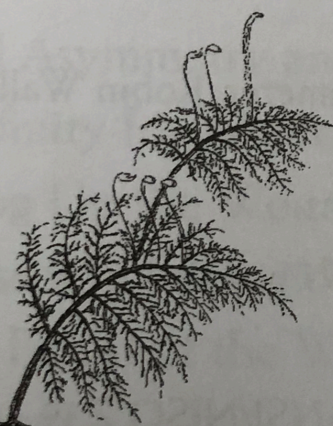
# *Gathering Moss*



*A Natural and Cultural History of Mosses*

by

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# Kickapoo

I finally got around to refinishing the bottom of my canoe. After the duct tape wore off. Ahh, duct tape, the great enabler of the procrastinator. I peel it off, layer after layer, where I'd slapped it on after a collision with a rock on the Oswegatchie, and where the stern bumped down hard on a ledge of the New River. Inspecting the various cracks and chips is like taking inventory of great canoe trips. Here's a souvenir of the rapids on the Flambeau and here the gravel beds of the Raquette. Along the gunnel there is a smudge of red paint, running for six inches or so along the sky blue fiberglass. I puzzle over that one for a moment and then I remember-the Kickapoo and the summer I spent immersed.

The Kickapoo River runs through southwestern Wisconsin in a region known as the Driftless Area. The glaciers which covered the upper Midwest skipped this one little corner of Wisconsin, leaving a landscape of steep cliffs and sandstone canyons. I discovered the stream with a fellow graduate student as she surveyed the area for rare lichens. We paddled down the river, stopping at cliffs and outcrops to scan the species. All along the river I was struck by the distinctive pattern on the cliffs. The upper reaches of the cliff were spattered with lichens, but at the foot of the sheer wall were horizontal bands of moss in different shades of green, rising from the water. I was looking to find a thesis question and this one found me. What was the source of the vertical stratification that striped the cliff?

I had some ideas, of course. I'd climbed too many mountains not to notice the changes in vegetation with elevation. Elevational zonation usually results from temperature gradients and it gets cooler the higher you go. I imagined that there would be some kind of environmental gradient that changed as the cliff rose from the water, and the moss pattern would follow.





The next week I went back to the Kickapoo by myself, ready to look more closely at the banded cliffs. I put my canoe in at the bridge and paddled upstream. The current was swifter than it looked and I had to paddle hard. I maneuvered alongside the rock face, but there was nowhere to moor the canoe. Every time I stopped paddling to look at the mosses I'd be pulled downstream. I could hang on with my fingers wedged in a crack, just long enough to snatch a clump of moss, and then I'd drift away again. Any kind of systematic study was clearly going to require a different approach.

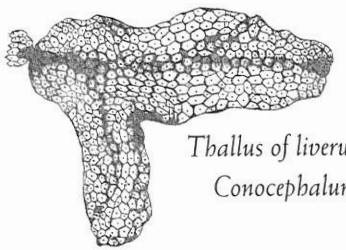
I beached the canoe on the opposite bank and decided to see if I could wade over to the cliff. The bottom was sandy and the river only knee deep. The cool water, swirling around my legs, felt wonderful on a hot day. This was starting to feel like the perfect research site. I waded over within arm's reach of the cliff. Suddenly, the bottom dropped away. The current had undercut the cliff and I found myself chest deep and clinging to the rock. But what a great face-to-face view of the mosses.

Right next to the water, extending upward for a foot or so, was a dark band of *Fissidens osmundoides*. *Fissidens* is a small moss. Each shoot is only 8 mm high, but it is tough and wiry. *Fissidens'* form is very distinctive. The whole plant is flat, like an upright feather. Each leaf has a smooth thin blade, atop which sits a second flap of leaf, like a flat pocket on a shirtfront. This envelope of leaf seems to function in holding water. All crowded together, the shoots make a rough-textured turf. *Fissidens* has well-developed rhizoids, root-like filaments that attach firmly to the grainy sandstone. At the waterline *Fissidens* formed a virtual monoculture. I saw hardly any other species, save a snail or two hanging on for dear life.

*Fissidens*

About a foot above water, the *Fissidens* disappeared and was replaced by assorted clumps of other mosses. Silky tufts of *Gymnostomum aeruginosum*, mounds of *Bryum* and glistening mats of *Mnium*, all are arrayed in a patchwork of different greens amidst empty patches of tawny sandstone.

