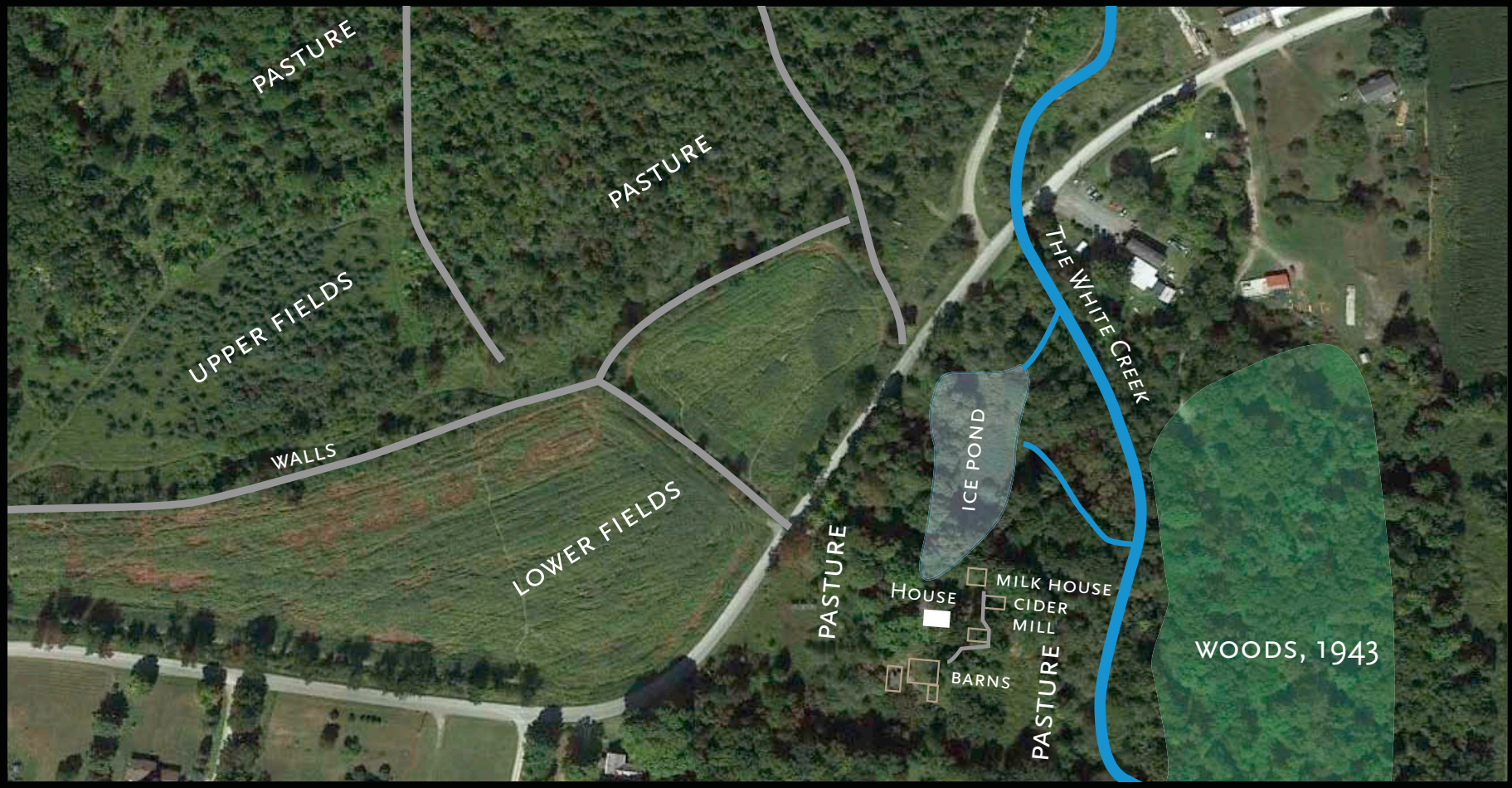
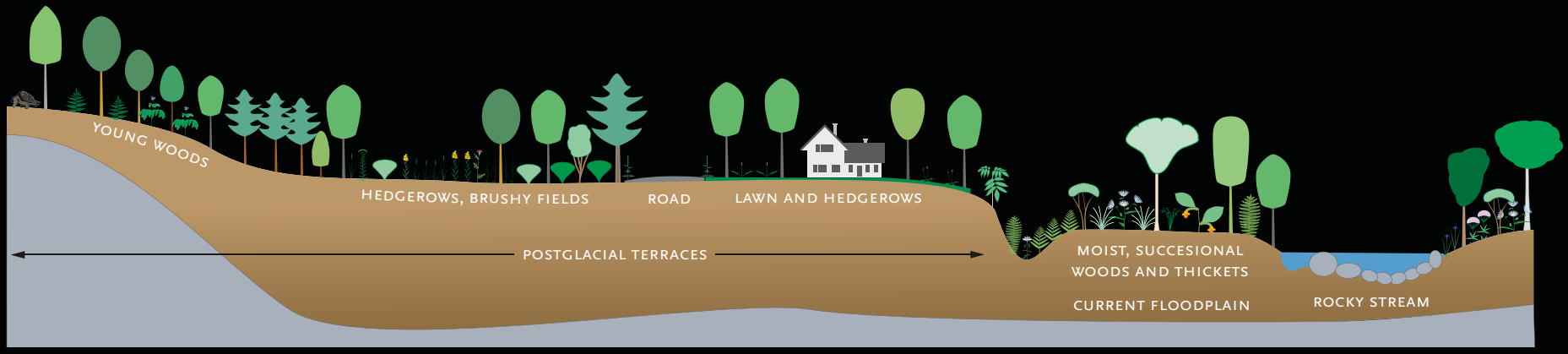




MOSS LESSON 2: WHAT MOSSES REALLY WANT

Jerry Jenkins ◆ The Northern Forest Atlas Project ◆ MAY 2020

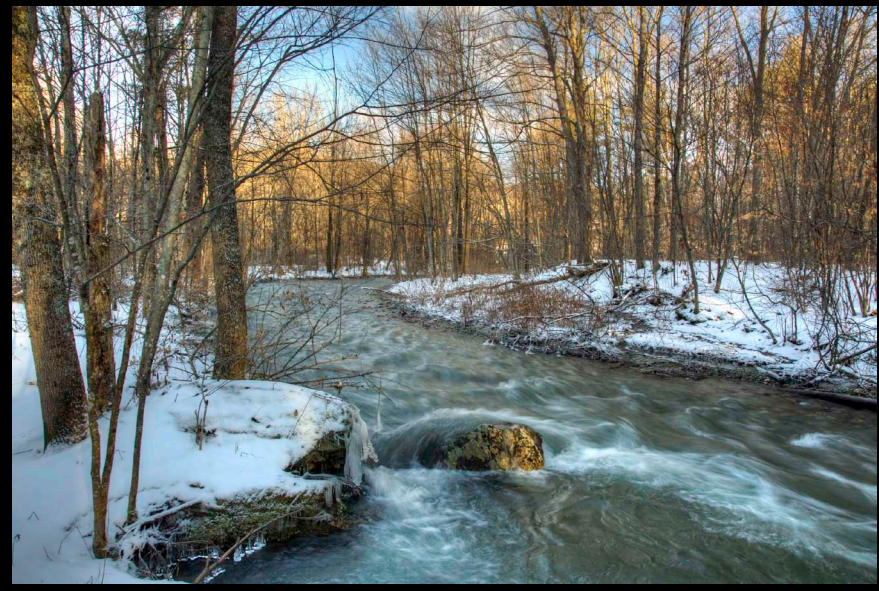
This is the second of eight moss lessons I am preparing for the online moss class, May-June 2020. They are intended to introduce common mosses and illustrate the Williams-Jenkins moss method, which uses ecology and growth form to narrow the pool of possible mosses and diagnostic characters to determine which moss you have.

Lesson 2 looks at the mosses that are locally dominant in second-growth woods and thickets on an abandoned farm. Actually, not abandoned, because they live there and so do I, Cindy and Urey, the foxes, Memphis the skunk, Mister Undershed the possum, and lots of others. But ungrazed for over fifty years. It features big mosses that are good at covering things: *Anomodon, Atrichum, Brachythecium, Climacium, Entodon,* and *Thuidium*. And also *Plagiomnium,* which, although not that big, is also good at covering.

The land includes two stream terraces. The lower was formerly grazed and is now a mixture of young woods, moist thickets, and a blackberry jungle. The upper has a cornfield, hedgerows, and an old brushy pasture. The land is fertile and grows herbs, weeds, and trees with abandon. It is also surprisingly mossy, though for a long time it wasn't mossy at all. It also grows squirrels and mice really well, but that is another story.

