ecostate Pleurocarps on Bark, Wood, or Rocks

1a. Plants forming distinct **fans**; leaves **undulate**; on hardwood trees and cedars, rarely on rocks . . . . . *Neckera pennata*
1b. Plants forming mats; leaves not undulate . . . . . 2.

2a. Larger plants (leaves usually > 1 mm) with s**omewhat flattened** to strongly complanate branches . . . . 3.
2b. Smaller plants (leaves usually < 1 mm) with **rounded branches**, often curved away from the substrate . . . . . 4.

3a. Moderately shiny plants with narrowly ovate-lanceolate and curved leaves with **acuminate apices, branches (and uniquely also the leaves) curved upwards** away from the substrate (sword moss); capsules **curved** extremely common in all forested mesohabitats, nearly always growing on the base of conifers and hardwood trees but also found on all other substrates in mesic and wet mesohabitats . . . . . *Callicladium haldanianum*
3b. Very glossy plants with wide ovate-lanceolate and **straight** or slightly curved downward **leaves with acute apices, complanate** on branches appressed to the substrate; capsules **erect**; mostly on rotten wood in mesic forests, sometimes on soil or rocks . . . . . *Entodon cladorrhizans*

4a. Leaves distinctly **falcate**; capsules curved; on bark in dry-mesic forests, also commonly on rocks . . . . . *Hypnum pallescens*
4b. Leaves **straight or curved**; capsules **erect** . . . . . 5.

5a. Dark-green to golden-brown plants with **clusters of propagula** near the tip of **straight** or only slightly curved **branches**; most common on fallen, rotten logs. . . . . *Platygyrium repens*
5b. Bright yellow-green glossy plants with **upcurved and curly branches** without propagula; mostly on bark of hardwood tree trunks. . . . . *Pylaisia selwynii*

Notes

Glossary

Note: The items of this glossary cover bryophyte structure and are based on Crum & Anderson (1981) and Magill (1990). For a glossary of wetland and ecological terminology, see Janssens 2007. See Janssens 2014b for an illustrated glossary specifically covering this field guide.

abaxial. The side away from the stem or axis (opposite of adaxial); in reference to leaves, dorsal.
acumen. A slender, tapering point. Pl. acumina.
acuminate. Tapered to a slender point.
acute. Sharply pointed (less than 90°).
adaxial. The side toward the stem or axis (opposite of abaxial); in reference to leaves, ventral.
alar cells. Cells in the basal angles near the leaf insertion, often attached and forming decurrencies along the stem. They are frequently highly differentiated from the other laminal cells, often hyaline or distinctly colored. See also auriculate.
antheridium. The male reproductive organ, in mosses an ellipsoid to broadly cylindrical, stalked structure producing sperm cells (antherozoids) and surrounded by a single jacket layer of sterile cells. See also perigonium.
apex. The tip, usually either of a stem, branch, or leaf.
apical bud. The apex of the stem in *Sphagnum*, formed by the growing tip of the stem and consisting of an apical cell, surrounded and protected by enrolled, young stem leaves; this apical or terminal bud is more or less obvious among the young branches of the capitulum and its degree of visibility is a reliable taxonomic character.
apiculate. Apiculate, abruptly short-pointed.
aporose. Without pores, opposite of porose.
appressed. Closely pressed against the stem or branch, see also imbricate, erect, spreading and squarrose.
archegonium. The female reproductive organ, a flask-shaped structure producing an egg in the basal part and a long neck above. See also perichaetium.
areolae. Small, angular areas enclosed in a network.
auriculate. With bulges or earlike lobes at the basal angles of leaves. With basal auricles. Often composed of differentiated alar cells.
basal membrane. A delicate but often well-developed membrane at the base of the inner peristome (endostome) of many mosses, commonly terminating in tooth-like segments and cilia; less commonly used in reference to the joined bases of peristome teeth.
basal. At the base of (usually referring to the part of a moss leaf nearest to its insertion on the stem or branch). See also medial and upper, proximal and distal.
border. Refers to the margin of a moss leaf when it is composed of cells more or less distinctly differentiated from those of the rest of the lamina.
bordered. Having margins differentiated from the rest of the leaf in shape, size, color, or thickness of cells; peristome teeth may also be bordered by inner cell-wall plates narrower than the outer and thus showing an apparent border.
bryophyte. A member of the moss, liverwort, or hornwort clades. The gametophyte generation is autotrophic dominant and the sporophyte is dependent and sessile on it, sometimes parasitic and often ephemeral. Consensus phylogeny doesn't consider bryophytes to be monophyletic any more.
bud. See apical bud. Also a more or less enlarged cluster of cells (primordium) along the stems of mosses, usually beneath a branch attachment, with the potential of vegetative propagation if the apex of the main stem dies.

