COMING TOGETHER

Looking again at the patterns on the marsh, it's starting to make sense. Down by the water the plants suffer the insults of being dunked by every high tide and left dry by every low tide. But over by the log that the seagull and I ate lunch on, it's only the tides of the full and new moons that inundate the land. From low to high, there is an environmental gradient, and the plants echo this pattern. But the real marsh is not like cartoon drawings in a textbook, in which the marsh slopes evenly up from the sea. There are a lot of subtle ups and downs along the way. You might not notice one patch of the marsh is an inch or two higher than another patch, but that inch can make a big difference to the plants—it might be the difference between the roots being able to breathe air or the roots being drowned in saltwater.

Beyond simple gradients, the patterns on the marsh are reflecting past disturbances. Government-dug trenches. Tire tracks. Landing spots of marsh flotsam. I wonder how our footprints will be recorded in the marsh record.

But when I look at the solid swatches of color in the marsh, I still am not convinced that they all tell a specific story of elevation changes or past disturbance. I think there's a little more to consider. Moving from one patch to the next, the transition is sudden. While one foot is standing in a dense upright grove of cordgrass, my other foot is standing on the twisted wisps of salt marsh hay. As you move from one patch to the next, it's just like flipping on a light switch. If this were entirely controlled by an environmental gradient as you move uphill, wouldn't there be a gradual intermingling of species as you transition from one species' niche to the next?

If I may drag salamanders into this one more time, I'm reminded of a ludicrous set of salamanders that don't fit into any species concept—my favorite kind. For the past five million years, unisexual salamanders have been cloning themselves in ponds

across the eastern United States. To reproduce, members of this all-female lineage steal sperm from one of five other species—whoever happens to be present in their pond—but then selectively discard most of the sperm DNA. The children, all of whom are daughters, inherit almost nothing from dad. These clonal salamanders dominate the ponds, crowding out the local host species by making near-exact copies of themselves.

Evolutionary biologists would usually say that clonal animals are at a big disadvantage. They don't get to enjoy the benefits of sex. Sex mixes up your genes each generation, allowing you to purge errors and invent new solutions to old problems. Without it you're doomed, and your lineage should be short-lived. But these crazy salamanders are incredibly successful. Their trick? Just a little bit of sex. Although they are mostly clonal, every once in a while a bit of dad's DNA leaks into the system, and that seems to be just enough for the salamanders to reap the benefits of sex without paying its hefty price.

What's the cost of sex? The most obvious answer is males. Males are a huge waste. A lineage free of males that clonally gives birth to only daughters can quickly outgrow a lineage that wastes half its energy on nonchildbearing males. And that's why this all-female lineage of salamanders dominates the ponds where old-fashioned sexual species still produce both males and females.

Beyond useless males, the whole process of sexual reproduction takes energy. Instead of shopping for the right mate, making eggs and sperm, and hoping to god that your offspring survive their early helpless phase, what if you could just grow a new copy of yourself whenever you felt like it by just sprouting a new limb? You'd be like the grasses in this marsh.

Sure, salt marsh hay can reproduce sexually, and it will do so just often enough to take advantage of the benefits of sex. In the meantime the hay multiplies by expanding clonally from its roots. Skipping the wasteful process of sex, salt marsh hay nurtures each

new shoot through connected roots, giving it a leg up in life. In so doing, it crowds out all other plants that try to grow in the dirt within its slowly expanding patch.

And that, I think, is why the patches of color in the marsh are so distinctly separated. It's a wrestling match between clonally expanding patches duking it out over territory. Who grows where, in large part, depends on who got there first. It's not strictly about the soil chemistry and tidal elevation. In fact, as they creep outward, the plants at the edge of a patch may begin to grow in places they don't really belong. Sometimes, as with the common reeds expanding into the marsh from the ditch-side berm, the plants might reengineer this new spot to fit their needs—a self-fulfilling prophecy unfolding across the marsh.

MAJOR LESSONS FOR INTERPRETING A LANDSCAPE

- Consider the global biogeographic context of the species and rocks at your site.
- Look at the small-scale patterns of the elements of your site. Are they distributed in a random, regular, or clumped fashion? What is driving this patterning?
- Consider nutrient flows and chemical cycles at your site. What limits productivity?

(overleaf)
Figure 7.1. A lookout on patterns.