In the lesson, I introduce eleven mosses and as two questions: how to they manage to survive, flourish even, in a landscape so dominated by vascular plants? And are these the same as the big-moss flora of the primary woods on the rocky hills? Or, as I will argue, a different group, good at floodplains or transitional woods or both?

The next 18 pages introduce the farm and what mosses do here. The rest of the lesson divides the mosses into groups and discusses them species by species.



The White Creek, White Creek, New York, and about 100 yards west of the New York-Vermont line. It has a slope of about 100 feet per mile here and a watershed of eight or ten square miles above this point. It not big enough to paddle safely when it is up, though I have tried.

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SUCCESSIONAL COVERUPS CHEAT SHEET: MOSSES THAT MAKE LARGE PATCHES

Atrichum undulatum group: large rippled leaves with sharp teeth; costa has vertical ridges and narrows to the leaf tip. Microscope needed to separate the species. D

Anomodon attenuatus: dull green, shaggy, blunt leaved; shoots somewhat flattened, some tapering to skinny tips. D

Brachythecium laetum: shiny, irregularly branched, forming deep mats; leaves costate, with slender tips. D

Brachythecium campestre: large, light colored, in loose shaggy mats; leaves pleated, with long slender tips; capsules short, dark, inclined; setae smooth. D

Brachythecium rutabulum: on wet wood and soil. Resembles *campestre* but with larger, more inflated alar cells, nonpleated leaves, and papillose setae.

Callicladium haldanianum: irregularly pinnate, light yellow green; shoots somewhat flattened, with closely overlapped, ecostate leaves. D

Climacium americanum and *dendroides*: large and treelike, with a central stem and spreading branches, or sometimes sprawling; stem leaves broad; microscope need to separate them. D

Entodon: shiny, gold-green shoots and closely overlapping leaves. *Cladorrhizans* is strongly flattened; *seductrix* is rounder.

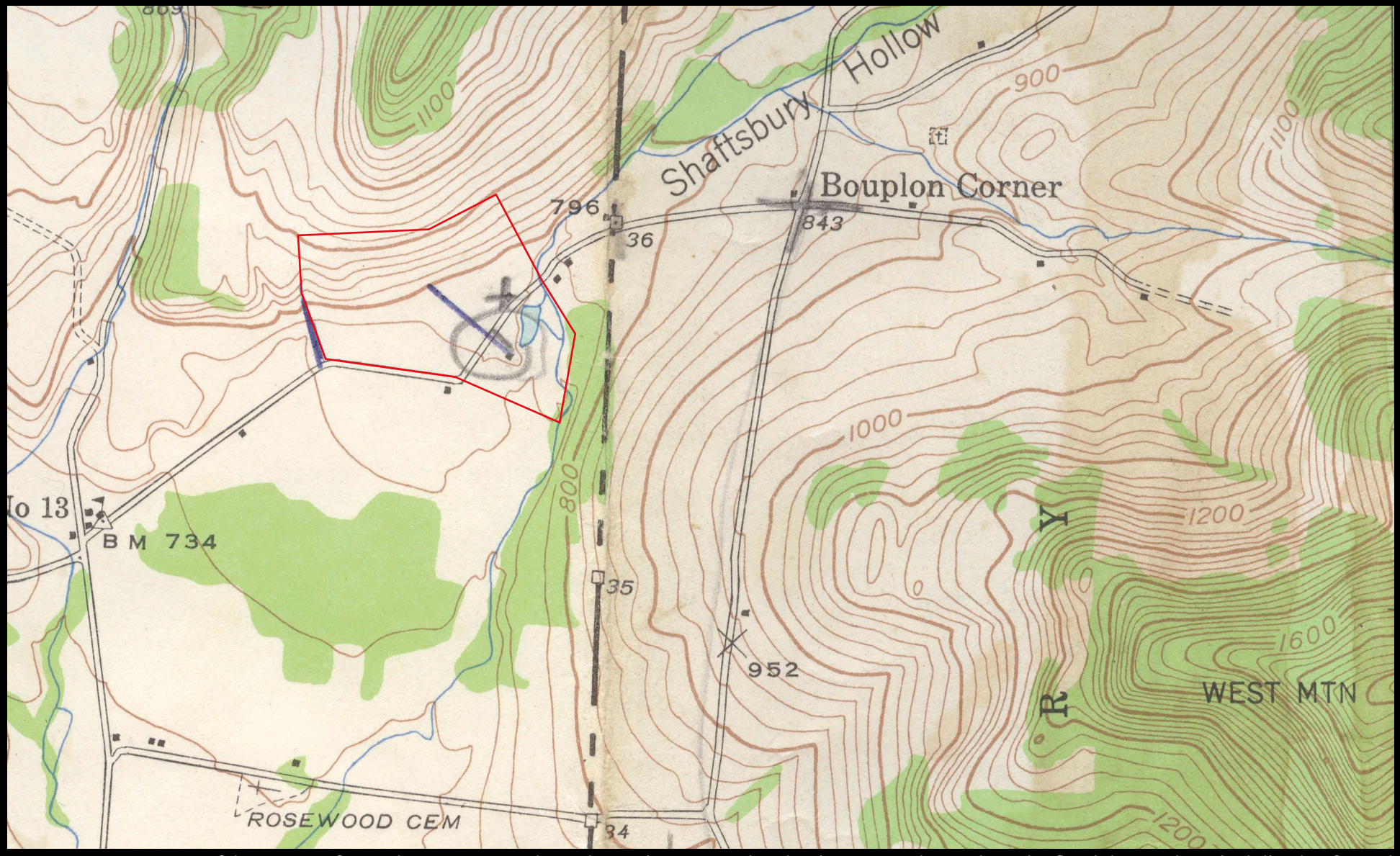
Plagiomnium cuspidatum: sterile shoots flattened and arching; leaves oval, bordered, with single teeth. *above the* middle . D

Thuidium delicatulum: shoots flattened, twice-pinnately branched, fern-like; leaves small, oval, opaque when dry. D

Large mosses, except for *Plagiomnium*, that make dense mounds or mats on soil, rocks, logs, tree bases, and tree limbs in the floodplain of the White Creek. The second growth here pulls together mosses from different ecological groups, so they are not grouped in the moss maps. *Atrichum* and *Climacium* are forest-floor and streambank species; *Anomodon* and *Entodon* are on trees, logs, and rocks, but never soil; the Brachytheciums are on soil, logs, and tree bases and occasionally in the crotches of trees; and *Plagiomnium* and *Thuidium* will grow on anything that is moist, near the ground, and, preferably, a little bit dirty.

Coverups in the flood plain In rows, from top: *Brachythecium salebrosum* and *Plagiomnium cuspidatum* on a millstone; *Thuidium delicatulum* on rocks; *Climacium dendroides* and *Atrichum undulatum* on stream banks; an odd mix of species on a stone wall; *Entodon seductrix* and *Thuidium delicatulum* on stones; *Entodon seductrix* on a stone wall; *Callicladium haldanianum* on a log; *Atrichum undulatum* on soil; *Anomodon attenuatus* and *Brachythecium salebrosum* on a large rotted log. Most of the were photographed in late winter; mosses in the open tend to stay green through February and then yellow in March and April. The *Brachythecium* on the millstone is shaded by the house.