calyptra. A thin structure enclosing the developing sporophyte, derived (by continued growth after fertilization) from tissue below the venter of the archegonium; in *Sphagnum*, a very delicate membrane ruptured at maturity of the capsule; in true mosses, ruptured near the base (leaving behind a collarlike vaginula) and carried upward by elongation of the seta as a cap or hood over the capsule.

capitulum. Head-like tufts consisting of clusters of young branches or fascicles at the tip of a the stem of *Sphagnum*; see also apical bud.

capsule. Part of the bryophyte sporophyte. The bryophyte spore case or sporangium, often differentiated into an upper spore-bearing urn and a sterile basal neck (which may be considerably differentiated as a broad apophysis, or hypophysis), and attached to a seta.

carpet. Tall turf with divergent branches: stems erect with many clusters of branches. Often considered as a separate major growth-form category. Typical for *Sphagnum*. See growth forms.

chlorocysts. See chlorophyllose cells.

chlorophyllose cells. One of the two types of cells found intricately intermixed as a network in the stem and branch leaves of *Sphagnum*. See also hyaline cells. The chlorophyllose cells in the upper parts of *Sphagnum* plants are living when mature and filled with protoplasm and contain chloroplasts.

chlorophyllose. Green, containing chlorophyll.

cilia. Delicate, threadlike structures alternating with endostome segments (see peristome); also applied to hairlike appendages fringing leaves or calyptrae.

ciliate. Having cilia.

circinate. Curved in a circle.

clasping. Surrounding the stem, branch, or seta, usually by the basal part of a leaf or sheath, as in *Polytrichum*; see also sheathing.

clavate. Thickened towards the apex, club-shaped.

commissural pores. Pores arranged along the margins or commissures of hyaline cells.

commissures. The margins of hyaline cells in *Sphagnum* leaves (where an apparent seam is formed with the adjoining narrow chlorophyllose cells).

comose. Like a head of hair or a mane; used in reference to stems with leaves larger and more crowded in tufts, or comae; comose stems with upper leaves spreading may be rosulate in appearance.

complanate. Flattened together, compressed.

complicate-bilobed. Leaves bilobed, with the lobes folded over each other.

concave. Rounded inward (for a leaf by the adaxial surface) like a bowl.

connivent. Directed or pointing together, though not fused, as the tips of leaf lobes inclined and converging towards one another.

contorted. Irregularly twisted, bent into irregular curves.

convex. Rounded outward (for a leaf by the abaxial surface) like part of a sphere.

cortex. The differentiated outer portion or cell layers of stems and branches.

cortical cells. The outer cells of stems and branches (including those at the surface making up the epidermal layer). Frequently inflated and hyaline. See also hyalodermis.

costa. The nerve, or vein, of a moss leaf, sometimes double, sometimes single, forming a midrib. Often it consists of nothing more than a multistratose central part of the lamina, without internal cell differentiation. In other cases there is distinct internal cell differentiation, best studied in transverse section, and significant as a taxonomic character.

costate. With a costa.

crisped. Wavy (like crisp bacon); often used more loosely to mean variously curled, twisted, and contorted.

cucullate. Hooded or hood-shaped; a cucullate calyptra is conic and split up one side, resembling a monk's hood, whereas a mitrate calyptra is undivided or several-lobed at base; cucullate leaves are concave at the apex in a hoodlike manner.