Higher still, just at the limit of what I could reach from my underwater perch, began a dense mat of *Conocephalum conicum*, a thallose liverwort. Liverworts are primitive relatives of mosses. They get their unappealing name from the botany of the Middle Ages. "Wort" is the old Anglo-Saxon word for plant. The medieval Doctrine of Signatures proposed that all plants had some use to humans and would give us a sign to reveal that use: any resemblance between a human organ and the plant would suggest it as a remedy. The leaves of liverworts are generally three-lobed, as is the human liver. There is no evidence that liverworts made effective cures, but the name has persisted for seven centuries. In the case of *Conocephalum* a better name might be snakewort, for it bears a close resemblance to the scaly skin of a green adder. This plant has no distinct leaves, just a sinuous, flattened thallus ending in three round lobes like the triangular head of a viper. Its surface is divided into tiny diamond-shaped polygons, contributing to its reptilian appearance. Closely appressed to the surface, it snakes its way over rock or soil, held loosely in place by a line of scraggly rhizoids on its underside. Brilliant green, exotic, *Conocephalum* completely covers the cliff at this height, making a striking contrast to the darker mosses below.



*Thallus of liverwort Conocephalum*

I was captivated by these plants and their layered distribution on the cliff. The fact that I could paddle to my research site cinched my choice of thesis topic. The only problem was logistics. How could I make all the detailed measurements I needed while chest deep in the river? Over the next few weeks I tried lots of things. I tried anchoring the canoe and leaning out toward the cliff. The number of dropped pencils and rulers was disheartening, as was the constant threat of capsizing. I tied little Styrofoam floats to all my equipment, but the current just carried them away, bobbing merrily downstream before I could grab them. So I tethered all my gear to the thwarts of the canoe and you can imagine the resulting tangle of camera straps, data books, and light meters. Eventually, I abandoned ship and simply planted my feet on the river bottom. I devised a kind of floating laboratory with the canoe anchored beside the cliff and me standing in the river where I could reach both rocks and canoe. Data books were impossible to manage. I kept dropping them in. So I collected my measurements using a tape recorder. The machine sat securely duct-taped to the seat of the canoe and the microphone was looped around my neck. I could then have both hands free to position my sampling grids and collect specimens, and still have a free leg to snare the canoe rope when it began to drift. I felt like the one-man band of the Kickapoo. It must have made quite a picture as I was talking to myself, immersed in the river, and singing out the locations and abundance of the mosses: *Conocephalum* 35, *Fissidens* 24, *Gymnostomum* 6. I marked all the plots with dabs of red paint, which still decorates my canoe.



In the evenings I'd transcribe the tapes, converting my recorded litany to real data. I wish I'd kept some of those tapes, just for entertainment value. In between the hours of droned numbers were bursts of inspired cursing as the canoe started to drift away, tightening the microphone around my neck. I recorded any number of squeals and frantic splashes when something nibbled at my legs. I even had tape of an entire conversation with passing canoeists who handed me a cold Leinenkugels Ale as they floated by.

The vertical stratification of species was very clear with *Fissidens* at the bottom, *Conocephalum* at the top, and a variety of others sandwiched in between. But my hypothesis about the cause of the pattern was not supported. There were no significant differences in light, temperature, humidity, or rock type along the face of the cliff. The pattern had to be caused by something else. Standing in the river day after day, I was becoming vertically stratified myself—shrivelled toes at the bottom, sunburned nose at the top, and muddy in between.

Oftentimes, an abrupt pattern in nature is caused by an interaction between species, such as territorial defense or one tree species shading out another. The pattern I was observing might well be the result of some competitive "line in the sand" between *Conocephalum* and *Fissidens*. I gave the two species a chance to tell me about their relationship, by growing them side by side in the greenhouse. Alone, *Fissidens* did fine. *Conocephalum*, likewise. But when they were grown together there was clear evidence of a power struggle, which was consistently lost by *Fissidens*. Time after time, *Conocephalum* extended its snaky thallus over the top of diminutive *Fissidens*, completely engulfing it. Their separation on the cliff became clearer. *Fissidens* had to keep away from the liverwort in order to survive. But, if competition was so important, why didn't *Conocephalum* grow all the way to the waterline and simply obliterate the other species?

One day in late summer I noticed a wad of grass snagged on a branch high above my head—a high-water mark. Clearly the river was not always at wading depth. Perhaps the vertical stratification was due to differences in how the species tolerated flooding. I collected clumps of each species and submerged them in pans of water for various times: 12, 24, 48 hours. The *Fissidens* remained perfectly healthy even after three days, as did *Gymnostomum*. But after only 24 hours the *Conocephalum* was black and slimy. So here was a piece of the pattern. *Conocephalum* must be confined to the higher levels of the cliff by its inability to withstand flooding.