SHAFTSBURY HOLLOW IN 1943

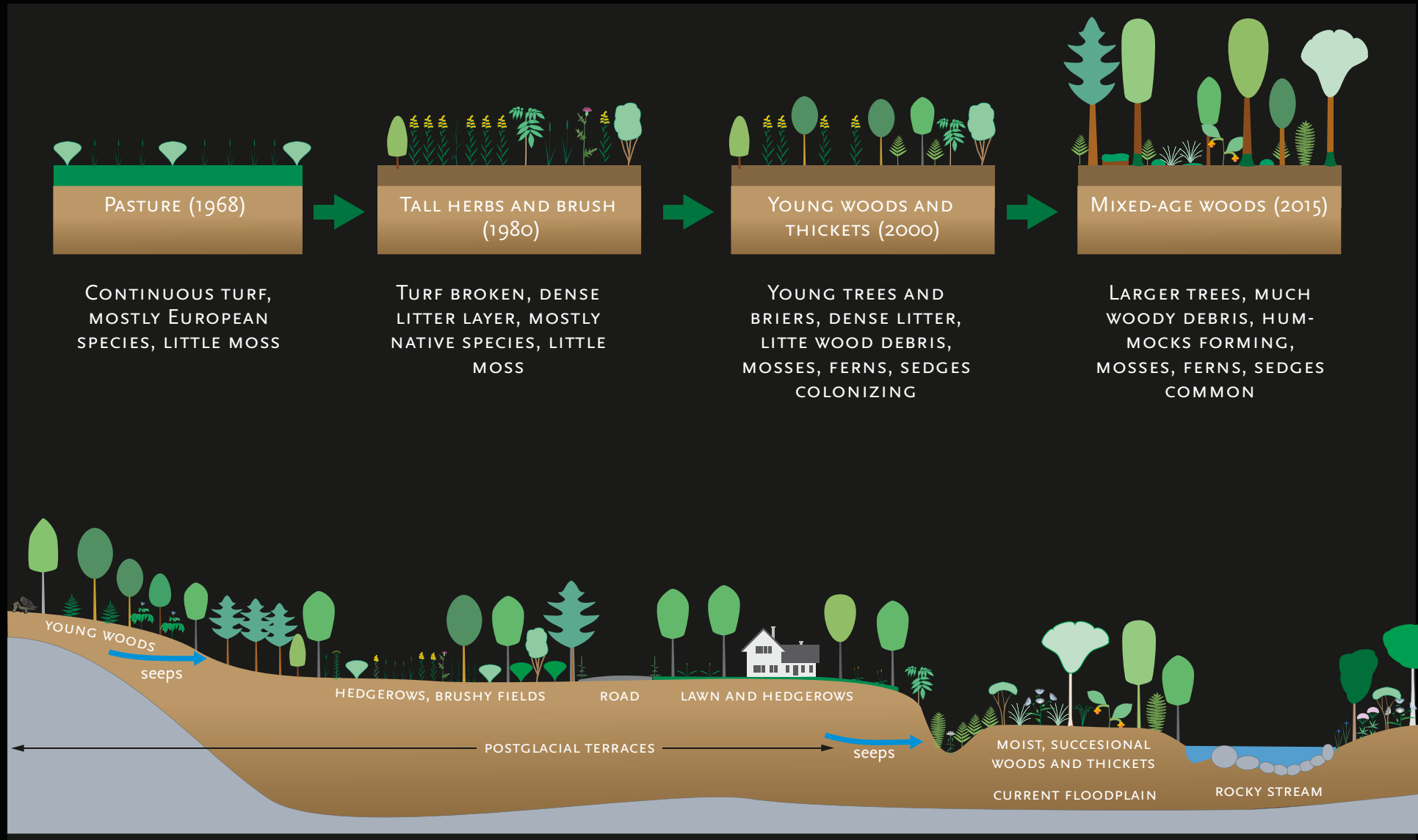


I LIVE ON THE HOUSE LOT of the Bennett farm. The 1943 USGS sheet shows the surrounding lands open, with woods in the floodplain and on the hills; this fits with what I see in the field. The red lines, based on walls and fences, bound the crop lands and lower pastures; the farm may have included other pastures to the north. There was an ice pond, a water-powered cider mill, and stones from a grist mill. Intensive farming likely ended before 1950, though there were horses here after that. The artifacts I found were pre-electric and mostly pre-fossil fuel: a dug well with a hand pump, canned goods, a battery operated radio, ice-saws, harnesses, a horse-drawn corn planter, pieces of a Model A, a one-cylinder hit-and-miss engine, a cooler for milk pails near the cider mill. There was no electricity until about 1970. The last two Bennetts, brother and sister, were Roy and Mildred. Mildred died around 1948, Roy about 1965. People remember Roy as lazy and as a character. They do not remember Mildred, the ice pond, the cider mill, or the grist mill. I pastured a horse here in 1969, moved here in May 1972 when the lilacs by the outhouse were blooming, and have been here ever since. I meant to leave and be a bosun on a research vessel somewhere, but didn't. How people will remember me I don't know.

THE BENNETT-JENKINS FARM, 2014

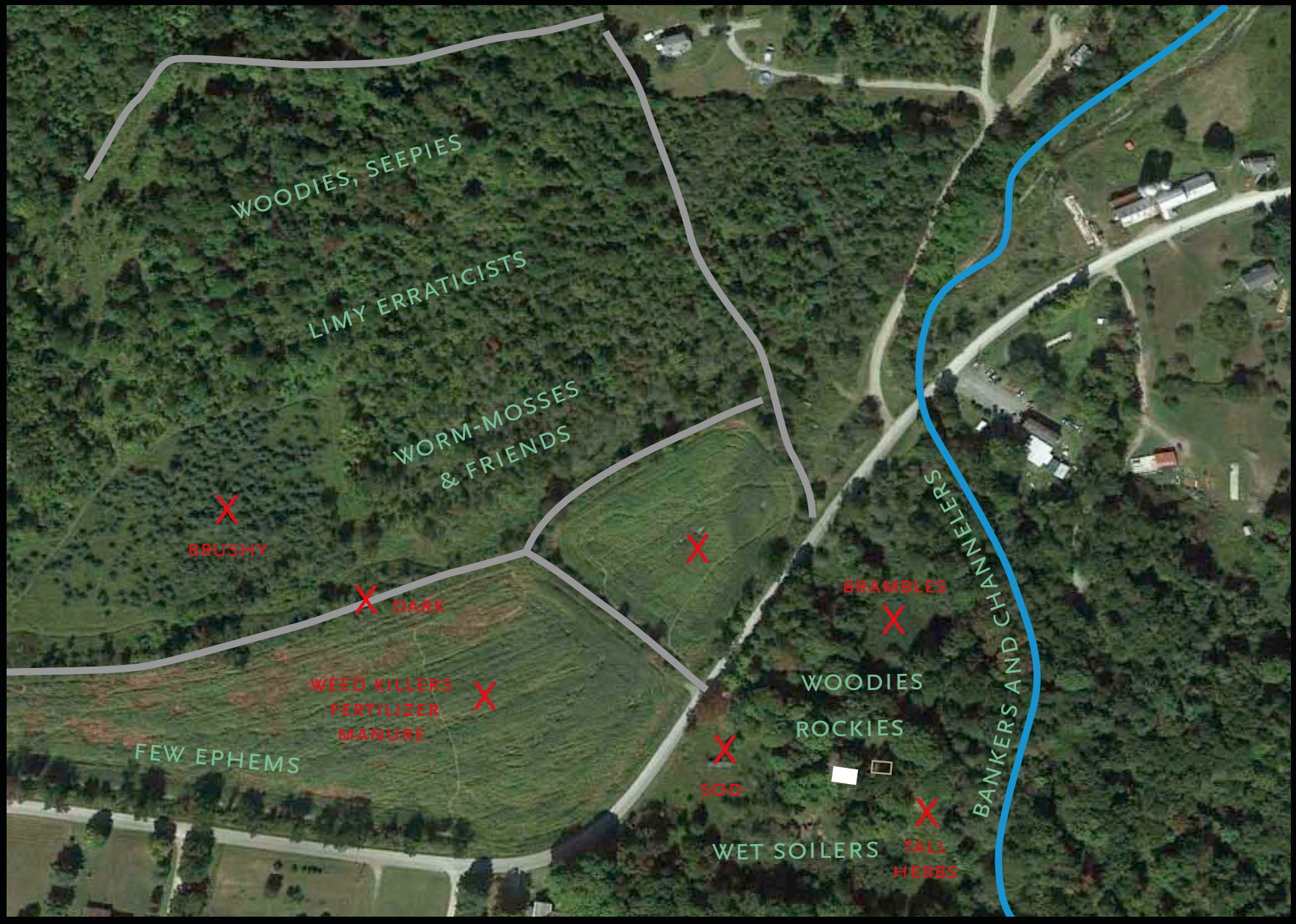
Here is the farm today, over a 2014 air photo. The walls are gray, farm buildings, now mostly gone, are open rectangles. The upper pastures and fields are brush and young woods; the lower fields are still in use; the ice pond is a blackberry jungle; the lower pastures, which were last mowed in 1974, are a mixture of young woods, blackberries, goldenrod, and wet thickets with ferns and shrubs. Successional lands are supposed to be low in diversity, but these are not; I have around 100 mosses and over 200 vascular plants between the creek and the upper pastures.

PASTURE SUCCESSION, 1969 TO 2020



In 1968 the farm was mostly open pasture, with trees along the creek and in hedgerows. There were mosses along the creek and on the stone walls, but almost none in the grassland. After mowing stopped, tall herbs, briers, and young trees invaded. The grassy turf broke up, but only slowly. For the next 20-30 years there was little moss. By 2000 the young trees had grown, eliminating the turf and tall herbs. Coarse woody debris was starting to accumulate; ferns, sedges, and mosses, were becoming common. Since 2000 the trees have expanded, the understory is shady and open, and there are now lots of moist logs and logs rotted down to soil mounds. I maintain a grassy path by mowing; herb, sedge, and fern diversity has increased several times; I find new species every couple of weeks. Moss diversity does not seem to have changed that much, but the shade, moisture, and woody debris has allowed the moss cover to increase greatly.