curved. Bend slightly, but less strongly than falcate (sickle-shaped).
cushion. Rounded clones formed of ± erect stems in a radiating arrangement (as in *Grimmia*). See growth forms.
cuspidate. Ending abruptly in a stout, often rigid point (a toothlike cusp).
decurrency. Ridge or narrow wing formed by the basal leaf margins extending down the stem below the leaf insertion.
decurrent. With the basal margins extending down the stem below the leaf insertion, sometimes as ridges.
decurved. Curved downward.
dendroid. Branched above a trunklike base and resembling a tree. See growth forms.
dentate. With sharp teeth directed outward. Teeth consisting of part of a cell (contrast with serrate).
denticulate. Finely dentate.
dichotomous. Equally forked, with paired branches.
distal. Away from the base or point of attachment; opposite of proximal.
distichous. Alternate in 2 opposite rows, 2-ranked. See also phyllotaxy.
divided. Specifically used for the hyaline cells of *Sphagnum* stem leaves, which frequently have one or two septae dividing the lumen. Not to be confused with fibrils.
dorsal. See abaxial.
ecostate. Without a costa.
elliptic. Having the outline of an ellipse, essentially oblong but with sides and ends convex.
emarginate. Notched at the apex (more deeply indented than retuse).
endpore. A, usually larger, pore at the distal end of the hyaline cells of *Sphagnum* branch leaves, characteristic of the recurvum group in the section *Cuspidata.*
enrolled. Margins curved towards each other on the adaxial side; leaves strongly rolled around the stem and each other, forming a tight tube.
entire. Not toothed; used in reference to leaf margins. See also dentate and serrate.
erect. Diverging at a steep angle < 45°, but not as closely appressed as imbricate. See also squarrose and spreading. Also used for leaf margins, when they are not exactly plane, but very slightly incurved; with straight, not curved capsules.
excurrent. Projecting beyond the apex; used in reference to the costa.
exostome. See peristome.
falcate. Curved like the blade of a sickle.
fan. A mat-like growth form with the tips of the pendent branches curving upwards, away from the substrate. See growth forms.
fascicle. A cluster of adjoined branches, a term specifically used for the configuration of branching along the stem of *Sphagnum*. See also pendent and spreading branch.
fibril. A spiral thickening of the inner cell wall of the hyaline or cortical cells of *Sphagnum*. Sometimes the remains of resorption of the cells walls at the edge of a stem leaf. Sometimes forming rings around pore openings.
fibrillose. With fine, fiberlike wall thickenings (fibrils); used in reference to hyaline cells of *Sphagnum* leaves, also the cortical cells of the hyalodermis in the section *Sphagnum*.
five-ranked. Leaf tips lining up in five longitudinal rows along the branch or stem; frequently used in reference to *Sphagnum* branch leaves; result of 2/5 phyllotaxy.
five-starred. A 5-pointed pattern obvious when some *Sphagnum* plants in larger clones are looked at from above, caused by the regular spacing of the fascicles around the stems.
flagelliform. Bearing flagella.
flagellum. A slender branch; referring to small, axillary brood branches and sometimes to long, slender, tapering stems or branches; sometimes used to mean cilium (pl.. cilia) on sperm cells. Pl. flagella.
foot. The basal absorbing organ below the seta by which the sporophyte is attached to the gametophyte.

