



MOSS LESSON 6: RICH FENS

Jerry Jenkins ♦ THE NORTHERN FOREST ATLAS PROJECT ♦ July 2020

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A WHITE-CEDAR FEN near the Hudson River, Tahawus, New York; shot from an AirCam on a photo flight with Ed McNeil, director of the Atlas Project, 4 August, 2007. Ground views on cover and page 12.

INTRODUCTION

THIS IS THE SIXTH of eight moss lessons I am preparing for the on-line moss class, May-June 2020. It introduces the characteristic mosses of rich fens. By a rich fen, I mean a wetland on deep peat that receives mineral-rich groundwater; by a characteristic species I mean one that is seen regularly in this habitat and either common there or commoner there than elsewhere.

The lessons are meant to accompany our photographic guide, the *Mosses of the Northern Forest* (Cornell University Press, 2020) and our digital atlas of the same title (online at northernforestatlas.org/products).

Peatlands are wetlands where more organic matter is produced than decays. Typically they are steadily wet but not deeply flooded and have low to moderate inputs of nitrogen and phosphorus. Salt marshes, with daily flooding and high nitrogen and phosphorus inputs, are an obvious exception.

Peat accumulates in many settings: bogs, swamps, ponds, marshes, fens, balds, barrens, seeps, cliff faces, heaths, and tundra. In most of these the peat is less than a meter deep. In bogs, fens, and some swamps it may be as much as 10 meters deep. The critical variables seem to be the levels of N and P and the constancy of the water table. Fertility (eutrophy) and drying promote decay; steady wetness and nutrient limitation (oligotrophy) promote accumulation.

From a moss's perspective, low nutrients and a constant water table are good things because they limit vascular plant productivity and allow the development of a continuous moss layer. Bogs, fens, and many conifer swamps have continuous moss layers; in raised bogs, at the extreme low end of the productivity gradient, the most productive plants are sphagnum mosses, and most of the peat is sphagnum peat. In rich fens, higher up the gradient, the most productive plants are sedges, and much of the peat is sedge peat.

Fens differ from bogs in the extent to which they receive base cations—calcium, magnesium, sodium, potassium—from ground and surface water. Raised bogs receive none, poor fens a little, medium fens enough to get by, and rich fens a lot. The differences are reflected in the pH and conductivity of the surface water and the species composition and productivity of the plants. Bogs and poor fens have low pHs and conductivities and are dominated by *Sphagnum* moss, heath-family shrubs, and stunted conifers. Medium and rich fens have high pHs and conductivities, more pleurocarps and less sphagnum, more sedges and white cedar, and less spruce and tamarack.

The focus in this lesson is on rich fens: wetlands on deep peat which receive calcium-rich groundwater. In the Northern Forest Region they are typically small or medium-sized wetlands and are dominated by narrow-leaved sedges, non-heath family shrubs, and northern white cedar. They are rare near the coast,



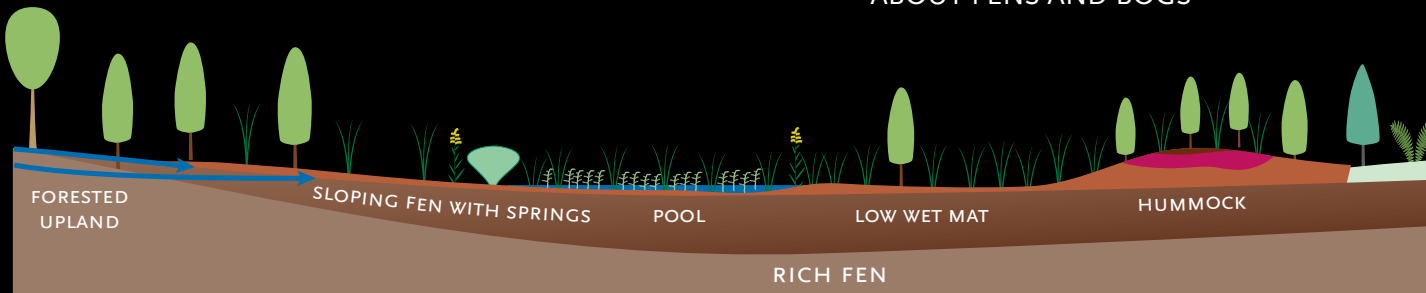
Brett Engstrom searching for the tiny *Eleocharis quinqueflora* in a fen in Williamstown, Vermont, October, 2017. Right place, wrong season. He found it anyway. Real botanists don't let vegetation push them around.

common though local in western New England, and common, again locally, near the Great Lakes.

Vegetationally, rich fens are among our most specialized habitats. Of the 27 mosses I present in this lesson, 21 are limited to fens or to related base-rich habitats like seeps, cedar swamps, and alvars. Finding them was challenging: fens look uniform, the hydrological and compositional gradients are less obvious than in bogs, and the rare species are hidden by the sedges and shrubs. With patience, good eyes, and a good sense of terrain, you can learn to find the rarities. Photographing them under the sedges is harder. If you figure out something that works, perhaps a string trimmer or goat, please let me know.

The floristics and geobotany of bogs and fens have been much researched, and the literature is fascinating and diverse. Barbara Bedford in New York, Joannes Janssens in Minnesota, and Dale Vitt in Illinois have been major contributors. Good starting places are Bedford B.L., Godwin K.S., *Fens of the United States* (Wetlands 23, 2003); Janssens, J.A., *Field Guide to Mosses and Liverworts of Minnesota's Calcareous Fens* (2014, on line); Vitt, D.H., Wieder, R.K., *The structure and function of bryophyte-dominated peatlands* (in Goffinet, B., and Shaw, A.J., *Bryophyte Biology*, 2009).

ABOUT FENS AND BOGS

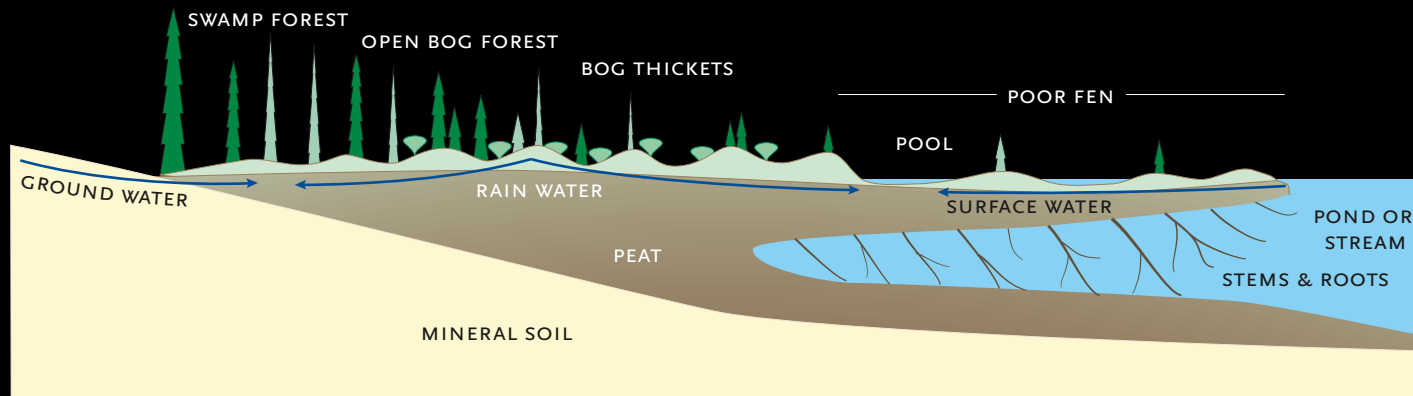


Limy ground water enters from adjacent uplands

Peat layer retains water; a moss layer develops over the peat

Hummocks grow up around sedges and shrubs in dryer parts of fen.

A rich fen is a peatland fed by limy groundwater, often from a glacial terrace that contains fragments of carbonate rocks. The fen is dominated by some mixture of shrubs and sedges and has a continuous moss layer dominated by one or more of rich-fen pleurocarps. It may also have hummocks dominated by *Sphagnum*.

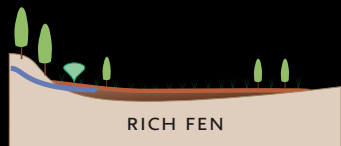


Ground water enters from adjacent uplands, creating a zone of spruce-tamarack swamp

A peat dome excludes ground and surface water, creating a rain-fed bog

A mat of shrubs and *Sphagnum* extends out over a pond or stream; surface water penetrates the mat; the outer parts float, the inner parts flood at high water, creating a poor fen

A poor fen is a peatland fed by surface water, often on the shore of a lake or stream. It may be grounded, or, as here, with a mat that extends out over the water. It is dominated by sedges and heath-family shrubs and has a continuous carpet of *Sphagnum*. Often, as here, part of the peatland is a rain-fed bog, and part a surface water-fed fen. The vegetation of bogs and poor fens is quite similar. Many poor fens are just wet bogs.