A MOSS'S MAP OF THE FARM, 2019



The guilds—ecological groups—of mosses on the farm today, using the Crick names. The cornfields and the tall-herb and brushy communities (in red) have relatively little moss, though many of the species discussed here can be found in them in small quantities. The Woodies and the Rockies, the most abundant groups, live on tree trunks, tree bases, moist logs, and rocks. The Seepies and Worm-mosses live on a wet hillside where limy spring water surfaces. The Wet Soilers live in low places in the flood plain; the Bankers on stream banks and bars; the Channelers on rocks in the stream; and the Erraticists on scattered limy boulders on the hill slope.

The White Creek: soil banks with seepage, cobble bars, larger stones in channel; *Climacium* and *Atrichum* on wet soil on the upper banks; *Brachythecium, Hygrohypnum, Amblystegium,* and others on rocks.

Young woods and glades, post 1970: mounds, moist soil, logs; *Anomodon, Atrichum, Brachythecium, Callicladium, Climacium, Plagiomnium, Thuidium,* and others. Lots of moss cover on tree bases, stones, and logs. The big mosses love a canopy.

Entodon cladorrhizans

Tree bark, trunks, crotches, knotholes, with lots of stemflow; *Amblystegium*, *Anomodon, Entodon, Leskea, Leskeella, Orthotrichum, Platygyrium, Pylaisia,* and *Ulota*. The large yellow-green mats with capsules are *Entodon cladorrhizans.* Trees can develop thick mats in crotches or on spreading limbs 5 or 10 meters above the ground; they never develop them on vertical surfaces. I speculate, without evidence, that mats on vertical surfaces lose water faster by gravity flow than those on horizontal ones. Or, from the mosses viewpoint, the soil is not always at ground level.

Anomodon attenuatus

Shaded tree bases in the floodplain: sparse or thick mats of *Anomodon attenuatus* (above), *Brachythecium, Callicladium, Thuidium,* often mixed with *Plagiomnium*. The thick mats typically end abruptly 30 to 50 cm above the ground and are replaced by sparse mats or none. I assume that there is a humidity pool— a layer of moist air— near the forest floor that decreases evaporative water loss; and that thick mats, which are water storage devices, can condense water from that pool at night. If this is true, the humidity pool is both a buffer against evaporative loss, and a water source through a vapor gradient established by radiative cooling.

A LOW WET PLACE IN THE FLOOD PLAIN, with sensitive fern, goldenrod, jewelweed, a few briers and elderberries. Dense vegetation and litter; small amounts of *Brachythecium, Thuidium, Eurynchium,* and others; no large patches of moss.

HABITATS, 2019 (WHICH FOR MOSSES ARE LANDSCAPES): MOWED PATH.

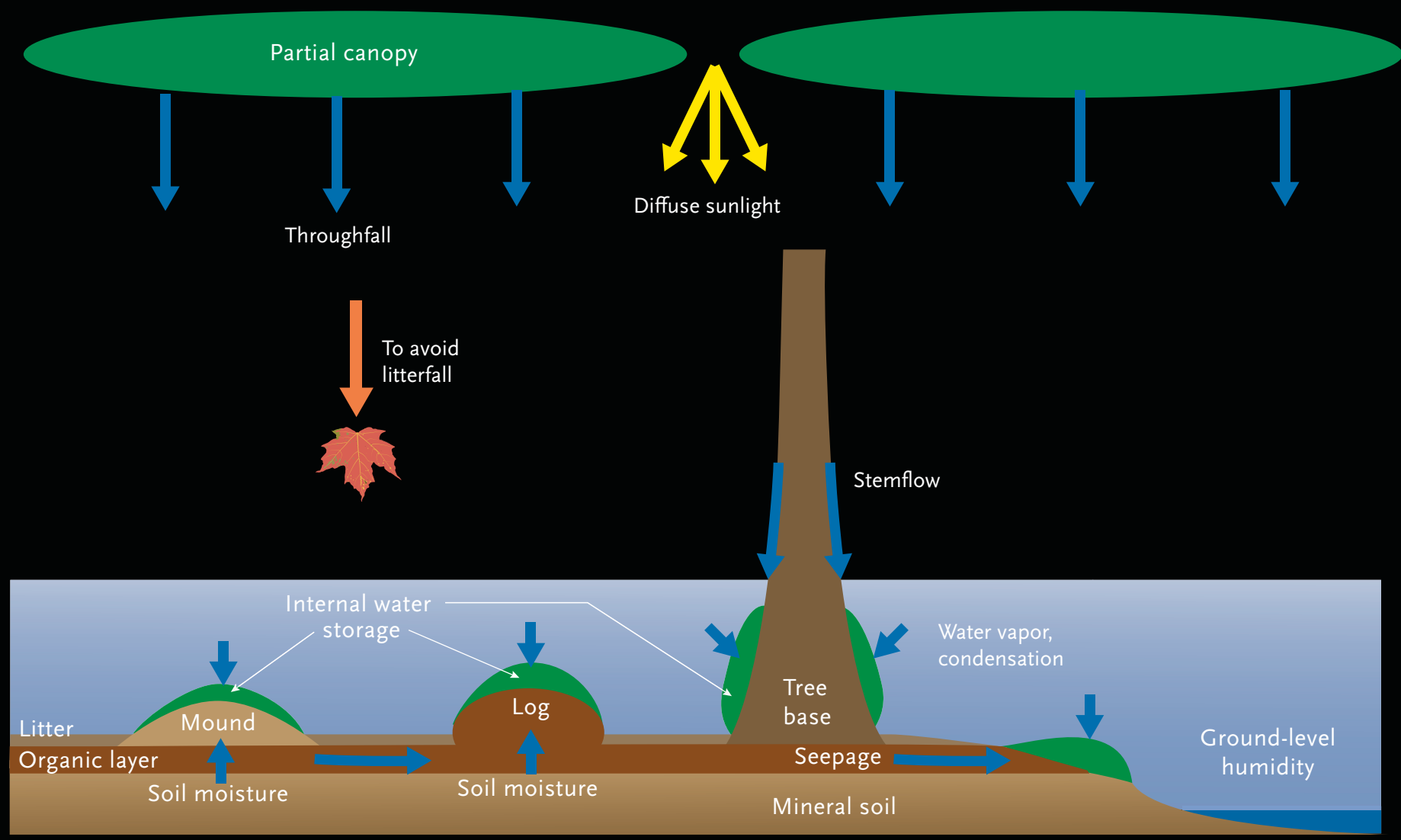
With about five years of mowing the trail supports ten to fifteen native sedges and grasses and many herbs. The soil is moist, litter blows off, and the grasses and herbs provide shade. *Atrichum*, *Climacium*, *Eurynchium*, *Plagiomnium*, and *Thuidium* are common in the ground layer.

A WALL IN THE BACKGROUND, with the wheel-pit of a water mill and an old shaft and pulley in the foreground. The pulley turned an apple grinder. The bolts just beyond it were part of the frame of a wooden cider press; the wheel drove a piston pump which driven powered a hydraulic cylinder below the press. The commonest large mosses are *Brachythecium* and *Entodon*; several others occur in smaller quantities.

The wheel-pit discharged into an old stream channel that is wet much of the year. Mosses used to grow in the channel when the floodplain was open. Now leaf litter accumulates and prevents moss growth; large mays of *Brachythecium* occur on stones and mounds.

The north cornfield, with Worm Moss Heaven in the background. Farming in Creek is episodic. Where the fields are heavily manured and herbicided, no moss grows. Where, as here, manuring has been lighter and there has been no herbicide, I can find short life-cycle mosses, especially along the edges. *Physcomitrium* and Bryums from the *lisae* group are commonest; I have also seen *Aphanorrhegma, Pleuridium, Ditrichum,* and *Weissia*.

WHAT BIG MOSSES NEED



The large mosses that dominate the ground layer here can tolerate dryness, but need to be moist to grow. Their moisture is complex. They acquire water from precipitation, stemflow, condensation, seepage, and conduction from below. Trees, seeps, and rocks provide additional flows. They store water within their clump. The soil and logs they grow on provide additional reservoirs of stored water. Elevated substrates, within the layer of humid air near the ground, promote radiative cooling and condensation. The lose water, quickly, by evaporation. To minimize evaporation they live in the shade and within the high-humidity layer near the ground, reduce surface air movement by creating a boundary layer, and shade themselves and the ground, which is an important water source. Ambient humidity is critical. Every forest has a characteristic level, rarely more than a meter above the floor, below which large mosses grow well and above which they grow poorly. In my floodplain woods, it is about 30 to 50 cm.

Mosses also require living space. With a forest, that means places where leaves do not accumulate and where large vascular plants don't grow: stones, logs, tree trunks bases, stream banks, and mounds, some of soil, some made by the mosses themselves.