fringed. Aspect of the margin or apex of a leaf, when the marginal cells are partly resorbed and fibril-like remnants are remaining.
gametangia. The sex organs, in bryophytes the antheridia (male) and archegonia (female).
gametophore. Part of the haploid phase (gametophyte) of a bryophyte that eventually produces the gametangia. In mosses the leafy plant.
gametophyte. In bryophytes the dominant autotrophic, haploid, and sexual generation; the initial protonemata and the subsequent gametophore in mosses; in liverworts, a leafy or thallose plant.
gap. A very large pore in a hyaline cell, extending over the entire surface wall of the cell, frequent in branch and stem leaves of some *Sphagnum* species.
gemma. Usually a globose, cylindrical, or discoid brood body consisting of a single to multiple undifferentiated cells, serving as a propagule for vegetative reproduction.
gemmae cup. A structure enclosing or presenting a cluster of gemmae.
globose. Spherical.
growth form. The branching pattern of a bryophyte clone. See also carpet, cushion, mat (including fan), turf, weft, and dendroid.
hairpoint. Excurrent costa, frequently hyaline.
hanging branch. See pendent branch.
hastate. Abruptly broadened and auriculate at base, shaped like an arrow.
helically. Spirally, twisted, and stretched out along a longitudinal axis, such as the insertion of leaves on a stem in most mosses. See also phyllotaxy.
hemispherical. Shaped like the top half of a sphere, referring to the bulbous capitula of certain *Sphagnum* species.
heteromallous. Pointing in all directions (as opposed to homomallous, pointing in the same direction).
homomallous. Pointing in the same direction (as opposed to heteromallous); secund is used to indicate a very homomallous condition.
hyaline cells. Or leucocysts. One of the two types of cells found intricately intermixed forming a network in the stem and branch leaves of *Sphagnum*. See also chlorophyllose cells. Also found in the alar-cell region of other mosses. The hyaline cells, when fully developed and mature, are empty and often reinforced by fibrils in *Sphagnum*. The walls are colorless, often perforated by pores, and completely transparent. The cortical cells of a hyalodermis are also hyaline.
hyaline. Colorless or transparent.
hyalodermis. The cortex of large, empty, hyaline cells in *Sphagnum* stem and branches and some other mosses. Often surrounding a wood cylinder.
imbricate. Closely appressed and overlapping, referring to the aspect of leaves on stem or branch.
incurved. Curved upward and inward; used in reference to leaf tips and margins.
innovation. A new shoot, a branch formed after the maturity of sex organs, usually just below the inflorescence.
insertion. The place of attachment, usually referring to the cell line between the basal part of the lamina of a leaf and the stem to which it is attached. See also alar cells.
internode. Stem section between two adjacent leaf insertions.
involute. Rolled adaxially (upward or tightly inward); applied in reference to leaf margins; opposite of revolute.
lacerate. Deeply and irregularly slashed or torn.
lamellae. Green ridges or platelike projections on the costa or the lamina of some moss leaves; projections at the back of peristome teeth (trabeculae).
lamina. The leaf blade as distinguished from costa and border. Pl. laminae.
lanceolate. Lance-shaped, narrow and tapered from base to apex (narrower than ovate).
leafy. With leaves, as opposed to thalloid.

lenticular. Doubly convex, lens-shaped.
leucocysts. See hyaline cells.
limb. The leaf blade distal of a differentiated base. See sheathing.
linear. Very narrow and elongate, with nearly parallel sides (narrower than lingulate). Used to describe both leaf and cell shapes.
lingulate. Tongue-shaped, oblong with a broad apex.
lobe. A major division of a leaf or other plant part (such as the base of a calyptra).
lobule. A small lobe. (Leaves of mosses are rarely lobed; those of leafy liverworts are commonly divided into two lobes and often unequally so, into lobe and lobule.)
lumen. The cell cavity, often also in reference to the internal cell shape observed in a transverse section of a leaf. Pl. lumina.
macronemata. Large, branched bundles of rhizoids.
mammilla. A bulging protuberance with a blunt central projection formed by both the cell-wall and the cell lumen. Pl. mammillae. See also papilla.
margin. The edge of a leaf or other structure. See also border.
mat. A densely interwoven, horizontal form of growth. See growth forms.
medial. Occurring in the middle section, between the distal and proximal parts of a structure, for example the medial cells of a leaf, located above the basal and below the upper cells.
membrane pleats. Longitudinal wrinkles in the thin abaxial or adaxial surface walls of the hyaline cells of stem leaves of *Sphagnum*.
mucronate. Ending abruptly in a short point usually caused by a shortly excurrent costa. (Apiculate indicates a somewhat longer tip and cuspidate a longer, stouter, toothlike tip.)
nerve. See costa.
nm. Nanometer, a unit of length equivalent to 1 billionth of a meter, or 1/1000 of a micrometer (μm).
nodulose. With minute knobby cell-wall thickenings.
oblique. An angle between transverse (perpendicular) and longitudinal.
oblong. Longer than broad, with the sides nearly parallel, rectangular, with rounded corners or ends.
obovate. Egg-shaped, with the broader portion at the apex rather than the base.
obtuse. Broadly pointed (more than 90°), sometimes used to mean blunt or rounded at the end.
occluding. Filling the lumina of cells.
orthophyllous. With straight leaves.
ovate. With the outline of an egg, with the base broader than the apex (broader than lanceolate).
overfolding. With laminae overarching a wide costa.
papilla. A minute protuberance of cell-wall material of various forms (simple, forked, C-shaped). Pl papillae. See also mamilla.
paraphyllia. Small, green, filiform, lanceolate or leaflike, sometimes branched scales produced on stems and branches of some pleurocarpous mosses; pseudoparaphyllia. Filiform, foliose, or orbicular green structures similar to paraphyllia but restricted to branch bases, comparable to bud scales in flowering plants (restricted to pleurocarps).
pendent branch. A branch from the fascicle that hugs closely to the stem, in contrast with the spreading branch.
pendent. Hanging.
percurrent. Extending to the apex. See also subpercurrent and excurrent.
perichaetium. The female inflorescence, consisting of a cluster of leaves or bracts surrounding the archegonia.
perigonium. The male inflorescence, consisting of a cluster of leaves or bracts surrounding the antheridia.
peristome. A single or double series of 2n (from 4 to 64) teeth arranged in a circle inside the mouth of the capsule. If double, the outer peristome (the exostome) consists of teeth and the inner peristome (the endostome) consists of segments, often arising from a basal membrane and sometimes alternating with cilia.