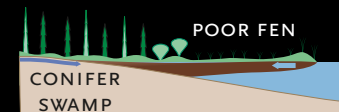
Rich fen on a bench below a glacial terrace



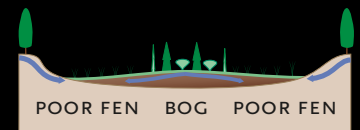
Rich fen in a basin surrounding a circumneutral pond



Poor fen in the open floodplain of a northern river



Conifer swamp and shoreline fen on an acidic lake

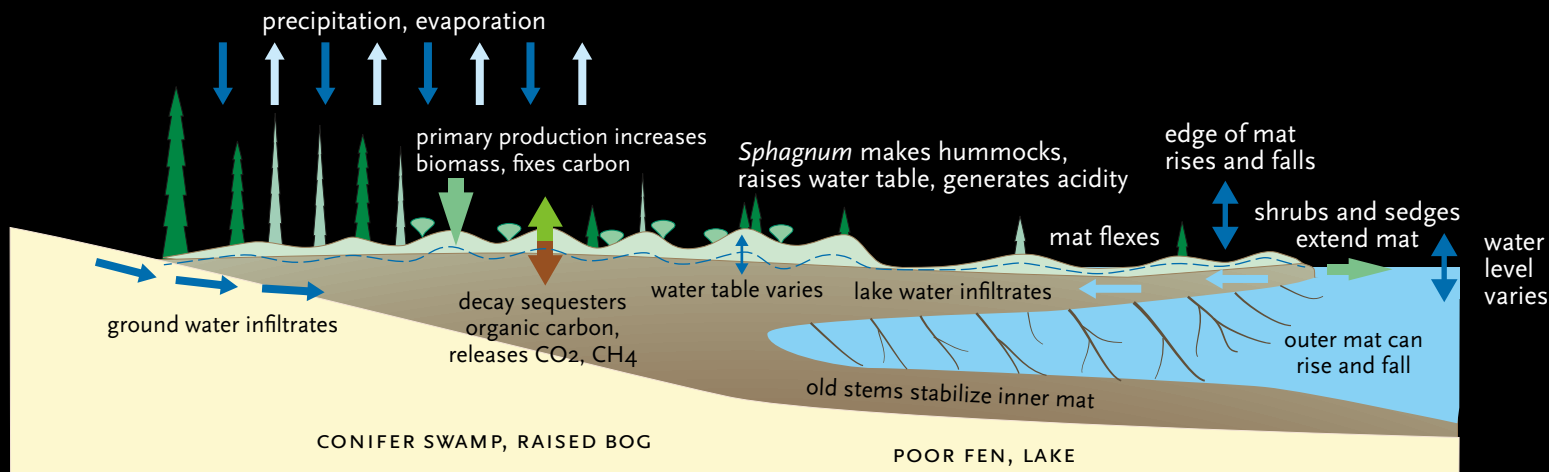


Poor fens in the margins or water tracks of a large raised bog

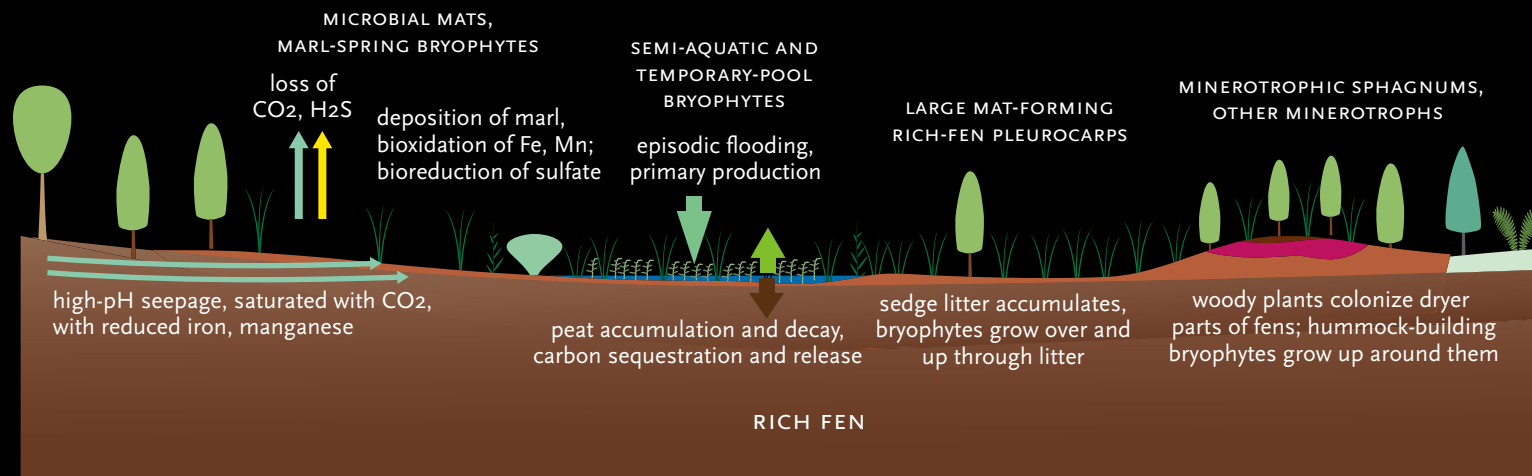
FENS ARE MINerotrophic PEATLANDS, meaning that they are underlain by a continuous layer of peat and receive at least some mineral-containing surface water or groundwater. They must be level with or below their water sources. They occur by lakes and rivers, in basins, and on benches. Depending on the alkalinity of the incoming water, they may be rich, medium, or poor. Rich fens have a specialized flora that only occurs in fens and fertile swamps. Poor fens are wet bogs with more sedges and fewer heath-family shrubs. Medium fens are what is left.

BOGS ARE CONVEX PEATLANDS that are raised above the local water table and receive most of their water from rain. Rainwater falling on the center moves radially outward and blocks the entrance of groundwater. They have a continuous layer of *Sphagnum*, few sedges, and lots of heath-family shrubs.

PROCESSES IN FENS



PEATLAND PROCESSES in a poor fen. The fen receives low-alkalinity water from rain, higher alkalinity water from groundwater and lake water; it loses water by evaporation and reverse flow into the lake. Growing *Sphagnum* releases acids; decay releases carbon dioxide and methane and generates peat. Short-term fluctuations in water-level bend the mat and create flooding and drying. Longer-term ones reorganize it and trigger growth or decay.



BIOLOGICAL PROCESSES in a rich fen. The richness of rich fens is driven by high-alkalinity groundwater; there are often specialized microbial and moss communities in the marl springs where the water surfaces. Intermittently flooded parts of the mat have “muck-pool” bryophytes that die back in the winter and re-sprout from the old stems as the pools dry. Sedge-dominated areas have tall pleurocarps that can grow over or through sedge litter. Hummock are dominated by a special group of slow-drying *Sphagnum*s that make tight mounds and retain water effectively.

PEATLANDS ARE BIOSTRUCTURES: the profile of the peatland, the flow paths of water and air, and the storage of water and nutrients take place within a system built and controlled by the plants. I look at them as biological landscapes in which the topography—the moss mats and peats—selects between water sources, controls the water flow, and alters the water chemistry. This in turn affects the relative rates of growth and decay—both high in pools, of example, and low in hummocks—and this in turn generates the topography. The underlying processes are slow; the resulting patterns are striking. The mineral inputs to a peatland predict the vegetation type, species composition, and diversity; the local variations in topography, water source, and wetness predict the distribution of species within the fen. Many, perhaps most, other bryophyte communities have an underlying chemical template. Few have the pattern as clear and as well studied as in peatlands; in even few are the patterns so completely controlled by the plants themselves.



WE START with a short tour. This is a lakeshore fen at Simon Pond, Tupper Lake, New York. The fen extends about 700 meters from the shore of the pond to the foot of the hill. The dominant sedge is *Carex lasiocarpa*, and there is a continuous moss carpet, without rich-fen indicators. The fen is in the floodplain of the Raquette River, and may have been altered or partly flooded when Tupper Lake and Simon Pond were created in the 1860s. All *lasiocarpa* dominated habitats are fens. Most of the large ones by waterbodies are poor fens.



A RIVERSHORE FEN along Big Mushquash Brook, in the St. Croix River drainage, east of Grand Lake Stream, Maine. Poor fens are common in the upper St. Croix River and Machias River watersheds. These extend north from Big Lake along Big Musquash Brook for about 8 kilometers. The mat is grounded and floods extensively at high water. The dominant sedges are *Carex lasiocarpa*, *Carex utriculata*, and *Eriophorum virginicum*. Sweet gale is a common shrub. There is a continuous carpet of moss, dominated by poor-fen sphagnums. Fens like this are really just bogs that flood seasonally and, as a result, have more tall sedges and fewer dwarf shrubs.



A POOR FEN within Spring Pond Bog. The whole bog is about 3 km long and contains large areas of poor fen that mingle, without clear boundaries, with smaller areas of raised bog. The dominant sedges are *Eriophorum vaginatum*, *Eriophorum virginicum*, and *Carex oligosperma*. There is a continuous moss carpet, dominated by *Sphagnum rubellum* and the *Sphagnum recurvum* group. Heath family shrubs are scattered throughout and form low mounds and ridges, oriented perpendicular to the flow.



SPRING POND, a peatland pond within Spring Pond Bog in the Adirondacks. Low wet floating fen with *Carex oligosperma*, *Sphagnum rubellum*, and *Sphagnum recurvum* and dwarf heaths; low hummocks with black spruce and leatherleaf. Photo from an AirCam flight with Ed McNeil, , 21 September, 2010.



PATTERNED FEN near the outlet of Spring Pond Bog, where water from the central dome descends to the outlet. Low ridges of shrubs, oriented perpendicular to the water flow, alternating with sedges and *Sphagnum* in the hollows between the ridges. Patterning is ubiquitous in northern fens, rare southwards. Spring Pond is the only fen in New York that shows patterning. Both poor and medium fens often show patterning. I do not know if rich fens do.



PATTERNING IN SPRING POND BOG, up close. Low oriented ridges of leatherleaf, sheep laurel, and Labrador tea, alternating with hollows with *Sphagnum rubellum* and stunted shrubs. The tussocks of *Eriophorum vaginatum* also appear to form rows perpendicular to the flow.



AN INTERMEDIATE FEN in Athens, Vermont, lying between two beaver ponds, probably with a history of intermittent flooding. The fen is on deep peat and dominated by the sedge *Carex lasiocarpa* and the grass *Calamagrostis canadensis*. Eleven other sedges occur, including the rare *Carex rostrata*; none are strong calcium indicators, but no poor fen would have this many. There are a few mosses in the hummocks, including the minerotrophic *Sphagnum subsecundum*, but no continuous moss layer. Heath-family shrubs are absent. The deep peat makes this a fen rather than a marsh or sedge meadow; the hummocky growth, mucky surface, dominance of broad-leaved sedges, and absence of a moss layer suggest recent flooding or varying water levels. I regard it altered fen that has become marshy. The vascular plant diversity, absence of Sphagnums, and absence of rich-fen indicator are all consistent with a medium-fertility fen.



A CEDAR FEN in Tahawus, eastern Adirondacks. The fen is on deep peat, in an old channel of the Hudson River. It is just below and likely receives seepage from a glacial terrace to the east. The dominants are an odd mixture: the sedges *Carex echinata*, *exilis*, and *michauxiana*, *Eriophorum viridicarinarum*, *Trichophorum alpinum*, and the rare grass *Calamagrostis pickeringii*. The moss layer is *Sphagnum* dominated; the minerotrophic species *teres* and *centrale* are present. The overall diversity and the abundance of cedar suggests at least intermediate status; the absence of rich-fen pleurocarps precludes rich-fen status. More pictures on the cover and page 2.