I wondered how often floods like the one I'd simulated actually happened. Could it be often enough to create a barrier for *Conocephalum*'s expansionist tendencies? As luck would have it, the Army Corps of Engineers was wondering the same thing, albeit for a different reason. They were considering constructing a flood-control dam on the river and had installed a gaging station at the bridge below my cliffs. They had amassed five years of daily measurements of water levels on the Kickapoo. I could use their data to calculate the frequency with which any point on the cliff had been underwater. I could also call in to the automated phone number to learn the current water level at the bridge. I've not been much of a cheerleader for the Corps, given their propensity for spoiling rivers, but these data were invaluable.

All winter long I analyzed the data to match them to the distribution of mosses on the cliff. Not surprisingly, the gaging station data matched the elevational zonation of the bryophytes very well. The water level was most frequently lapping at the base of the cliff where *Fissidens* dominated the vegetation. It was tolerant of flooding and its wiry streamlined stems allowed it to withstand the frequent company of the current. Flood frequency declined with rising elevation on the cliff. The zone dominated by loosely attached *Conocephalum* was inundated very rarely. High above the water, *Conocephalum* could safely spread its snaking thallus over the rock in an uninterrupted blanket of green. One species dominated where flood frequency was high. Another species



dominated where disturbance was low. But what about in the middle? Here was a tremendous variety of species, as well as patches of open rock as bare as a billboard advertising "space available." In the zone of intermediate flood frequency no one species dominated and diversity was high. As many as ten other species were sandwiched here between the two superpowers.

At the same time as I was wading the Kickapoo, another scientist, Robert Paine, was exploring a different gradient of disturbance frequency, wave action on the rocky intertidal zone of the Washington coast. He was looking at communities of algae, mussels, and barnacles, which may seem to have little in common with mosses. And yet both are sessile, attached to rock and engaged in a competition for space. He observed an intriguing pattern—-few species lived where the wave action was constant and fewer still lived on rocks which were virtually undisturbed. But in between, where disturbance was intermediate in frequency, species diversity was extremely high.

The rocky coast and the Kickapoo cliffs helped to generate what has become known as the Intermediate Disturbance Hypothesis, that diversity of species is highest when disturbance occurs at an interval between the extremes. Ecologists have shown that in the complete absence of disturbance, superior competitors like *Conocephalum* can slowly encroach upon other species and eliminate them by competitive dominance. Where disturbance is very frequent, only the very hardiest species can survive the tumult. But in between, at intermediate frequency, there seems to be a balance that permits a great variety of species to flourish. Disturbance is just frequent enough to prevent competitive dominance and yet stable periods are long enough for successional species to become established. Diversity is maximized when there are many kinds of patches of all different ages.

The Intermediate Disturbance Hypothesis has been verified in a host of other ecosystems: prairies, rivers, coral reefs, and forests. The pattern it reveals is at the core of the Forest Service's policy on fire. Fire suppression with Smokey Bear's vigilance produced a disturbance frequency which was too low and the forests became a monocultural tinderbox. Too high a fire frequency left only a few scrubby species. But like Goldilocks and the Three Bears (one must have been Smokey himself), there is a fire frequency which is "just right," and here diversity abounds. Creation of a mosaic of patches by mid-frequency burning creates wildlife habitat and maintains forest health, while fire suppression does not.

When the ice went out on the Kickapoo the next spring I called the gaging station and an electronic voice informed me that the river was in flood. So I jumped in my car and drove down to see what the mosses looked like now. The river was chocolate brown with dissolved farmland. Logs and old fenceposts were pushed along in the torrent, bumping against the cliff. My red paint markers were nowhere to be seen. By the next morning the waters had receded as quickly as they had come and the aftermath was revealed. The *Fissidens* had emerged unscathed. The mid-level mosses were sodden with mud and battered by the logs and the pull of the water. A few more bare patches had been made. The *Conocephalum* had not been submerged long enough to die, but it was torn away in great swaths, hanging from the cliff like ripped wallpaper. Its flat loose form had made it particularly vulnerable to the pull of water, while *Fissidens* was unaffected. The open patches created by the removal of *Conocephalum* made temporary habitats for a new generation of mosses which would persist there until *Conocephalum* gathered its strength and returned. These are the species which are not able to compete with *Conocephalum*, nor to withstand the frequent flooding. They are fugitives between two forces, living in the crossfire between competition and the force of the river.

I like to think of the satisfying coherence in that pattern. Mosses, mussels, forests, and prairies all seem to be governed by the same principle. The apparent destruction of a disturbance is in fact an act of renewal, provided the balance is right. The Kickapoo mosses had a piece in telling that story. Sandpaper in hand, I look at the splotch of red paint on this old blue canoe and decide to let it be.