phyllotaxy. The arrangement of leaves on a stem (usually in spirals); formerly referred to as dispositio ("disp. ½" means in 2 rows or distichous; "disp. 3/8" means that 8 leaves occupy 3 complete turns of the spiral; and "disp. 2/5" means that 5 leaves occupy 2 turns of the spiral, the latter also called five-ranked if longitudinal rows are obvious by the alignment of the leaf apices, commonly seen in many *Sphagnum* species).

pinnate. With branches spreading on both sides of the axis (sometimes crowded and regularly spaced in a featherlike fashion).

pitted. See pores.

pleats. See membrane pleats.

plicate. Folded in longitudinal pleats (plicae). Sulcate is used to describe unusually strong plication; striate or striolate is applied to weakly plicate conditions.

polysetous. With many setae derived from the same perichaetium.

pores. Small openings or pits in the walls of some cells, sometimes conspicuous as thinnings in thick walls between adjacent cells (which may be described as pitted or porose); in *Sphagnum*, the pores are particularly large and conspicuous in the ab- and adaxially exposed surface walls of the hyaline cells. See also pseudopore, endpore, gap and retort cell.

porose. With pores. Opposite of aporose. Also used in the combinations uni-porose (with a single pore) or multi-porose (with several pores).

propagule. A reduced bud, branch, or leaf serving in asexual reproduction, a specialized type of brood body. See also gemma.

propaguliferous. Bearing propagula.

prostrate. Growing with stem and often branches parallel to the substrate.

protonema. The juvenile stage of the gametophyte produced on germination of spores and giving rise to the leafy gametophore; in true mosses it consists of branched, green filaments; in *Sphagnum* and *Andreaea* it consists of a thallose or platelike structure; secondary protonemata are sometimes produced on leaves or stems of mosses, sometimes at wounds (on broken leaves, for example). Pl. protonemata.

protonematous rhizoids. Macronemata capable of producing protonemata if detached from stems.

proximal. Toward the base or point of attachment; opposite of distal.

pseudopodium. An elongation of gametophytic tissue serving in place of a seta to elevate the capsule of *Sphagnum* and *Andreaea.*

pseudopore. Small porelike areas encircled by fibril rings but not perforated, in the hyaline cells of branch leaves of *Sphagnum*.

recurved. Curved downward (abaxially) or backward, referring either to leaf margins or the upper part of leaves.

reflexed. Bent backward.

resorbed. Absent because of resorption.

resorption. The absence of portions of cell walls in *Sphagnum* (perhaps as a result of some lysigenous, or digestive, process in the early stages of cell differentiation), appearing as irregular membrane gaps on the surface of hyaline cells, sometimes at the margins of leaves. See also squamae.