From the mosses perspective, my farm is a sea of unsuitable habitat with small islands that, though far from perfect, can be made habitable with a little work. What is striking is how sharp the transitions are, and how they are almost always associated with transitions in substrate and slope. Top line: dry terrace with deep litter, no moss; *Thuidium* on rock in a dense stand of goldenrod. Lower line: *Plagiomnium* on a stone in a collapsed wall; *Thuidium* on a rotted log, surrounded by dense litter.

In a habitat where vascular plants and vascular plant litter are abundant, being a big moss requires discipline. Shade, convexity, flows, humidity, and storage are critical. The rules are: stay in the shade and the high-humidity layer; seek out convexities and flows; grow on things that are wetter than you are; and make mounds and shade of your own. Left-to-right, by rows: *Plagiomnium* and *Anomodon* on a tree base; a mound of *Climacium* on a stream bank, made by trapping sediment; *Brachythecium* on wet muck in an old stream channel; *Thuidium* on stones.

We now look at individual species. *Atrichum undulatum* and *Climacium dendroides* are large common species of wet soil, found in swamps and depressions in flood plains, along the edges of trails, and on stream banks and banks with seepage. They make raised mounds that push up through litter or allow it to blow off. They trap sediment and make raised moss-levees that stabilize stream banks, often in association with *Mnium hornum*. Of the large temperate-forest mosses, they and *hornum* are probably the ones most regularly associated with wet soil.

Atrichum undulatum has sharp-toothed, slender, ripply leaves with moderately broad points. The costas have low ridges—lamellae—on the upper side. Looking obliquely, you can just make them out with a strong lens. The capsules are long and often curved; the peristome teeth are joined to a central membrane, like a drumhead. The lamellae and drumhead make it a member of the *Polytrichaceae,* related to *Polytrichum, Polytrichastrum,* and *Pogonatum*.

Atrichum undulatum is a species group, containing the (unsatisfying) sister species *undulatum, altecristatum,* and *crispulum*. Some people believe in them. Some don't. You get to choose. It is closely related to another common species, *Atrichum angustatum*, which is smaller, has narrower leaf tips, and is more often found or rocks or disturbed soil.

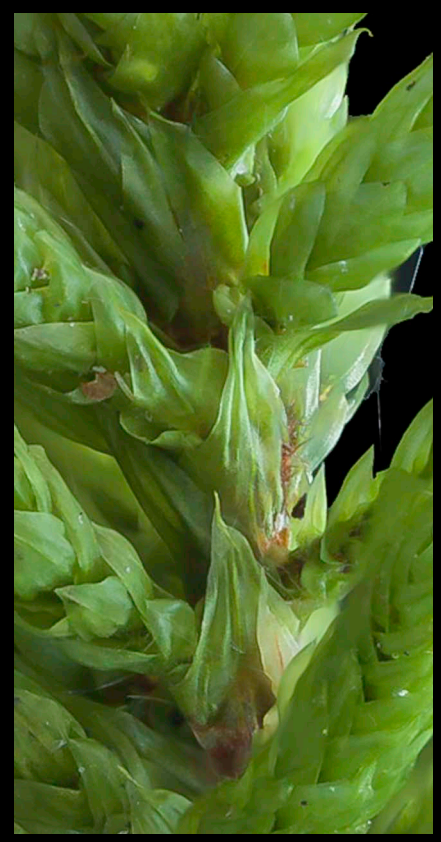
A NICE SPRAWLING PATCH OF *ATRICHUM UNDULATUM*, on wet soil in the floodplain, with sedges, grasses, herbs, and *Brachythecium*. The *Brachythecium* is on rocks and doesn't spread across the soil or try to compete with the vascular plants. The *Atrichum* does, though just how I am not sure. It ability to come up through litter, grow fast, and make a fairly dense turf likely help.

Another patch, ignoring litter and competing with sedges, grasses and herbs. The old growth is darker and taller. The new leaves within the clump are expanded, the old leaves on the shoots above the clump are all curled up. All our *Polytrichaceae* curl, very quickly, when you remove a shoot from a clump; my assumption is that the lateral cells of the photosynthetic lamellae have thin walls and can lose water rapidly when the ambient humidity decreases. The brown shoots by the hole on the left are dead. Lots of small mammals burrow in moss. I am guessing chipmunk here.

Good field marks are the wavy lanceolate leaves with sharp teeth and fairly broad tips that curl like corkscrews when dry; the long capsules with the peristome teeth fused to a membrane; and, with a strong lens, the ridges on the costa.

A STREAMBANK COLONY, with new and old growth and red stem, mixed with a few shoots of *Thuidium delicatulum* and *Plagiomnium cuspidatum*.

The tree moss, *Climacium dendroides*. It is a pleurocarp and spreads by creeping stems. The picture shows old plants from last year, with central stems and lots of spreading branches; and new stems that arose from buds on the creeping stems and will expand in the next month or so. They look a bit like *Sphagnum palustre*, but only a bit. *Climacium* is a distinctive genus; no other moss looks like it. The species are wet-soil specialists, found in seeps and wet hollows, along streams, around pools, and in springy places in the woods, usually on soil but occasionally on well-rotted logs or tree bases. They are hard to tell apart, and may not be good species, if there is such a thing.



Books describe two species of *Climacium*, *dendroides* and *americanum*, differentiated by the shape of the branch-leaf and stem-leaf tips, the length of the branch leaf cells, the strength of the auricles on the branch leaves, and the thickness of the walls of the branch-leaf basal cells. Pat Eckel has a beautiful drawing of the differences in the *Flora of North America*. I don't believe it. I can find almost all those differences on a single stem. The stem leaves aren't bad; branch leaves are lawless rascals. A moss from the banks of my creek on the desk today, which has the rounded stem leaf tips of *dendroides*, has branch leaves with both truncate and acute tips, short and long cells mixed, basal cells thick-walled or thin-walled, and basal leaves with and without auricles. Thus four out of the five characters that are supposed to differentiate the species can vary on the leaves of a single branch. I call everything here *dendroides*.

New and old shoots, with old capsules, forming a mound in the flood plain.

On the creek bank, spring 2019, after multiple ice-jam floods which scoured the banks, removing litter and soil, and undercutting the banks. The clumps of moss are largely intact; the areas in between them are scoured. *Atrichum undulatum* can do much the same. Moss are good at holding things together. As a rule, steep mossy streams in the mountains run clear after storms and are surprisingly stable.

The humidity-pool mosses are restricted to, or are best developed, near the forest floor where the humidity is highest. *Anomodon attenuatus* is a very common species of tree bases, logs, and limy rocks and ledges. On ledges it often grows quite high from the ground; I expect the microclimate is different, but don't really understand it. On boulders and tree bases it stays near the ground, forming thick mats or stockings. Above the socks, as here, there are often stunted plants which don't form mats. The difference can't be water supply; the water here comes from stemflow, and so the stunted plants farther up the trunk have, if anything, more water than those below. It is very common to find that mat-forming mosses are restricted to the lowest meter of the trunk or less; my hypothesis is that this represents a sort of "compensation height," above which losses to evaporation are not replaced by condensation and stemflow.

The Anomodons have triangular-oval leaves with costas; the cells are papillose—minutely roughened—which makes them opaque and gives them a dull rather than shiny surface when dry. It also makes them hard to photograph clearly. We have six species, of which four can live on trees. *Attenuatus* is the commonest and the one that you will meet first. It is more branched than the other species, with thick branches that end in curled club-like tips, and thin tapering ones with tiny leaves. Stunted plants with only thin branches are common and will fool you until you know them.

Anomodon attenuatus often makes thick stockings on tree bases. in Adirondack old growth,the stocking may reach 10 cm thick or more. The ones here are about 5 cm thick. Someone likes to tear them up and look under the pieces. It looks like skunk work to me but I don't know for sure.

A LARGE (50 CM) MAPLE LOG that is well rotted and moist. Susan Sawyer drew it once. We told her it would be impossible but she did it anyway. From the left, a small patch of *Anomodon;* a big patch of *Brachythecium,* recognizable by the light color and stringy branches; a big patch of *Anomodon,* recognizable by the pinnate branching and clubbed tips. There is no stemflow on a fallen tree; the mosses get water from throughfall, buffered by storage in the log. To get patches this thick the log has to be rotten enough that you can stick a pencil in it.

Dry and partly dry shoots, showing the characteristic pattern of rat-tails and pom-poms. This pattern, by itself, is diagnostic for *attenuatus*.

Wet plants of *attenuatus*, fuller and leafier, with widely spreading leaves and somewhat flattened shoots. The leaves have oval bases that contract to sharpish tips.

Thuidium delicatulum, fern moss, is a common moss in deciduous woods throughout the Northern Forest area. It can grow on soil, rocks, logs, and tree bases; anything that is at least partly shaded and is either moist or in a humidity pool will do. It has the largest ecological amplitude, and hence the large cover of all the mosses in the floodplain here. The picture, taken in March, shows it on a rock. The late-winter sun yellows the leaves. The greener leaves by the stick were covered with litter that I removed.