THE GROUNDLAYER OF THE TAHAWUS FEN, 14 July 2019: narrow-leaved sedges, royal fern, pitcher plant, horned bladderwort, rose pogonia, sundews, *Scheuchzeria palustris*, *Sphagnum rubellum*. More sedgy and diverse than poor fens, without the characteristic indicators of rich fen, hence intermediate.



FEN ON THE MIDDLE BRANCH OF THE UNION RIVER, near the Whaleback, Maine, 5 October 2017. Large fen dominated by *Carex lasiocarpa* and *utriculata*, *Calamagrostis canadensis*, and shrubs. Large areas of flat fen near the river that flood seasonally and are poor fen; some rich-fen indicators along the south edge, below a glacial terrace that likely contributes seepage. Overall plant diversity is low. Moss layer mostly *Sphagnum*, particularly *fulvum*, *fimbriatum*, and species from Section *Sphagnum*. *Sphagnum warnstorffii*, and *teres*, both rich-fen species, are present in small amounts near the south edge.



RICH SHRUB-SEDGE FEN in Pownal, Vermont, 6 June 2020. Dominant sedges are *Carex lacustris* and *Trichophorum alpinum*. The fen has tamarack and white pine; it is about 50 miles south of the range limit of white cedar. Common shrubs are speckled alder, hoary willow, bog willow, and shrubby cinquefoil. Rich-fen mosses include *Sphagnum centrale*, *warnstorffii*, *contortum*, and *teres*, *Scorpidium scorpioides*, and *Calliergonella cuspidata*. The fen has a glacial terrace on two sides and a wide moat at the foot of the terrace.



CHICKERING FEN, Calais, Vermont, 7 June, 2016. A classic rich white-cedar fen with a wet center. *Carex lasiocarpa*, *Trichophorum alpinum*, and *Eleocharis elliptica* are common sedges; *Hematocaulis vernicosus*, *Campylium stellatum*, and *Sphagnum recurvum* are dominant in the pools, *Sphagnum warnstorffii* on hummocks. The rare rich-fen species *Pseudocalliergon trifarium* and *Meesia triquetra* occur in small amounts.



WET SEDGE-MOSS MATS at Chickering Fen. *Carex lasiocarpa* is the dominant sedge, with sweet gale, pitcher plant, and bog bean. There is a continuous carpet of *Campyllum stellatum* and *Hematocaulis vernicosus* below the sedge.




RICH FEN IN WILLIAMSTOWN, VERMONT, 24 October 2017. Dominant sedge is *Carex lasiocarpa*. Dominant mosses are classic rich fen species—*Calliergon giganteum*, *Calliergonella cuspidata*, *Campylium stellatum*, *Hematocaulis vernicosus*—, with the rich fen specialists *Helodium blandowii*, *Tomenthypnum nitens* and *Paludella squarrosa* in smaller amounts. The spruce is red spruce. In a poor fen or raised bog it would likely be black spruce.





FLOODED FEN IN SHAFTSBURY, VERMONT, 19 October 2020. A wet sedge-fen surrounding a pond and receiving seepage from a glacial terrace to the south, from which the photo was taken. Originally dominated by a continuous stand of *Carex lasiocarpa*. Flooded by beaver over 20 years ago, creating pools dominated by cattails and bog bean, with sedges and other herbs on the hummocks. Mosses only on near the edges. Rails and bitterns have bred here.

CHARACTERISTIC SPECIES OF RICH FENS




Calliergon giganteum: large, pinnately branched; leaves blunt, concave, with a strong costa. 



Calliergonella cuspidata: pinnately branched; leaves concave, without a costa; branch tips pointed.  





Campylium stellatum: large, widely spreading ecostate leaves with slender channeled tips. 




Cratoneuron filicinum: large, dark, pinnate, often encrusted with lime; hooked branch tips; broad stem leaves with slender tips.





Sphagnum centrale: thick branches, hooded leaves  





Sphagnum fuscum: small, densely packed, round heads; dark brown with a dark stem; hummock tops. 



Sphagnum magellanicum: thick branches, hooded leaves; red or green  





Hamatocaulis vernicosus: green or brown moss with costate, falcate-secund leaves.  



Helodium blandowii: large, erect, regularly pinnate; oval leaves with short points.





Limprichtia revolvens: large green, red, or brown moss with costate, falcate-secund leaves.  




Meesia triquetra: stiffly erect; slender wide-spreading leaves in 3 rows; long necked, nodding capsules.



Sphagnum recurvum group: green, 5-parted heads; young descending branches paired; small triangular stem leaves.  



Sphagnum subsecundum group: a variable group; leaves deeply concave with a short pointed tip. 



Sphagnum teres: yellow green to red brown, with a clear terminal bud; stem leaves oblong.




Paludella squarrosa: tiny, slender, with short hooked leaves in five rows. Nothing like it.




Pseudocalliergon trifarium: yellow brown, wormlike; leaves broad, closely overlapping, without points.




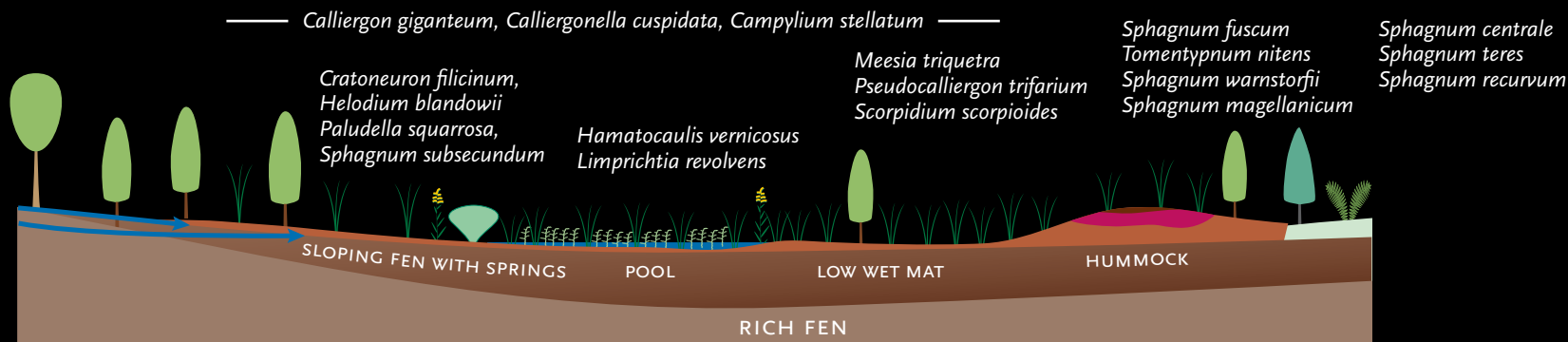
Scorpidium scorpioides: wormlike; leaves pinched in to a short tip, often secund at the branch tips. 



Tormentypnum nitens: large, erect, pinnate, often golden yellow; long straight slender-tipped leaves. 



Sphagnum warnstorffii: purple red, glossy when dry; branch leaves in five clear rows, spreading or hooked when dry. 





WE START WITH TWO SPECIES that are common and sometimes locally dominant in rich fens but are not limited to them. You will meet them in many other wetlands, and we need to get them out of the way.

AULACOMNIUM PALUSTRE is a large moss found on mounds and hummocks in almost every sort of wetland: bogs, poor and rich fens, swamps, pond shores. It likes at least partial sun and something convex to get it above the water table: it grows on hummocks, logs, and stumps in wetlands; on wet muck in pools; and in seepage cracks on rocky shores. It is not an obligate fen moss, but lots of fens have hummocks and if they do you have a good chance of seeing it. Look for a large, light yellow-green, shaggy acrocarp, somewhat mop-headed, either in masses or mixed in with other mosses. Lanceolate leaves, abundant rhizoids on the lower stem, and leafless stems with gemmae are good field marks.



Aulacomnium palustre up close. Note the sparse branching, light color, lanceolate leaves with a strong costa and abundant red rhizoids. The long curved capsules with light peristomes and (not shown) the gemmae on both the sides and tips of leafless stalks are good confirmation.



PHILONOTIS FONTANA is a slender, yellow-green, densely colonial acrocarp that can grow on wet rock, mineral soil, or peat. It is commonly associated with minerotrophic seepage. You will find it on wet ledges, in shoreline seeps, in medium and rich fens, in marshes, and on disturbed soil in ditches and borrow pits. Young plants, like these, are unbranched; older plants develop a crown of branches from the top of the stem. Plants on shaded ledges grow more loosely and are less erect. All will have light yellow-green leaves with long sharp tips, a matte (papillose) surface when dry, and no borders. Look for them on muck near springy banks in the upper parts of fens.



capsule



antheridial cup

CRITICAL FIELD CHARACTERS FOR *PHILONOTIS FONTANA* are the lanceolate leaves with long sharp tips and no borders; the yellow green color; and the dull (minutely papillose) leaf surfaces. The plants are dioecious; females have round capsules, similar to those of *Bartramia*. The males have antheridial cups surrounded by long-tipped leaves. *Philonotis marchica* is identical in the field and barely separable with the scope. *Pohlia wahlenbergii* looks quite similar in the field but has shinier leaves with shorter tips.



GOOD FIELD MARKS are the slender shoots, red stems, colonial habit, and yellow-green leaves with long slender tips.



A COLONY ON DISTURBED MINERAL SOIL, eastern Maine, middle June. The whorls of branches at the tips of their stems, rare in other acrocarps, are a good field character. The capsule at lower left is from something else.



NEXT, THREE GENERALIST *SPHAGNUMS* that grow in a wide range of bogs, swamps, and fens. *Sphagnum fuscum*, a dark-brown species recognized by the small, tightly packed heads, grows on the tops of hummocks in open peatlands. It is common and close to ubiquitous in bogs and poor fens and frequent in rich fens: if a peatland has hummocks at all, and if the hummocks are reasonably high, it will likely have *fuscum*.

THE PEATLAND GENERALISTS: *SPHAGNUM FUSCUM* (SECTION *ACUTIFOLIA*)



THE BEST FIELD MARKS are the rich brown color; small, somewhat rounded, indistinctly five-parted heads; and dark brown stems. The clumps look darker in the field than under our studio lighting. In coastal bogs and poor fens you will meet *Sphagnum flavicomans* (page 31), which has larger, lighter-colored heads and longer stem leaves.



LIKE MANY OF THE HUMMOCK-FORMING *Acutifolia*, the branches elongate, bend downwards, and form a dense mop. These plants are somewhat greenish. Just when *fuscum* gets green enough to be something else is debated, usually secretly, by insiders. My friend Nomenclator says, wisely, that there are many good species with bad boundaries.