retort cells. Large, elongated and flask-like cells, hyaline and projecting at the upper end as a short neck terminated by a pore, found in the cortex of branches of many species of *Sphagnum*.

retuse. Slightly indented at a broad apex; see emarginate.

revolute. Rolled backward (abaxially); referring to leaf margins. Opposite of involute.

rhizoids. Simple or branched filaments, appearing dead at maturity, attaching the plant to the substrate, sometimes ± covering stems, rarely found at back of costa or at leaf tips.

rhombic. Diamond-shaped.

rhomboidal. Longer than rhombic, elongate with parallel, oblique ends, or oblong-hexagonal.

ringed. With a slightly thickened rim, referring to ringed pores. Often the rings are only visible after dense staining or by using special optical settings at the microscope.
rugose. See undulate.
secund. Conspicuously turned to 1 side, strongly homomallous.
segment. See peristome.
serrate. With sawlike teeth pointing forward (toward the apex of the leaf). Teeth consisting of nearly an entire cell or even several cells (contrast with dentate).
seta. The stalk supporting the capsule. Persistent in most mosses, but ephemeral in most leafy liverworts. In *Sphagnum* the seta doesn't elongate but the entire sporophyte is elevated by a gametophytic pseudopodium.
sheathing. Surrounding and clasping the stem or the base of the seta; used in reference to very concave leaves or the proximal part of leaves surrounding the stem as in *Polytrichum*. The distal part of the leaf above the sheath is called the limb.
simple. Leaf shape without any lobes, cilia, etc.
spatulate. Tapered from a broad, rounded apex (similar to lingulate but more abruptly narrowed to a more noticeably constricted basal portion).
spherical. Having the form of a sphere or part of one. Rounded.
spirally. See Helically. See Phyllotaxis.
sporophyte. The diploid, spore-bearing generation, produced by the fertilization of an egg, remaining attached to the gametophyte in bryophytes, and partially dependent on it (or, in liverworts, parasitic), typically consisting of foot, seta, and capsule.
spreading branch. A branch from the fascicle that sticks out at nearly right angles to the stem, in contrast with the pendent branch.
spreading. At an angle of 45° or more. Wide-spreading means nearly 90°, and squarrose means 90°. See also erect and imbricate.
squamae. Cell-wall remains forming protuberances at the apex of the convex surface of the branch leaves of species of the section *Sphagnum*. See also resorption.
squarrose. Spreading at right angles.
squarrose-recurved. Spreading at right angles, with the tips curved even farther downward.
subsecund. Somewhat curved in one direction.
subsquarrose. Approaching squarrose.
subulate. Slenderly long-acuminate, shaped like a needle or an awl.
terminal bud. See apical bud.
thalloid. With a plant body not differentiated in stem and leaves; ribbon-like.
tomentum. Thick woolly, densely radiculose layer formed by rhizoids.
tr.s. See transverse.
transverse. Perpendicular across the longitudinal axis, as in transverse section (tr.s.).
trapezoidal. In the shape of a trapezoid, usually used in reference to the transverse section on the chlorophyllose cells of *Sphagnum* branch leaves. The shape is box-like, with either the abaxial or adaxial surface wider than the opposite one.
triangular. In the shape of a triangle, usually used in reference to the shape of the transverse section on the chlorophyllose cells of *Sphagnum* branch leaves. The triangle is exposed either to the abaxial (e.g., section *Cuspidata*) or to the adaxial surface (e.g., section *Acutifolia*).
truncate. Abruptly cut off or squared off at the apex.
turf. A tufted form of growth, with stems erect and parallel, often in extensive and dense clones. See growth forms.
umbonate. Having a rounded, blunt elevation at the center.
underleaves. Third row of usually smaller leaves along the underside of prostrate liverwort stems and branches.
undulate. Wavy; rugose refers to a more pronounced waviness.
unguiculate. Ending in a point similar to an animal's claw.
unringed. Without rings. See ringed.

upper. At the most distal part of (usually referring to the part of a moss leaf farthest from its insertion on the stem or branch). See also medial and basal.

vaginula. The ring or sheath enveloping the foot of the sporophyte and base of the seta, derived from the base of the archegonium and remaining after separation of the calyptra.

venter. The swollen basal portion of an archegonium, containing the egg.

ventral. See adaxial. See growth forms.

weft. A loosely interwoven, often ascending growth form, very easily removed from the substrate, usually forest or treed swamp floor.

wood cylinder. The cylindrical layer inside a *Sphagnum* stem, consisting of cells with thickened and frequently colored walls. Often surrounded by a hyalodermis.