Thuidium is a distinctive genus, immediately recognizable from the two-times pinnate branching.* The leaves are small and papillose and look dull and opaque when dry. The stems have mats of paraphyllia—crinkly branched hairs— around the bases of the stem leaves. (Rhizoids are much the same but are brown and have angled cell walls.) The tips of the stem leaves curl in towards the stem when dry and their costas stop below the tips. *Thuidium recognitum,* a related a species that is locally common on calcareous ledges and in calcareous swamps, has stem leaves whose tips curve outward when dry and whose costas fill the tip and stick out in a point.

**Hylocomium splendens,* the stepladder moss, is also fernlike; it has broader leaves and three-times or four-times pinnate branching.

Thuidium delicatulum makes dense mats, and can grow over pretty much anything near the ground, as long as the forest is wet enough and it is not under conifers. It is recognizable as a *Thuidium* on sight; confirming that it is *delicatulum* takes a strong lens or a microscope.

Thuidium mixed with *Callicladium* or *Entodon* on a tree base. On trees it is more pendent and shaggy looking than on logs or rocks. The same is true for other mosses; on horizontal surfaces they interweave and make mats; on trees they dangle and make fringes.

Thuidium on a log, with grasses and herbs in the background and a little *Climacium* in the foreground. *Thuidium* is a great coverer and, like *Anomodon, Brachythecium,* and *Entodon,* it often occurs in pure colonies. It can also live on soil, but only where the wind removes the litter. It can't push the litter away like *Atrichum* or *Climacium.* In a place like this where the litter is thick, it can cover every inch of the log, but has no chance of spreading from the log onto the soil. In my mowed paths, which are largely litter-free, it grows happily among the grasses and sedges.

Brachythecium is a large genus of pleurocarps that thrive on patchy, successional habitats. We have six common large ones, one common small one, one uncommon small one, and at least seven rare ones that we leave to people who understand them better than we do. Our common species are mostly irregularly branched mat formers, often stringy, often pale green or white green, with pointed leaves with weak costas and differentiated alar cells. The capsules are curved and inclined and quite dark and fat when young. As a group they are ecological generalists, growing on soil, rocks, logs, tree bases, cliffs, shores, and on muck in swamps; outside of peatlands, there are few Northern Forest habitats in which you can not find a *Brachythecium*.

There are no field characters that will distinguish all Brachytheciums, but, because they so common, you will soon develop a sense of them, if only by elimination. The look above—light colored, stringy, shiny, irregularly branched, with pleated, costate leaves with long skinny tips—marks the *campestre* group. You will see it again and again.

THE HUMIDITY-POOL SPECIES: TEAM *BRACHYTHECIUM*, MAT AND MOUND FORMERS

CAMPESTRE

LAETUM

POPULEUM

PLUMOSUM

RUTABULUM

RIVULARE

Six common Brachytheciums that make extensive mats or mounds. All live near me, and at least five live or used to live on the farm. They have some ecological separation: *Laetum* and *populeum* are in the driest places; *campestre* and *rutabulum* in wetter ones; *plumosum* is on rocks in streams; and *rivulare* in swamps, on stream banks, and on wet ledges. Exact identification requires a microscope and experience. I call them *level-3* plants, meaning the differences are gradational and they need to be compared to each other and to reference specimens to make accurate identifications. A table covered with *Brachythecium* collections may or may not be inviting, but there are good ways of dealing with them. A single collection, especially if you are out of practice, can be risky. This is particularly true with the species related to *campestre* and *laetum* that have recently been redefined; what I called *campestre* in 1995 is not the same as what Bruce Allen and Bill Buck call *campestre* today. A bit like landing on a moving runway. I sort them by ecological groups and don't try too hard for species-level IDs in the *campestre* group.

A BIG BUSHY PLANT ON A ROCK; light color, silky and shiny look, irregular branching, pleated leaves. Everything about it shouts *Brachythecium*. If fertile, it is most likely *campestre,* which is autoicous. If sterile, either *salebrosum* or *laetum*. This one was sterile; under the scope, the alar cells looked like *campestre.*

A SIMILAR-LOOKING PLANT, light colored, medium-sized, with pleated leaves with long tips, this time on a log. It is fertile and so we guess *campestre.* The greener plants down on the side with long creeping soots are *Callicladium. Callicladium* does good *Brachythecium* imitations. If it fools you, you are not the first one.

A PALE PLANT ON A ROTTEN LOG; again, the silky look, light color, and long leaf tips are all *Brachythecium.* Under the lens, it had the pleated leaves with long tips of the *campestre* group. Under the scope, it had the enlarged, rectangular lower alar cells of *campestre.* For years, everyone called this *salebrosum,* "healthful," which was a nice name. Now we are told, by advanced friends, that it is more rounded at the base than "true" *salebrosum,* and we are to call it *campestre.* I have two reactions to this. The first is that the bases of our plants vary a lot, and I am not particularly comfortable with that as a species character. The second is that, as a blue-collar botanist, I am not sure I care.

Brachythecium laetum, here on a tree base in the floodplain, is a loose, curly, stringy species, very common on ledges, boulders, and tree bases, also on logs. It is dioicous and rarely fruits. In the field it looks very similar to *campestre*: light color, shiny pleated narrow leaves with long tips. They overlap ecologically, though *laetum* may be a bit more likely in dryer habitats. They are distinguished microscopically by the smaller, squarer alar cells of *laetum*. In the field, a fruitless *Brachythecium* of this sort, especially on a tree or ledge, is often *laetum*. But *campestre* can be sterile, and often isn't always.

A big erect *Brachythecium*, common on mucky soils in an old stream channel in the flood plain. The channel dries in the summer and the moss is shaded by jewelweed, which it appreciates. The leaves are broadly rounded triangular, concave, and unpleated; the leaf tips are narrow and often twisted. This suggests a field id of *rutabulum,* a large common species of wet soils. The scope showed enlarged alar cells and narrow decurrencies, confirming *rutabulum*.

Another big erect *Brachythecium*, growing on stones at the edge of the stream channel. It looks much like *rutabulum* in the field: broad, deeply concave leaves, no pleats. The leaves seem to have short tips and the habitat is classic *rivulare* habitat, so we guess *rivulare*. The scope confirms the short tips and shows striking groups of inflated alar cells running down into broad decurrencies, so *rivulare* it is.

Callicladium haldanianum is a large common moss of logs, tree bases, and moist soil. Its leaves are oval, concave, and smooth rather than pleated, with short sharp tips and short costas. The capsules are long and curve from erect bases to nearly horizontal lids. Under the scope, the alar cells are strongly inflated. In its most distinctive form, shown above, the branches are somewhat flattened and the leaves spread. Less distinct forms have rounded branches with tightly overlapping leaves. They look like *Entodon*, which has erect capsules, or the *Brachythecium campestre* group, which has pleated, costate leaves with really long tips. It is a classic imposter: it can look like other things, but nothing else looks like it. I have often mistaken *Callicladium* for *Brachythecium or Entodon cladorrhizans,* especially at a distance; I have almost never mistaken *Entodon* or *Brachythecium* for *Callicladium.* Fortunately, the microscope always knows; once you see the big alar cells, you know, once again, that it is *Callicladium*.

Callicladium at the base of an ash, in its characteristic form: shiny yellow green, creeping stems with short, flattened, swordlike branches. Far left, new capsules of *Plagiomnium cuspidatum*. Above the *Callicladium*, a dark green patch of *Anomodon attenuatus*, with lighter pompoms. Much of the dark green scruffy stuff on the bark at right is also *Anomodon*.

Two pictures of *Callicladium* on tree bark, neither very good; the one on the left is a faded plant in early spring; the one on the right, with new growth, is in middle May. Note the light green color, creeping horizontal stems, flattened swordlike branches, and long curved capsules with white peristomes. The short capsules along the right edge of the first photo are *Plagiomnium cuspidatum*.

Callicladium on a rotted log, with *Thuidium delicatulum*. The branches here are more elongate and less flattened than the typical and strongly resemble the *Brachythecium campestre* group. The long curving capsules and the smooth, short-tipped leaves without pleats are the best distinctions. I wish I could say that this form has never fooled me, but it has.

The Entodons are medium-sized mosses that form glossy mats on rocks, tree bases, logs, and tree limbs. The leaves are oval and closely overlapping; the capsules are cylindrical and erect, which is uncommon among the big pleurocarps. Under the scope they have short double costas, long middle cells, and short square alar cells. They are very common in successional woods here, occurring both at ground level and on inclined tree limbs higher up. They are much less common northwards and in the mountains. *Seductrix* (above) has round shoots and can make dense mats, like a shag rug. *Cladorrhizans* has flattened shoots with sharp edges and makes looser mats. Other than that, I see little difference between them.