THREE SIMILAR ACUTIFOLIA: *SPHAGNUM FUSCUM*, *FLAVICOMANS*, AND *CAPILLIFOLIUM*



THE INTENSELY COLORED ACUTIFOLIA are easy to recognize but hard to separate. Here *fuscum*, *capillifolium*, and *flavicomans* grow together on a hummock in a coastal fen in eastern Maine. They differ fairly consistently in color and size when side by side; individual plants, and especially shade forms with weaker color, can be hard to separate. The shapes of the stem leaves and some other microscopic characters help, but are not as dispositive as the books would have you believe. Nomenclator smiles and says "A desperate taxonomist will try anything."



SPHAGNUM MAGELLANICUM is a large hummock-former, deep wine-red in the sun, light green in the shade, recognized as a member of Section *Sphagnum* by the thick branches and deeply concave leaves. It is a peatland generalist, common in raised bogs and poor fens, surprisingly and deceptively common in green forms in conifer swamps, and often common on hummocks in medium and rich fens. Hummocks, when high enough, are effectively insulated from surface water and can function as ombrotrophic islands within minerotrophic wetlands. The yellow plants are likely the *Sphagnum recurvum* group, p. 35.

THE PEATLAND GENERALISTS: *SPHAGNUM MAGELLANICUM* (SECTION *SPHAGNUM*)



COLOR VARIANTS OF *MAGELLANICUM*, verified by leaf cross-sections. All have the deeply concave leaves with hooded tips of the Section *Sphagnum*. Red plants that look like this can only be *magellanicum*. Green and orange ones can be *palustre*, *centrale*, or *imbricatum* as well. Cross-sections are necessary to separate them.



GREEN *MAGELLANICUM*, on the floor of a white-cedar swamp in eastern Maine. Here, the colored branch tips are suggestive, but I would still go to the microscope to be sure. European workers have recently separated *magellanicum* into three species. According to them, our eastern North-American plants are *Sphagnum medium* or *Sphagnum divinum*, and “true” *magellanicum* doesn’t occur here. We don’t yet know how important the differences are, whether they make sense ecologically, or if they can be applied consistently in the field.



THE *RECURVUM* GROUP is either a single variable species or complex of three or four closely related ones. Either way, the group is found in almost every sort of peatland: it is ubiquitous in the carpets and lawns of bogs and poor fens; common in wet hollows and around pools in conifer forests and swamp; and also occurs, in much smaller quantities in cushions and low hummocks in medium and rich fens. Its best field marks are the five-parted heads; slender blanches with sharp, inrolled leaves; paired descending branches between the rays of the head; and small triangular stem leaves. The plants may be green, yellow, orange, or pale brown, but never red or deep brown.

THE PEATLAND GENERALISTS: THE *SPHAGNUM RECURVUM* GROUP (SECTION *CUSPIDATA*)



CHARACTERS OF THE RECURVUM GROUP: five-parted heads; slender branches and leaves; dry leaves often recurved; young descending branches in pairs (circled); color from green through yellow and orange to brownish; branch tips drying quickly and turning white; capsules common. The group is common and often dominant in acid peatlands; look for them and you will find them. The species in the group are separated by small differences in the branch and stem leaves. These differences are supposed to correlate with each other and with ecology. Thus *Sphagnum flexuosum* is supposed to have broadly ovate branch leaves, triangular-lingulate stem leaves under 0.7 mm, and to be restricted to ombrotrophic bogs and poor fens. My experience has been that the correlations don't work. Nomenclator says "People who make species out of tenths of millimeters usually come to bad ends."



THE *RECURVUM* GROUP UP CLOSE. Stem leaves short or long triangular, often pointing downward; wet leaves narrow and inrolled; dry leaves unrolling, often recurved, often with wavy edges; plants either stiff or soft; bases of branches often pink. The two plants on the right, from a poor fen on the Osgood River in the Adirondacks, had the ovate, ripple-edged branch leaves and apiculate stem leaves of *Sphagnum fallax* and the pink branches of *Sphagnum angustifolium*. Within the group, nonconforming individuals are common; we treat them as a single variable species and don't try to sort them out.



THE *RECURVUM* GROUP makes extensive mats in wet conifer forests and conifer swamps. *Sphagnum girgensohnii*, which often grows with *recurvum*, looks much the same from above: green plants with 5-parted heads in loose mats, stiff branches that whiten as they dry. The two are easy to mistake for each other. In the field, you *have* to see the paired young descending branches of *recurvum* (visible here if you look hard) or the oblong stem leaves with rounded tips of *girgensohnii* to be sure. Please write in your notebooks “Not everything that looks like *girgensohnii* is.” The principle is general and applies to other species too. Always check.



THE *RECURVUM* GROUP, DRY AND WET, from a poor fen at Branch Pond, Sunderland, Vermont. The recurved branch leaves are characteristic of the group but hardly unique to it. Carpet-forming *Sphagnum*s tend to differ structurally and physiologically from the hummock builders. They form looser mats, grow faster when wet, and dry out faster as water tables drop. *Sphagnum* productivity in carpets and hollows is higher than in hummocks. Decay is also faster, and so, in the long run, hummocks remain higher than hollows.



SPHAGNUM CENTRALE, the last of our generalists, is a large-headed species of Section *Sphagnum* that is found in areas with groundwater influence. We see it commonly in poor and rich fens, in conifer swamps, and on pond shores. It is usually replaced by *Sphagnum palustre* in deciduous swamps and on mineral soil, and by *papillosum* and *magellanicum* in raised bogs. The thick branches and deeply concave leaves with hooded tips make it Section *Sphagnum*. Leaf cross-sections are needed to confirm the species. Compare the size of the plants and the thickness of the branches to those of *capillifolium* in Section *Acutifolia*.



PLANTS OF *CENTRALE* verified by leaf cross-sections. *Centrale* varies from light green to yellow or brown. The heads are large; the leaves may angle out but are not squarrose or recurved. The leaves, like all those in Sect *Sphagnum*, have minutely rough edges at 20 power.



SPHAGNUM CENTRALE, on the floor of a cedar swamp in eastern Maine, enlarged from page 39. Note the large heads, short fat young branches, and concave leaves. This finishes the generalists. From here on, the species are obligate minerotrophs, rarely seen except in seeps, fertile swamps, and rich fens.



BOGS AND POOR FENS have a continuous layer of *Sphagnum*, covering both hummocks and hollows. Medium and rich fens still have *Sphagnum*s on the hummocks but other species, mostly pleurocarps in the hollows and lawns. The most important of these, and often the most abundant, are a group of six obligate minerotrophs we call the rich-fen pleurocarps (RFPS).^{*} We treat them alphabetically here.

CALLIERGON GIGANTEUM grows at the water level in fertile swamps and fens, often in places that flood and freeze in the winter. Look for it in pools in swamps and forming a loose carpet between the bases of sedges in fens. It is regularly pinnate and has oval leaves with blunt, concave tips, a strong costa, and strongly inflated alar cells. The leaves are oval and rounded but when young or dry, as here, they can look spiky. Like many mosses of shallow pools, it senesces in the winter and regenerates itself from new shoots in the spring. In April, all you can find are old dead shoots with buds that will produce the new growth. By summer, as in the picture, there are loose groves of new shoots above a black mat of old ones.

^{*} Books call the RFPS *brown mosses*. They shouldn't: many RFPS aren't brown; many mosses, including *Sphagnum*s, are.



YOUNG PLANTS OF *CALLIERGON GIGANTEUM* in the studio. Note the regularly pinnate growth and broad leaves with costas. The spiky branches will unroll later, if they want to. Plants vary. *Calliergonella cuspidata*, page 46 and also an RFP, is similar but lacks a costa and always has inrolled leaves at the branch tips. *Calliergon cordifolium*, the common species of acid swamps, is less regularly pinnate.

THE RICH-FEN DOMINANTS: *CALLIERGON GIGANTEUM*



CALLIERGON GIGANTEUM with the liverwort *Marchantia polymorpha*. The leaves are in fact broad and, but can roll up and look narrow. Look carefully, especially up by the tip of the stems. In minerotrophic wooded swamps, young *Bryhnia novae-angliae* looks similar. It is smaller at maturity and has distinct points, often twisted, on the leaves.



CALLIERGONELLA CUSPIDATA growing on a stick frozen in the ice at a fen in Shaftsbury, Vermont, February, 2016. Plants light colored and pinnate; leaves concave and blunt, without costas, often rolled into a cone at the branch and stem tips; stems red. Well developed plants like these look like some sort of an aquatic *Pleurozium* with sharper tip. *Calliergonella* is frequent in fens, but not as abundant or universal as *Calliergon giganteum* or *Campylium stellatum*. It typically grows at water level, often in pools, often on submerged wood or on and amidst old sedge and grass leaves.



CRITICAL FEATURES OF *CALLIERGONELLA*: plants loosely pinnate; leaves oval and blunt, though looking sharp when rolled up, without costas; young leaves at branch tips rolled into cones. Lots of mosses have sharp tips on young shoots; *Calliergonella* keeps them to maturity. Compare *Calliergon giganteum*, which has a costa; *Scorpidium scorpioides* which has sharper-tipped leaves that tend to point one way at the tips of the branches; and, for laughs, *Pleurozium schreberi*, which is similar but lacks the rolled up tips and doesn't grow in wet hollows.



SKINNY PLANTS, with some of the leaves rolled in, from under a canopy of *Carex lasiocarpa* in a flooded fen. Note how closely the leaves sheath the main stems and form long points at the stem tips.



SOFT FEATHERY PLANTS, growing on sedge litter at the edge of a fen. The red stems and long sharp tips of the shoots are good field characters. Many of the RFPs live in dense stands of sedges. The sedge leaves mat down over the winter, covering the mosses. The new shoots of the mosses have to grow through and over the mat of sedge leaves. *Calliergonella* is very good at this.



CAMPYLUM STELLATUM is perhaps the most easily recognized, and certainly one of the commonest of the rich-fen pleurocarps. It grows at the water table or submerged and is dark with light tips and irregularly branched. The oval leaves that narrow to long inrolled tips are diagnostic. From above the leaves spread widely and the shoots look starry. Unlike *Calliergon* and *Calliergonella*, in which shoots grow for a season and then die, the shoots of *Campylium* persist and grow from their tips, continue, making a thick mat. Here it forms a continuous carpet in a wet fen in central Vermont, among the stems of *Carex lasiocarpa*, with bog bean and pitcher plant.