Appendix 3: Literature Cited

Anderson, L.E. 1990. A checklist of *Sphagnum* in North America north of Mexico. The Bryologist 93: 500-501.

Anderson, L.E., H.A. Crum, and W.R. Buck. 1990. List of the mosses of North America north of Mexico. The Bryologist 93: 448-499.

Crum, H.A. 1984. Sphagnopsida, Sphagnaceae, in North American Flora, Series II, Part 11. The New York Botanical Garden. 180 pp.

Crum, H.A. 2004. Mosses of the Great Lakes Forest. 4th. ed. University of Michigan Herbarium. 592 pp.

Crum, H.A. and L.E. Anderson. 1981. Mosses of Eastern North America. Columbia University Press, New York. 1328 pp.

Flora of North America Editorial Committee, eds. 2007. Flora of North America north of Mexico. Volume 27, Bryophyta, part 1. New York and Oxford, Oxford University Press. 713 pp.

Janssens, J.A. 2000. County Atlas of Minnesota Mosses. Website by Ecological Services, Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, Minnesota 55155, @ http://www.dnr.state.mn.us/plants/flm/mossatlas/index.html

Janssens, J.A. 2005. Classification of the Bryophyte Assemblages of Minnesota's Extreme Rich Fens and the Bryophyte Criterion for the Evaluation of Potential Calcareous-Fen Ecotopes, update October 2005. Report to the Minnesota Department of Natural Resources, Division of Waters.

Janssens, J.A. 2005-2009. Reports of the bryophytes of MN counties, comprehensive site reports and county checklists. Available as PDF from the author.

Janssens, J.A. 2007. Description of Bryophyte Assemblages of Mesohabitats. Available as PDF from the author.

Janssens, J.A. 2010. Rare Species Guide: Listed and Newly Proposed Endangered and Threatened Bryophytes. Report to the Minnesota Department of Natural Resources, St. Paul, Minnesota, June 2010.

Janssens, J.A. 2014a. 'MNbryoChecklist.mdb' MS Access® database. Retrievals (taxonomic group or county/ECS subsection checklists) available by request from author.

Janssens, J.A. 2014b. Illustrated Glossary to the Field Guides of the Mosses & Liverworts of Minnesota. © 2014 State of Minnesota, Department of Natural Resources.

Janssens, J.A. and E.E. Orf. 1999. Liverworts of Minnesota: county records based on Schuster's Boreal Hepaticae, and on additional authenticated specimens of the MIN herbarium (UofM St. Paul). Submitted to the Minnesota County Biological Survey, Department of Natural Resources, 500 Lafayette Road, St. Paul, Minnesota 55155, February 1999.

Magill, R.E. Editor. 1990. Glossarium Polyglottum Bryologiae. Missouri Botanical Garden, St. Louis, MO, USA. 297 pp.

Minnesota Department of Natural Resources. 2003-2006. Field Guides to the Native Plant Communities of Minnesota. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.

Schuster, R.M. 1977 (1953). Boreal Hepaticae, a Manual of the Liverworts of Minnesota and Adjacent Regions. American Midland Naturalist 49: 257-684 and republished as Bryophytorum Bibliotheca Band 11, by J. Cramer, 332 pp.

Stotler, R. and B. Crandall-Stotler. 1977. A checklist of the liverworts and hornworts of North America. The Bryologist 80: 405-428.

Notes

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Species Index

To keyed species only: page numbers in ***bold-italic*** font refer to both key entries and illustrations; in **bold** font to key entries; in *italic* font to illustrations; and in regular font to all other references.

Notes

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