THE SHOOTS OF *CLADORRHIZANS*, left, are flattened and have distinct edges; those of *seductrix* (right) are round, or rounder. Both have closely overlapping leaves which are glossy and have relatively short tips. The erect capsules are a great field mark: Brachytheciums, Hypnums, and the wily *Callicladium,* all of which make thick mats in the same sort of places, have inclined capsules. Like other pleurocarp genera with erect capsules, the inner peristome is simplified; apparently the classic trick of flicking spores out with the endostome segments either isn't needed or doesn't work with erect capsules.

CLADORRHIZANS

SEDUCTRIX

The two Entodons in the field. Both are glossy and have tightly overlapping leaves with short tips and erect capsules. If you see something with long slender leaf tips, spreading leaves, or, inclined capsules, it isn't *Entodon*. *Cladorrhizans* has strongly flattened branches with edges, and may have wider branch angles; *seductrix* has round or slightly flattened branches.

Entodon seductrix growing on an inclined limb, about 1.5 m off the ground. The stringy dark plants around it are *Leskea*. *Entodon* loves to grow in crotches and on inclined limbs (and on rocks and logs), but is rarely on vertical trunks or bases. It may get more sun or retain more water that way.

Entodon seductrix growing horizontally on a dry stone in a old wall. The rock is an everyday Taconic schist, not particularly limy. Some of the moss is growing over the lichens; some of the lichens are growing over the moss; both store water and moisten the boundary layer. To Neodarwinists this is competition. To Gaians, it is collaboration.

Plagiomnium is an acrocarp genus with oval leaves with borders and single teeth, nodding capsules, and flattened, arching sterile shoots. *Cuspidatum,* with the leaves toothed above the middle, is our commonest species. It makes mats, either pure or mixed with other species, within the humidity pool. Here it is growing with a *Brachythecium,* most likely *campestre*. The large light-colored capsules are *Plagiomnium*. The small dark ones are *Brachythecium*.

The leaves are oboval, bordered, and toothed above the middle; the lower edges run down the stem. Capsules nod and have beaked calyptras. Fertile shoots are erect; sterile shoots (next page) arch. Our two other common Plagiomniums, *ciliare* and *ellipticum*, have leaves that are toothed below the middle. Those of *Ciliare*, common in cool moist woods, are several cells long. The genus *Mnium* is similar, but has the teeth in pairs. The pairs are visible with a strong lens if you look at the leaves on edge.

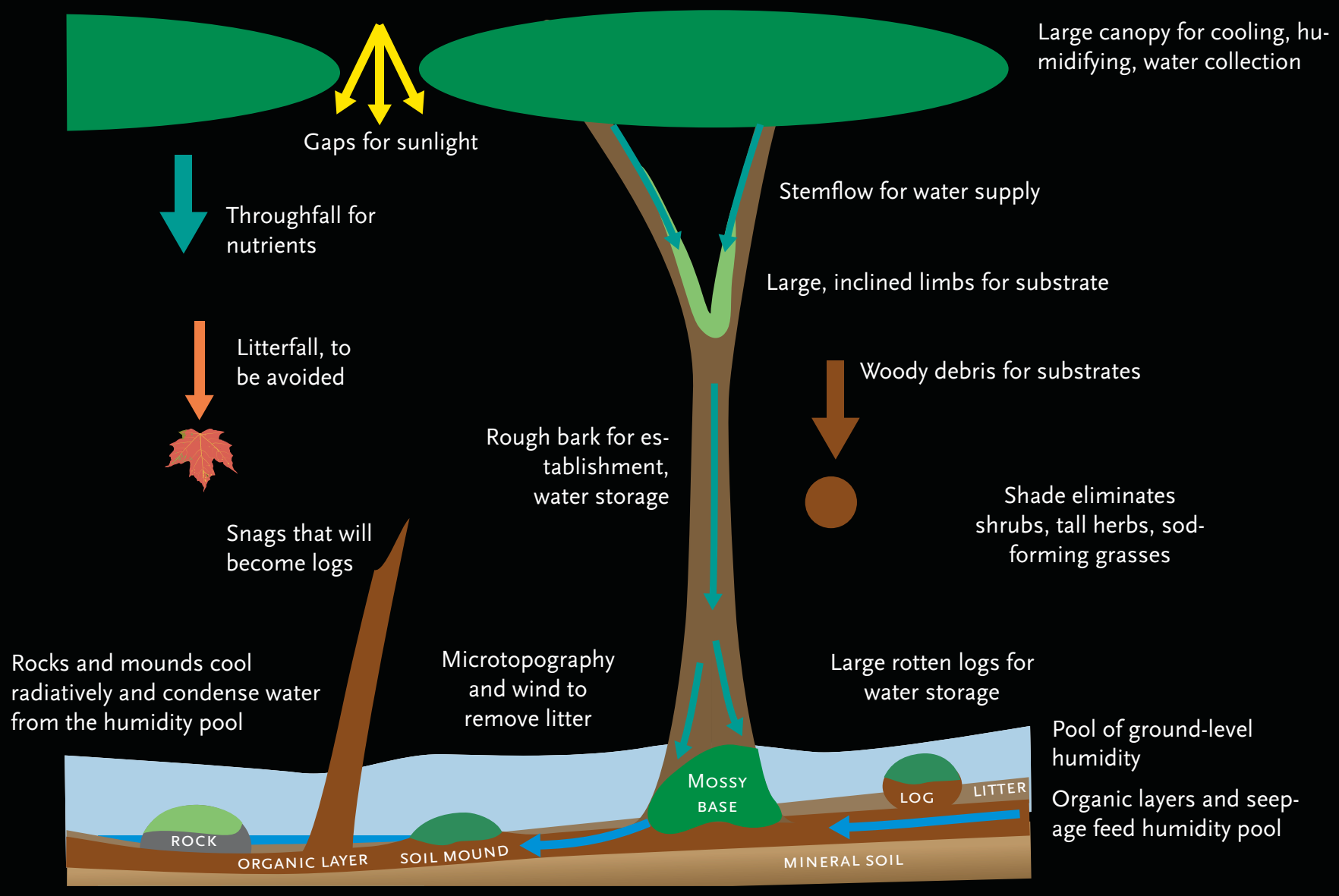
THE ARCHING STERILE SHOOTS OF *PLAGIOMNIUM CUSPIDATUM*. The sterile shoots are flattened, with oval leaves that have borders and are toothed above the middle. They elongate gradually through the season, and can be quite conspicuous in summer. One of the pleurocarps mixed in is *Anomodon attenuatus*. The other may be *Eurynchium*. Our other Plagiomniums (and the rare *Cyrtomnium*) produce similar sterile shoots. *Mnium* and *Rhizomnium* don't.

A PATCH OF *CUSPIDATUM* ON A TREE BASE, with new capsules and leaves, hard to photograph clearly at this distance. New clublike shoots of *Anomodon attenuatus* to the right, a fine dark mat of *Leskea* above.

Erect fertile shoots, with new setae and calyptras covering the developing capsules, in March, 2016. They may be yellow and wiggly because they were under something. *Plagiomnium*, like many other mosses, takes its time about reproducing. The setae—the new sporophytes—result from a fertilization that took place the previous spring or summer. The setae appear in late fall, develop slowly in winter, produce capsules in spring, and shed spores in late spring. They say, "One of the perks of local dominance is that you get to make plans."

Fertile plants in early May; calyptras gone, spores maturing, capsules turning from green to brown. Most lids still on. A week later, 16 May, the lids were off and the peristomes visible. A few sterile shoots are visible at the top. My guess is that the small pleurocarp is *Brachythecium*.

WHAT MOSSES REALLY WANT



"What lands maketh most Moss" the late-medieval bryologian Carolus Cambriensis asked. On my farm, the answer is clearly "the Woods, Forests, and Rides." Canopies shade the ground and still the air, allowing a humidity pool to develop. They provide substrates—limbs, bark, bases. They collect, enrich and concentrate water and deliver it to the ground by tree trunks, which happen to be places mosses can grow and vascular plants can't. They generate a litter layer, which provides water storage, and coarse woody debris, which provides both substrates and storage. There are mosses other places, among the tall herbs, on rocks and walls, along the creek. But the bulk of the post-abandonment moss cover is under trees, and much of it is on wood. From this point of view, what the large mosses really want is a woody canopy that is tall and continuous enough to create a moist microclimate; made of trees with large crowns for stemflow and large branches and bases for habitat; and that generates large snags and logs for microtopography and water storage.

1 The Bennett farm had relatively few mosses when grazing stopped around 1970. There were mosses on the stone walls, along the creek, at the bases of the larger shade trees. There were almost none in the pastures or cornfields. Most of the ones that were there were small; the large mat- and mound-formers that dominate now were absent or scarce.