THE RICH-FEN DOMINANTS: *CAMPYLUM STELLATUM*



THE PLANTS branch irregularly; the leaves have oval bodies and long (but soft) needle tips which are channeled or slightly inrolled; the bases of the leaves are erect, the tips spread widely. There are no costas, though it is hard to tell that in the field. It is a strict minerotroph, abundant in rich fens, occasional in pools in cedar swamps, in shoreline seeps, and on ledges with limy seepage. No other rich fen species looks like it.



GROWING ON LEAF LITTER, from a pool in a limy swamp in Cambridge, New York. Note the irregularly pinnate branching and the slender leaf tips that are bent outwards from erect bases. *Campylium chrysophyllum* has similar leaves and is also a calciphile. It is smaller, more of an upland species, and has a costa.

THE RICH-FEN DOMINANTS: *CAMPYLUM STELLATUM*



AMONG SEDGES, in a wet open fen in central Vermont. Old stems brown and persistent, the new growth coming from their tips. Young leaves yellowish, needle-tipped and spreading; branchy and starry. Nothing else looks like it.



HEMATOCAULIS VERNICOSUS among bog bean and *Carex bean* on the wet mat of Chickering Fen, north-central Vermont. *Hematocaulis*, like *Limprichtia* (page 57), was once part of the portmanteau genus *Drepanocladus*.^{*} Both have slender, strongly curved, costate leaves. (A δρεπαν is a scythe.) We call them Drepanocladoids to remind ourselves of the relationship. Or “Dreps,” which is short and convenient, though not respectful.

^{*}This was in what bryologists who grew up with the works of Howard Crum and Lewis Anderson call the old days. Moss taxonomy then was simpler but not necessarily clearer. The problem with the old broad *Drepanocladus* was that we never knew where it stopped; anything wet and narrow, we thought, might be *Drepanocladus*. With five segregate genera the problem is reversed; similar mosses turn out to be in different genera, and we never know, until we are back in the lab, how many genera we have seen.

THE RICH-FEN DOMINANTS: *HEMATOCAULIS VERNICOSUS*



OUR WETLAND DREPANOCLADOIDS are now in four genera: *Drepanocladus*, *Warnstorfia*, *Hematocaulis*, and *Limprichtia*. *Limprichtia* is sometimes merged with *Scorpidium*, but doesn't look like it. All have slender costate leaves which are often curved and turned to one side (falcate-secund). They are separated by microscopic differences in the leaves and stems and cannot be separated reliably in the field.

Hematocaulis vernicosus and *Limprichtia revolvens* are the common species of rich fens. Both are loosely pinnate and have strongly curved leaves that hook backwards. The young growth is greenish, the older growth colored. I expect one or both in any rich fen that is wet enough. In the lab, *Hematocaulis*, the moss-without-characters, is distinguished by what it doesn't have: no hyalodermis, no central strand, no enlarged alar cells, no teeth, no rhizoid initials. If you look in the scope and see nothing but leaves, stems, and costas, you have it.



HEMATOCAULIS, FLOATING AMONG SEDGES in the wet mat at Chickering Fen, central Vermont, 9 June 2016. Often grows half submerged in large wet masses, with just the growing tips out of the water. Like *Campyllum* and unlike *Calliergon*, the new growth is from the tips of the old stems. Note the strongly curved leaves and the red-brown color of the older growth. *Limprichtia revolvens*, the only other Drepanocladoid that would be expected in a rich fen, looks much the same.



LIMPRICHTIA REVOLVENS, also called *Scorpidium revolvens*, is the other common Drepanocladoid of rich fens. It looks much like *Hamatocaulis*, and, like it, grows in wet mats at or just above the water table. It is distinguished microscopically by the combination of a stem with a central strand and inflated cortical layer, and leaves with enlarged alar cells. I can see the alar cells in the lab at 50x with a dissecting scope, but have not tried to see them in the field.



FIELD CHARACTERS FOR *LIMPRICHTIA* are the red-brown color, pinnate growth, and costate falcate-secund leaves. *Hamatocaulis vernicosus* is the same. *Drepanocladus* and *Warnstorfia*, the other common wetland Drepanocladoids, are quite similar, though usually not deep red.



A WET MAT OF *LIMPRICHTIA REVOLVENS* at the edge of a pool in a rich fen in Shaftsbury Vermont. *Hamatocaulis vernicosus* looks similar and occurs in the same habitats.



Hamatocaulis vernicosus



Limprichtia revolvens



HEMATOCAULIS VERNICOSUS AND *LIMPRICHTIA REVOLVENS* are both pinnate and both have costate, falcate-second leaves that hook way around. In my photos, *Limprichtia* runs a bit redder, but I am not sure that is generally true. I don't try to distinguish them in the field. Under the scope, *Limprichtia* has inflated alar and stem cortical cells; in section, its stems have a central strand.



A LARGE MOSS with closely overlapping, deeply concave leaves, forming cylindrical wormlike branches. Leaves with short double costas, appearing ecostate in field, contracted to short sharp tips, often curved and secund at the branch tips. Young growth green to golden, older growth often brown or black. A large striking moss, common in the wettest parts of northern fens. I remember large black expanses of *Scorpidium* fen in central Labrador. I could cross them where there were sedge hummocks, but didn't dare step where there was only moss. Transcontinental in the north, rarer in the Northern Forest Region. Typically at the bases of hummocks and in pools in river fens and, northwards, in limy seeps along rivers. Often with *Calliergon giganteum* and *Calliergonella cuspidata*.



GOOD FIELD CHARACTERS are the cylindrical branches and deeply concave, closely overlapping leaves that are secund at the branch tips. Young shoots can look like *Calliergonella*, which often grows with it. The leaves at the branch tips—apiculate and secund in *Scorpidium*—will usually distinguish them. Under the scope the leaves have a few strongly inflated alar cells and the stems have an inflated cortex. *Pseudocalliergon turgescens*, an interesting species found in rock pools in limy alvars, looks similar in the field but tends to grow flat on the rocks and lacks inflated alar cells and an inflated stem cortex.

Scorpidium scorpioides is the last of the true rich-fen dominants. The others were the three C's—*Calliergon giganteum*, *Calliergonella cuspidata*, and *Campylium stellatum*—and the two Drepanocladoids, *Hamatocaulis vernicosus* and *Limprichtia revolvens*. Amazingly, given how diverse fens are, these are all there are. If a large dark moss covers large areas down near the water table in a rich fen in the Northern Forest Region, it is likely one of these. Other mosses are also important but more local. The commonest of these form hummocks or low mounds. We turn to these next.



THE HUMMOCKS IN BOGS AND FENS are mounds of moss, usually built by *Sphagnum* on a scaffolding of woody plant stems. Low hummocks may be built by other genera and may be built on sedges or free standing. Tall hummocks, over half a meter high, almost always involve sphagnum and woody plants, though they may contain other mosses and materials. Raised bogs, with abundant woody plants, almost always have hummocks. Low wet fens, with no woody plants, usually have no hummocks. The most common hummock builders in open peatlands are the Sphagnums of section *Acutifolia* and Section *Sphagnum*, particularly *centrale*, *magellanicum*, and *papillosum*. In rich fens, most commonly encountered species are *centrale* and *magellanicum*, from Section *Sphagnum*, and *fuscum* and *warnstorffii*, from Section *Acutifolia*. The first three are generalists and have already been treated; *warnstorffii* is treated here. The picture shows low hummocks of shrubs and moss, oriented perpendicular to the gradient, at the northwest end of Spring Pond Bog, western Adirondacks, July, 2011. Spring Pond Bog is a raised bog with extensive areas of poor fen. More pictures on pages 8-11.

THE HUMMOCK SPECIES: *SPHAGNUM WARNSTORFII* (SECTION ACUTIFOLIA)



THE COMMONEST RED SPHAGNUM IN CEDAR SWAMPS AND RICH FENS is *Sphagnum warnstorffii*. It forms low hummocks or cushions, often mixed with other sphagnums, and is recognized by the five-parted heads, branches with the leaves in 5 clear rows, and often some purple in the red. None of these are fully decisive. We guess in the field and confirm in the lab by looking for tiny ringed pores near the tips of the branch leaves. Because *warnstorffii* is much commoner in fens than *russowii* or *rubellum*, we are often right. But, because the chemistry of hummocks is to some extent decoupled from that of the fen as a whole, we are never sure until we check.

THE HUMMOCK SPECIES: *SPHAGNUM WARNSTORFII* (SECTION *ACUTIFOLIA*)



WELL-DEVELOPED *WARNSTORFII* IS A STRIKING PLANT; flat-topped, five-parted heads; long spreading branches with the leaves in strong rows; color often mottled, mixing red, pink, and green, often with a bit of purple; long branch leaves that are strongly recurved when dry. *Rubellum* and *russowii* are similar and can be mottled. Neither has as strongly ranked branch leaves or becomes as recurved when dry.

THE HUMMOCK SPECIES: *SPHAGNUM WARNSTORFII* (SECTION *ACUTIFOLIA*)



COLOR VARIANTS OF *WARNSTORFII*. All show the strongly ranked branch leaves that tend to recurve when dry. Green forms, which are common, usually have a red or pink stem and a little pink on the branches. The two in the lower row definitely have some blue mixed with the pink. The ones in the upper row don't seem to.

THE HUMMOCK SPECIES: *SPHAGNUM WARNSTORFII* (SECTION *ACUTIFOLIA*)



A MAT OF *WARNSTORFII* from a low hummock in a rich conifer swamp in Shushan, New York. All the *Sphagnum*s here, green and red, appear to be *warnstorfi*. The purple-red color, when present, is diagnostic. When it is not, you look for strongly ranked leaves and check the pores with the microscope.



BROWN-STEMMED MOSSES are reasonably common on hummocks in medium and rich fens. The deep brown ones that are closely packed together on hummock tops are *fuscum*; the pale or orange ones with distinct terminal buds and large oblong stem-leaves fringed across their tips are *teres*; a remnant group, green brown, growing loosely, bigger than typical *fuscum*, are either shade forms of *fuscum* or the rare *subfulvum*. The pictures show some from eastern Maine. They are clearly brown-stemmed plants in Section *Acutifolia*. The stem leaves look big for *fuscum*; *subfulvum*, or possibly a pale form of the coastal *flavicomans*, remain open. Beyond that I am not prepared to go. The books don't help much. More specimens would help a lot.