2 The shrub and tall herb communities that followed abandonment had small mosses, but relatively few large ones. It was only about thirty years after succession, with the growth of trees and the formation of a partial canopy, that the large mosses became common.

3 Today, fifty years after abandonment, eight genera and eleven species of large mosses are common, mostly along the creek and on the floor of the young woods. Their habitat is discontinuous: they can't live where leaves accumulate and so must reach and colonize islands, or build mounds, from which litter is blown or washed away.

4 The formation of a woody canopy has been a big part of their success; the canopy creates a shaded environment with a ground-level humidity pool, populates that environment with trunks, branches, and logs that mosses can grow on, and creates a layer of organic litter. It also creates a mosaic of small watersheds, with each tree crown a collecting area and the branches and trunks the waterways draining them.

5 For mosses deciduous leaf litter is both blessing and bane. They can't live any place that it accumulates, but, because it stores water and humidifies the ground layer, they can't live without the moisture pool it creates. This means that 90% of the forest floor is uninhabitable and 10% in high demand.

6 Other commonalities in big-moss ecology include the use of elevated substrates to avoid litter and to increase radiative cooling and water vapor transport; the dependence on wet substrates and the ground-level humidity pool; the storage of water within clumps; and the creation of moss canopies to shade wet substrates and limit evaporation.

7 The mosses that live here divide roughly into two ecological groups. *Atrichum* and *Climacium* are mound builders. *Anomodon, Brachythecium, Callicladium, Entodon, Plagiomnium,* and *Thuidium* are mat-makers. *Atrichum* and *Plagiomnium* are acrocarps, the other pleurocarps. The mound-builders depend on moist soil and seepage; the mat-makers on stemflow, condensation, and wet substrates. Two species of *Brachythecium, rivulare* and *rutabulum,* have features of both groups.

8 All of these mosses, no matter what group, have similar features: they form loose colonies into which light, water and fine litter can penetrate; they are dense enough to shade themselves and the substrate; and they can spread horizontally and cover a whole island of substrate.

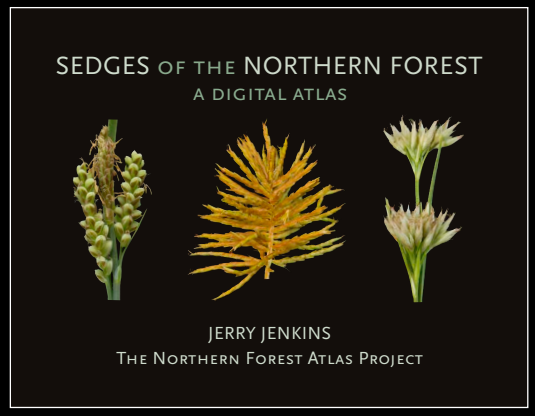
9 Many substrate islands have only one or two dominants. One log may be all *Brachythecium,* the next *Thuidium* or *Callicladium*. This suggests a race where the early establishers have an advantage rather a niche process where the microenvironment favors a certain species. Niches certainly exist, and competition for them certainly exists. But mosses remodel their niches to their liking, and early arrivals seem to have a big advantage.

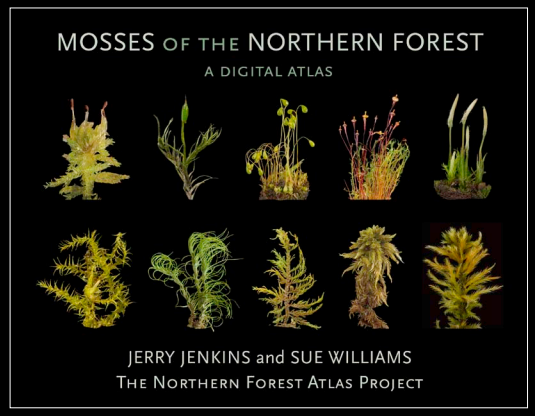
10 Fifty years after abandonment, there are a lot of mosses here. My old count, which I need to update, was over 100 species between the creek and the adjacent hill. The areas covered by moss are still quite limited; this is true in most deciduous woods and may not change as the forests mature. Only the best mound builders can handle deciduous litter.

11 Much of the moss cover there is contributed by eight genera. All are common, and these woods don't differ much from other moist successional woods near here. They do however, differ greatly from older woods that have never been farmed. The Entodons seem less common in older woods. *Dicranum, Hypnum, Leucobryum, Pleurozium,* and *Polytrichum*, all common in older woods, are scarce or absent here. This seems odd, the moss equivalent of a highway without Fords and Chevys. We meet these genera in the next lesson, and I will have more to say then.

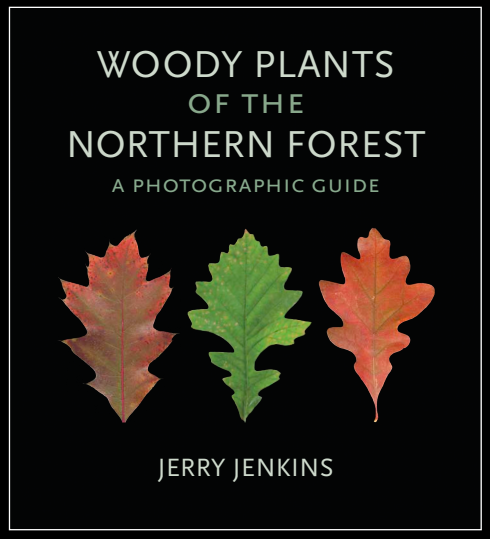
PUBLICATIONS OF THE NORTHERN FOREST ATLAS PROJECT

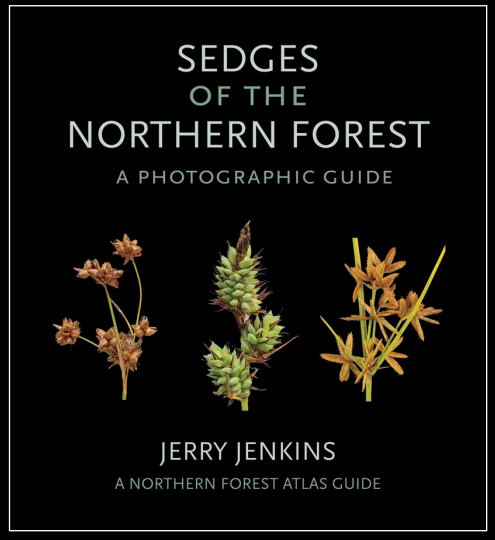
DIGITAL ATLASES

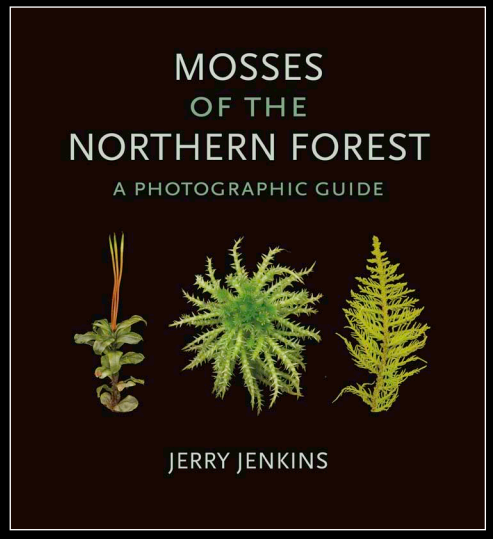




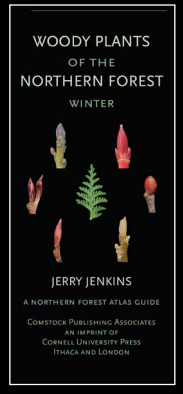
PHOTOGRAPHIC GUIDES

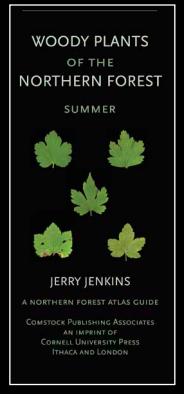


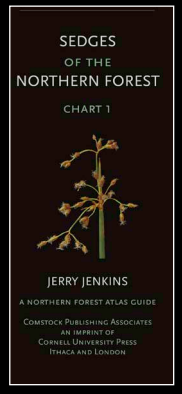


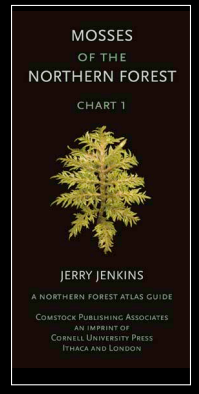


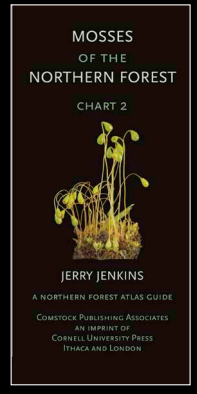
WATERPROOF FOLDING CHARTS











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.