THE HUMMOCK SPECIES: *TOMENTYPNUM NITENS*



Tomenthypnum nitens, the needle-leaved plant in the picture, is a northern transcontinental species, frequent in rich fens in our area. It grows in rich fens and cedar swamps, typically in with other species in hummocks or around the bases of trees. It seems to be a hummock resident but not a major hummock builder. The yellow color, pinnate branching, and long slender leaves are distinctive. Look for a golden moss with needle leaves on paintbrush branches and you have it.

THE HUMMOCK SPECIES: *TOMENTYPNUM NITENS*



GOOD FIELD CHARACTERS are the erect, pinnate growth; yellow-green color; widely spreading lower branches; and slender costate pleated leaves with long tips. Nothing else really looks like it. *Tomentypnum falcifolium*, a northern species with falcate-second leaves, very rare in our area, is less minerotrophic. I have never seen it. The later spelling *Tomenthypnum* occurs in older books. I prefer it, but that doesn't count.

THE HUMMOCK SPECIES: *TOMENTYPNUM NITENS*



OLDER PLANTS, showing dark stems and spreading branches. In any stage, the long leaves and spiny look will identify it.

THE HUMMOCK SPECIES: *TOMENTYPNUM NITENS*



TOMENTYPNUM NITENS, in a *Sphagnum warnstorfi* hummock in a fen in Shaftsbury, Vermont. The fen is low and wet and has a stream running through, and may have been partly flooded by beavers. The only hummocks are among shrubs at the edges of the fen. This is a fairly common situation; it may be that the return of the beaver in the last 70 years altered many of our fens. In any event, in some of our fens the hummocks are hidden and may be relictual. They often have interesting species and are worth looking for.



THE NEXT THREE SPECIES make carpets and low mounds, above the pools where *Calliergon*, *Campylium* and the Drepanocladoids live, usually below the hummocks where *Sphagnum warnstorffii* and *fuscum* live. They are most commonly found in the shrubby parts of fens or around tree bases in cedar swamps. They also can turn up in shrubby meadows or on river shores where there is limy seepage. The picture above is from a seepy meadow near a beaver pond in Rowe, Massachusetts. The yellow mound is *Helodium blandowii*, a big distinctive species that looks something like a short-leaved *Tomentypnum* and often grows with it.



HELODIUM BLANDOWII is tall, yellow green, regularly pinnate, and fairly stiff. It is distinctive, and can be recognized on sight. The leaves are oval, with strong costas and slender tips. The stem leaves are much broader than the branch leaves; the branches often curve at the tips. With a lens, you can see slender crinkly things—paraphyllia—around the stem leaves. With a microscope you can see that the leaf cells are long and protrude at their tip.

I use the spelling *Helodium*, following Bruce Allen who argues that it is a conserved name, in spite of a few missteps along the way. The *Flora of North America* account by Patricia Eckel uses *Elodium*, on this basis of a seven page summary of nomenclatural history (Eckel, P.M., “The genus *Elodium* (Bryophyta, Helodiaceae): A history and new combinations,” *Phytoneuron* 2012-70.) that reads like a Supreme-Court brief. Law aside, I prefer *Helodium*. The family is the *Helodiaceae*. In English the Greek rough breathing is universally represented with an *h*: *hypothesis*, *hypnotize*, *helotry*, and so on. Consistency may not always be legal, but it is still good taste.



A HANDFUL OF *HELODIUM BLANDOWII* from the meadow on page 70. Yellow green with brown stems; stiffly pinnate and featherlike; large oval stem leaves and smaller branch ones, neither falcate secund. Some shoots of *Aulacomnium palustre* and *Thuidium recognitum* are mixed in.

THE CARPET AND LOW HUMMOCK SPECIES: *HELODIUM BLANDOWII*



A LOOSE MOUND FROM ABOVE: stiffly pinnate fronds, brown stems, yellow foliage, loose erect growth, leaves neither needlelike nor secund. Nothing else looks like it.



THE *SUBSECUNDUM* group contains about five closely related entities formerly treated as varieties of a broad *subsecundum* and now treated as species. They are reasonably common in fens, and you need, at least, to know the group. In the laboratory, they form a natural group, recognized by the numerous small pores along the edges of the upper cells of the branch leaves. In the field, they are variable and there is no combination of characters that will always pick them up. I look at the branch leaf shape—deeply concave, like Section *Sphagnum*, but with more pointed tips that aren't hooded—and at the young branches, which are often curved. If I am in doubt, I look for relatively large, oblong stem leaves. If I am still in doubt, I go to the microscope.



FIELD CHARACTERS OF THE *SUBSECUNDUM* GROUP: heads loosely five parted, the young branches often curved or twisted; stems brown; stem leaves oblong or rounded triangular, blunt at the tips; branch leaves oval, deeply concave at their bases, short pointed above, not hooded, sometimes curved in one direction (secund). None are decisive by themselves, but the combination works pretty well.

SPHAGNUM SUBSECUNDUM GROUP COMPARED TO OTHER SECTIONS



SECTION ACUTIFOLIA

SECTION CUSPIDATA

SECTION SUBSECUNDA

SECTION SPHAGNUM

HEADS AND BRANCHES OF OUR FOUR MAJOR SECTIONS OF *Sphagnum*. Note the slender, long-pointed, tightly overlapping leaves of the *Acutifolia* and *Cuspidata*; the loosely arranged, deeply concave leaves of the *Subsecunda*; and the thick branches and rounded leaf tips of Section *Sphagnum*. Because the *Subsecunda* are variable, they are often what you are left with when you have eliminated the other three groups.

SPHAGNUM SUBSECUNDUM GROUP, VARIATION WITHIN THE GROUP



Sphagnum subsecundum



Sphagnum subsecundum



Sphagnum contortum



Sphagnum lescurii

THE SPECIES OF THE *SUBSECUNDUM* GROUP share some general characters, particularly curved or twisted branches in the head and loosely arranged, deeply concave branch leaves. They can be guessed at by appearance and habitat but can only be separated microscopically. Of the ones I know, *subsecundum* proper is the most widely distributed, found in fens, on pond shores, along wood roads and trails, and in seeps. *Lescurii* is a minerotrophic generalist, found in poor fens and on shores. *Contortum* is a rich fen specialist, often in low hummocks under shrubs.

THE CARPET AND LOW HUMMOCK SPECIES: *SPHAGNUM SUBSECUNDUM* GROUP



WET *SPHAGNUM* MAT at Chickering Fen in central Vermont. The *subsecundum* group makes low mounds or thick carpets near the water table; when the water is high, they will also be found floating in pools. This form, with curved and twisted branches and secund leaves at the branch tips, is likely *Sphagnum contortum*. It is a strong minerotroph, and often grows with *Sphagnum warnstorffii* and *teres* in rich fens.

THE CARPET AND LOW HUMMOCK SPECIES: *SPHAGNUM CONTORTUM* (SUBSECUNDUM GROUP)



VERIFIED *CONTORTUM* from a rich fen in Pownal, Vermont. The species in the *subsecundum* group can't be identified with certainty in the field, but the combination of a rich-fen habitat, strongly curved or twisted branches, and curved secund leaves at the branch tips points to *contortum*. It is typically found in low hummocks or carpets, sometimes below shrubs in thickets, sometimes in the open in wet mats under sedges.



AT LEAST TEN *SPHAGNUMS* can occur in rich fens and cedar swamps. Only four— *warnstorffii*, *contortum*, *teres*, and the puzzling *subfulvum*—are rich fen and swamp specialists. *Warnstorffii* tends to be up on the hummocks; *contortum* and *teres* grow lower down, making carpets or mounds. Just what and where *subfulvum* is still open. The picture shows *teres* from near the edge of a fen in Maine. It is yellow green in early summer, and tends to turn orange or red brown in fall. It is a small moss with slender, fairly straight branches, a conspicuous terminal bud, and oblong stem leaves, 1-2 mm long, that are fringed across the tip.

THE CARPET AND LOW HUMMOCK SPECIES: *SPHAGNUM TERES* (SECTION *SQUARROSA*)



GREEN PLANTS OF *TERES*, from Pownal, Vermont, June 2020. Small heads with a definite terminal bud (circled), slender branches, brown stem, some tendency for the leaves to curl outwards from the branches.

THE CARPET AND LOW HUMMOCK SPECIES: *SPHAGNUM TERES* (SECTION *SQUARROSA*)



YELLOW-BROWN *TERES* from the (famous) Cranberry Pond Fen in South Woodbury, Vermont, with enlargements showing the terminal buds. The terminal bud (τ) consists of the stem tip sheathed by a spiral of stem leaves, much like a young pine cone. The young branches (B) originate in the axils of the stem leaves (S), pushing them outwards. Note the combination of compact heads, slender spreading branches, and brown stems. The plants have the general aspect of the *Acutifolia*, but the details are wrong. *Subfulvum* and *fuscum*, which have brown stems, don't have conspicuous terminal buds or stiffly spreading branches; *fimbriatum*, which does have a terminal bud and spreading branches, is all green.

THREE COMMON SECTIONS COMPARED



Sphagnum recurvum group,
Section *Cuspidata*,
paired descending branches

Sphagnum teres,
Section *Squarrosa*,
large terminal bud, brown stem

Sphagnum fimbriatum,
Section *Acutifolia*,
large terminal bud, green stem

Sphagnum subfulvum?,
Section *Acutifolia*,
brown stem

BOOKS ON *SPHAGNUM* advise you that you a good first step is learning to recognize the sections in the field. What they don't tell you is that this is not always possible. Some times it is easy: a fat-branched sphagnum is in Section *Sphagnum*, a bright red one in Section *Acutifolia*. Sometimes it is not easy at all. Compare *Sphagnum teres*, in Section *Squarrosa*, with three species from the *Cuspidata* and *Acutifolia*. All have 5-parted heads, slender branches, and slender-tipped branch leaves of about the same size. They can all be separated in the field, but not at a glance and not without a lens. *Recurvum* has paired descending branches; *teres* has a brown stem, a conspicuous terminal bud, and a big stem leaf; *fimbriatum* has a conspicuous terminal bud, green stem, and broadly fringed stem leaf; and *subfulvum*, always the leftover, has a brown stem, inconspicuous terminal bud, and big stem leaf. None of these character combinations will identify every species in its section. There are, in fact, no combinations of field characters that will identify every species in any of these sections.



A MAT OF *TERES* in a medium fen in eastern Maine, July, 2020. The small heads, yellow brown color, and, up close, the conspicuous terminal buds are distinctive.

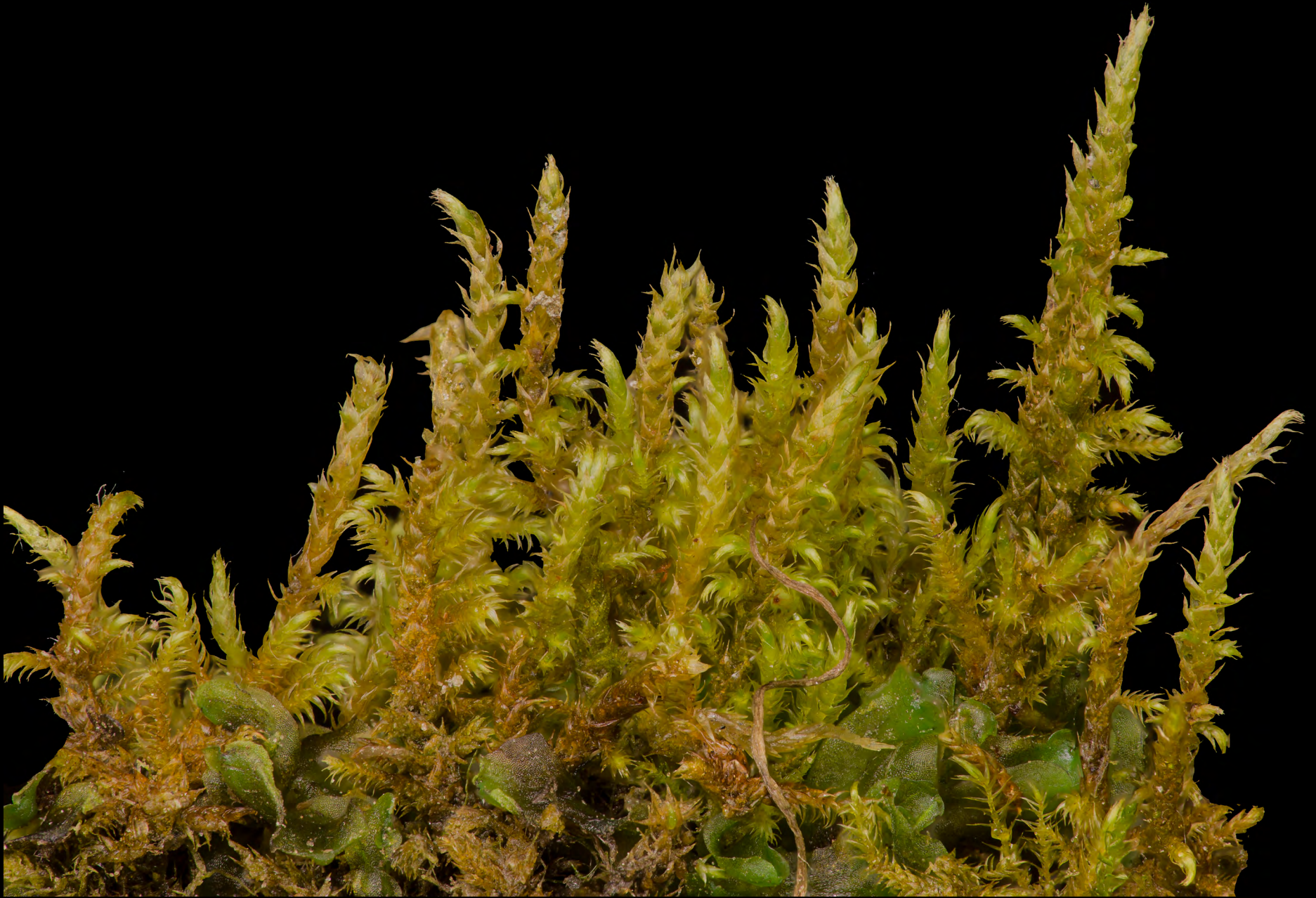


CRATONEURON FILICINUM is a soft-looking, somewhat feathery species with fern-like fronds that grows in limy seepage. It is found in rich fens, shoreline seeps, and cedar swamps, especially where seepage emerges from a bank and flows over the surface. It has broad costate stem leaves and smaller branch leaves that are secund (curved one way) near the branch tips, making the tips looked hooked. The combination of fernlike growth, broad stem leaves, and hooked leaves at the branch tips is usually enough to identify it. Young clean plants growing above the water level are a pretty light mottled green. Older plants in pools fed by seepage can be a smelly mess, encrusted with lime and iron bacteria and smelling of sulfur.

A SEEPAGE SPECIES: *CRATONEURON FILICINUM*



A PLANT FROM A SEEP AT THE EDGE OF A RICH FENG in Shaftsbury, Vermont, July 2020. Pinnate, frondose growth; erect stems with broad sheathing leaves with slender tips; narrower stems leaves with curved, secund tips. The microscope will show tiny teeth on the leaf edges, relatively short leaf cells, and large inflated alar cells. It has paraphyllia but not very many. For serious paraphyllia, try *Helodium* or *Thuidium*.



A PLANT WITH YOUNG BRANCHES; the pinnate growth, hooked branch tips, and striking contrast between stem leaves and branch leaves are good marks. The liverwort looks like *Aneura pinguis*, greasewort to its friends.

A SEEPAGE SPECIES: *CRATONEURON FILICINUM*



CRATONEURON FILICINUM MAKING A MAT ON PLANT LITTER, at the edge of a fen in Shaftsbury, Vermont. Pinnate growth, a soft feathery look, and hooked stem branches. *Helodium blandowii* grows in the same sorts of places but is yellower, stiffer, and sparser and doesn't have the hooked leaves at the tip. *Drepanocladus* and its relatives have the hooked branch leaves but not the broad stem leaves.

Cratoneuron is the last of the characteristic rich-fen species that occur relatively frequently in the Northern Forest Region. We finish with seven rarities—species that are commoner elsewhere than here and occur rarely and unpredictably in our fens.



RICH FENS ARE NORTHERN HABITATS, transcontinental in the subarctic, scattered southwards, rare south of the glacial boundary. Many of the fen mosses are correspondingly northern, and rare with us. I show seven that I have been able to find and photograph; there are others that I have never found. Most of these I have only seen a few times, some only once. They are still mysterious plants to me. I know what they look like and something about how to look for them, but I have little idea of what they like or why they are in one place and not another.

CATOSCOPIUM NIGRITUM is a tiny acrocarp with a high-northern distribution, very rare with us. These plants were growing in with *Campylium stellatum* in wet hollows in a rich fen in northwestern Newfoundland. The shoots are slender and erect, with lanceolate leaves in three rows; the lower stem is black. Except for the black stems and three-ranked leaves, they look like a small *Pohlia*. The seta and capsule are deep brown or black, and look like a golf club. The capsule is tiny, only about 1 millimeter, and doesn't look like any other moss in our area. The plants are very inconspicuous. I might not have noticed them if I hadn't picked up the *Campylium*.



ANOTHER HIGH-NORTHERN SPECIES, rare with us. Large or small, with oval, strongly bordered leaves. Strongly resembling *Rhizomnium*, but differing in the needle points on the leaves, the black on the lower stems and leaves, the one-celled thick borders, and the rhizoids in lines. These plants were in with *Campylium stellatum* and *Catoscopium nigrum* in a pool in a rich fen in northwestern Newfoundland.



A NORTHERN *DICRANUM*, hard to recognize in the field, apparently rare in fens and seeps. In the field it is a large species with straight, slightly ripply leaves, similar to *Dicranum ontariense* or *undulatum*. In the lab it resembles *Dicranum scoparium* but with smoother leaves and the ridges on the costa poorly developed. Given the variability in *scoparium*, it can be hard to differentiate from *scoparium* variants. Specimen from a calcareous seep on the northwest end of Manitoulin Island, Lake Huron.



FRUITING *BONJEANII* from hummocks in a rich fen, Pownal Vermont. The leaves are erect or secund but not strongly curved, and slightly ripply but less so than in *Dicranum undulatum*. The young capsules are erect, but will bend over as they mature. This is a technical species and must be confirmed in the lab.



A DISTINCTIVE NORTHERN *DICRANUM* with a wide ecological range, reported from bogs, poor and rich fens, seeps, and variety of conifer swamps. I have seen it in hummocks, often with *Sphagnum*, in both poor and rich fens. It can be recognized in the field, with care, by the ripply leaves that are rounded at the extreme tip and the costas that stop just short of the tip. As with most *Dicranums*, bringing a bit back to the lab is prudent. A plant from a shoreline seep in eastern Maine.



MORE *UNDULATUM* FROM MAINE. The wavy leaves that are held erect and tend to be twisted together like party favors at the tips of the stems are good field characters.



PLANTS FROM A RICH FEN IN NORTHWESTERN NEWFOUNDLAND, with stiffly erect leaves that are faintly ripply and held together, though in this case not twisted, at the tips of the stem. The odd-looking thing is a pitcher-plant seedling.



A large, high-northern species of calcareous fens, occurring sparingly in our area. It is distinctive: erect stems, lanceolate leaves bent outwards stiffly from erect bases and arranged in three rows that spiral around the stem. The moment you see it you will know that you have something unusual. These plants are from the famous Dogpond Fen in South Woodbury, Vermont.



LEAVES BENT ABRUPTLY OUTWARDS FROM AN ERECT BASE. Only a few other Northern-Forest species (*Dicranella schreberiana*, *Paludella squarrosa*...) do this, and none of them have the spiralling rows.



THE SPIRAL ROWS OF LEAVES of *Mesia triquetra*; geometrically they resemble a drill or milling cutter with three flutes, or three spiral staircases twisted together.



A SLENDER NORTHERN SPECIES, restricted to rich fens and rare with us. The plants are erect and sparsely branched, with the leaves in five rows. They arch out from and erect base and then turn down at the tips. The plants may be free-standing, something like *Philonotis*, or mixed in with other species. In central Labrador I often found them growing up through the branches of *Sphagnum*. The shoots can be very slender and stringy: 5 cm or more high and only a few millimeters wide.



SHOOTS OF *PALUDELLA*. The leaves are in five rows, and arch outwards and downwards from erect bases. The shoots are 2 mm to 5 mm wide. Plants from the upper, spring-fed part of a rich fen in central Vermont.



OUR LAST SPECIES, AND ONE OF THE ODDEST. *Pseudocalliergon trifarium* is a northern calciphile with a scattered distribution in rich fens. The leaves are broad and blunt, with only a short costa; they overlap tightly; the shoots are sparsely branched and look like a brown worm with green tips. *Scorpidium scorpioides*, which can also look wormlike, is looser and more branched and has curved, secund leaves with distinct points at the branch tips. The plants shown were found, in small quantities and mixed with other species, by Matt Peters at Chickering Fen in northern Vermont. He had a big grin.

1 FENS ARE PEATLANDS that receive minerals from ground or surface water; the water and minerals influence their structure and vegetation. They occur in four main situations: in basins in glacial deposits; in the open floodplains of northern rivers; as floating mats around lakes and ponds; and in the wetter parts of large raised bogs. In all cases they require continuous moisture—a positive water balance—in the growing season to allow the development of peat.

2 Fens may be arranged on a compositional gradient from poor (low productivity, lots of *Sphagnum*, no pleurocarps, low species diversity) to rich (high productivity, less *Sphagnum*, pleurocarps dominate, high species diversity).

3 The compositional gradient correlates well with water chemistry. Poor fens have no alkalinity and pHs under 5.5; medium and rich fens have alkalinities of over 500 microequivalents per liter and pHs over 5.5.

4 The compositional gradient also correlates well with the physiographic situation and hydrology. Poor fens are often adjacent to lakes and rivers or on the flanks and in the water tracks of raised bogs. Medium and rich fens are often in basins below glacial terraces. Poor fens usually get their water from flooding and from the runoff from peat domes; medium and rich fens get their water from mineral-rich groundwater.

5 In composition, chemistry and structure, poor fens are very close to bogs. I regard them as flat wet bogs with interesting patterns. In the field, we think of them as *Sphagnum-dominated* peatlands with more sedges (particularly *Carex lasiocarpa*, *exilis*, and *oligosperma*, *Eriophorum*, and *Rhynchospora alba*) than bogs, and fewer heath-family shrubs.

6 Medium and rich fens (MR-fens) are quite different from bogs. We think of them as pleurocarp-dominated peatlands with sedges and shrubs that don't occur in bogs and poor fens, lots of cedar, little spruce, and few heaths.

7 MR-fens vary in their details. They may be large or small and level or sloping; have springs, ponds, or standing water; be hummocky or flat; have few shrubs and trees or many; and, if rich enough, may have iron, manganese, and marl deposits. To some extent attributes correlate. Hummocks form around shrubs and trees; drier fens and parts of fens have more shrubs and trees and hence more hummocks. Deposits of marl and metals occur where springs surface; springs are commonest in sloping fens below a glacial terrace.

8 MR-fens also vary in their histories. Many have been altered by beaver in the last 60 years, and are now either flooded or recovering from flooding. Some seem to me more shrubby than when I first knew them.

9 Notwithstanding 7 and 8, there is a great deal we don't know about the structure, patterning, and history of MR-fens. I have been in many, but, unlike in bogs and poor fens, am still unable to anticipate what I will find and where I will find it.

10 This lesson treats 27 mosses of MR-fens. Nineteen are common, 8 rare; 6 are generalists, found in other sorts of wetlands; an impressive 21 are MR-fen specialists, only found in minerotrophic peatlands.

11 The breakdown by life forms is distinctive. The 19 common species include 2 acrocarps, 9 pleurocarps, and 8 *Sphagnum*s. On a diversity basis, pleurocarps and sphagnum are similar; on a coverage basis, the 6 that I call rich-fen pleurocarps (RFPs) supply most of the cover. The 8 rare species include 6 acrocarps, 1 pleurocarp, and 1 *Sphagnum*. On a diversity basis, the acros have it. There are, however, another half dozen rare MR-fen pleurocarps to our north that we don't see here.

12 The bryophytes are organized here by ecological groups, with the warning that these groups are provisional, and not as clear-cut as I would like. That said they go like this:

Six species are generalists with wide ecological ranges. The four *Sphagnum*s—*centrale*, *fuscum*, *magellanicum*, *recurvum*—are particularly important. Almost every peatland will have one or more.

Six species are RFPs that grow low to the water and form extensive mats. These are a core group; you can't have a rich fen without one or more of them. The commonest are *Campylium stellatum*, *Calliergon giganteum*, *Hamatocaulis vernicosus*, and *Limprichtia revolvens*.

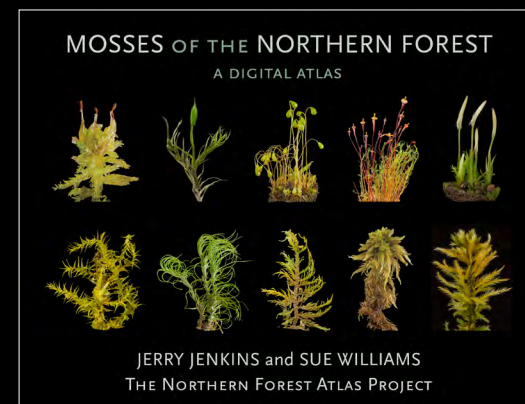
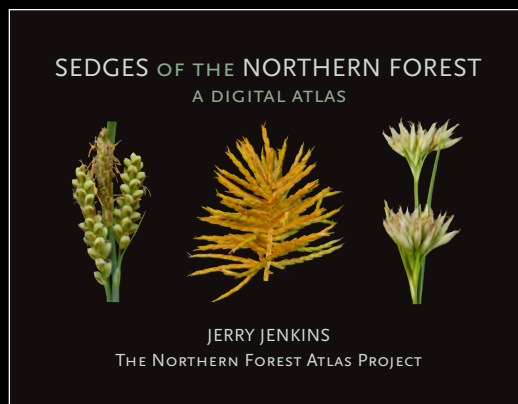
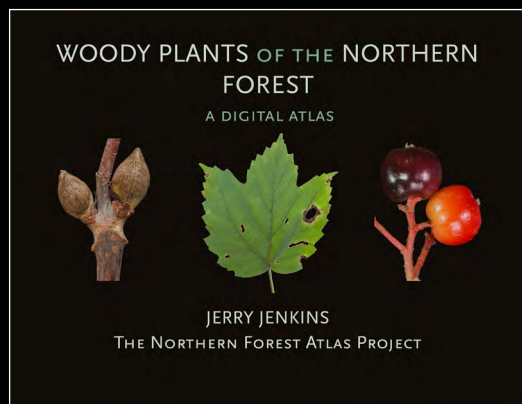
Five species—the generalists *Sphagnum centrale*, *fuscum* and *magellanicum*; the specialists *Sphagnum warnstorffii* and *Tomentypnum nitens*—are dedicated hummock formers. They are conspicuous in the field and you will find them whenever you find hummocks.

Four species—the generalist *Sphagnum recurvum* and the specialists *Sphagnum teres* and *subsecundum* and *Helodium blandowii*—are somewhere between carpet and hummock species. The three specialists are classic rich-fen indicators and worth knowing.

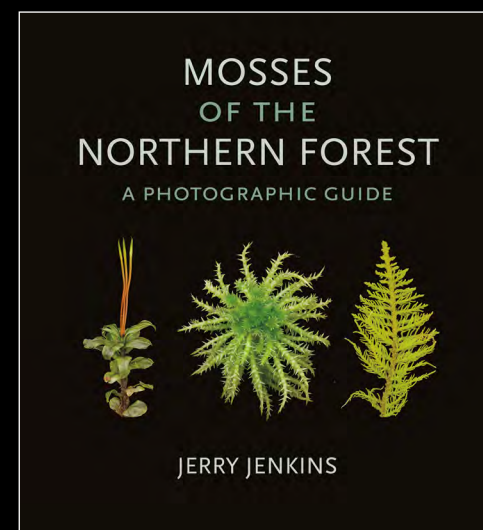
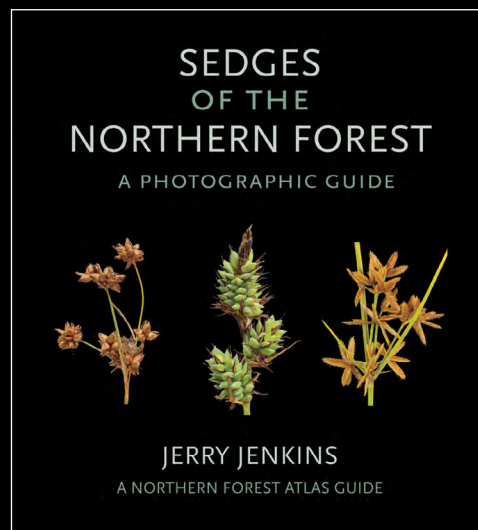
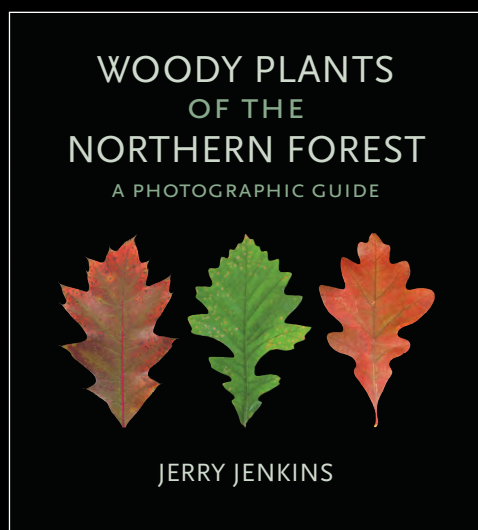
The remaining nine species are uncommon or rare. They are ecologically diverse, occurring in springs, carpets, mounds, and hummocks. All are secretive and beautiful. Go find them, and you will see.

PUBLICATIONS OF THE NORTHERN FOREST ATLAS PROJECT

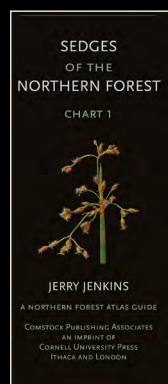
DIGITAL ATLASES



PHOTOGRAPHIC GUIDES



WATERPROOF FOLDING CHARTS



As of Spring, 2020, the Atlas Project has produced digital atlases, paper photographic guides, and folding charts to woody plants, sedges, and mosses. The digital atlases are available for download from our website, northernforestatlas.org; the photographic guides and charts from Cornell University Press, cornellpress.cornell.edu. Photographic guides to grasses, a digital atlas of grasses, and a book-length field guide to woody plants will be published in 2022.