7. Elevation

As I hauled my canoe back up onto the mainland at the mouth of the Connecticut River, I met several locals who were out admiring the view. One older couple sat in a pair of lawn chairs, reading as the sun set over the marsh. A birdwatcher asked me what I was up to, and then he asked if I had read a recent book about canoeing the full length of the river, from the source to the sea. Starting at the mouth, if we were to swim upstream, the river would get narrower and narrower as tributaries branched off. Passing fork after fork of successively smaller rivers and then streams, we would eventually arrive at a tiny beaver pond on the border of Canada.

Floating the full length of the river is definitely on the list of things I want to do, although it always feels a bit arbitrary as to which of the many forks gets the honor of carrying the official name of the river. Is that beaver pond up by Canada so different from the beaver pond where the coyotes barfed-up voles at the head of another tributary of the river? If we really want to experience the full range of the river valley, perhaps we could seek out more ecologically meaningful extremes. Instead of traveling the length of the watershed from one end to the other, what if we were to go from top to bottom? At the lowest elevation we have a coastal salt marsh. And at the top? The alpine summit of Mount Washington in the White Mountains of New Hampshire.

I'd love to take the kids up Mount Washington, but a hike with toddlers to the top of the tallest mountain in the Northeast didn't seem in the cards this year. There is, however, a cog railway to the summit. It was getting late in the season, so we planned a trip for the following summer when the train would be running and the alpine wildflowers would be blooming. In the meantime I took an afternoon trip to a different summit in our watershed, Mount Cardigan.

By the time I reach the trailhead at 3:30 PM, the day feels almost over. Unlike all the other field sites in my book, I've never been here before. I arrived late because I was following my car GPS—it kept sending me on dirt roads marked by warning signs, "GPS route not recommended." Then the GPS batteries died. In the gravel parking lot, one other hiker is waiting to meet a friend so they can race up the mountain to catch sunset at the rocky summit.

Before entering the forest I spot some brown stalks of mullein standing in a little field and run over to collect them for our woodstove. It's been over a month since our new stove was installed in our house. The weather is getting cold, but I haven't let us start a fire in it yet. I want the first fire in the stove to be made the old-fashioned way: with fire by friction.

Cross-legged on the floor of our house, with the kids watching and mimicking, I've been trying and failing to make a fire by rubbing sticks together over the past few weeks. Why struggle at something so anachronistic? There's little natural about the factory-cast iron of the stove, and our house is loaded with matches, electric heaters, and propane burners. But as naturalist Jon Young once remarked to me, the woodstove is the heart of the house. And I want to hold something sacred in our heart. If I don't draw some lines for myself, I'd never be motivated to struggle. Sydne understands this line I've drawn and hasn't complained about the cold.

There are several ways to make a fire by friction, and the hand drill is my favorite. A set consists of two parts: a baseboard, which

is a piece of wood about the shape of a TV remote; and a spindle, which is a pinky-thick, knee-high stick. You hold the spindle between your flat, prayer-like hands, rubbing palms back and forth to twist the spindle as you apply downward pressure. As you spin, smoke billows from the tip of the spindle and dust collects in a notch carved into the baseboard.

When things go right, the dust will be fine and black, and soon an orange ember will start to glow in its center. If the spindle is the male part, the baseboard the female part, the pressure from your hands the force of god, then the spark is the little embryo. Carefully, oh so carefully, you nudge the little ember into a fluffy nest-like womb of fibers you've prepared. You breathe into the nest, gently at first, then a little a bit harder and with increasing force, never pausing for too long so the fire doesn't collapse. At last the nest bursts into flames, and you transfer your baby fire into a pre-prepared home of small sticks.

With a good hand drill set made out of the right materials, when your body knows what to do, you can have flames in under a minute. Otherwise you can struggle until your hands are bleeding and you collapse from exhaustion.

In college when I was first learning to start fires, I would practice this daily. Bloody blisters on my palm near the base of my middle fingers turned to callouses. "Stigmata," my brother and I used to call these marks. I haven't made a hand drill fire in years, and my callouses are subtle. I still have a collection of old baseboards, the edges lined with dozens of little black circles from attempts at fire making. Looking at the circles, I can generally tell which ones successfully made fires—the notches are centered, the sides are straight, and the smell of smoky wood is perfect.

Once the muscles in my arms know what to do, there are really two keys to making fire. The first is mental centering. Trying to simply power through and just make fire never works for me. I can only make a fire if I first take my shoes off, sit up straight, close my

eyes, do some meditative breathing, and say a little thanks to the wood, fire, and the elements of nature. I can't tell you how many times I've come to a hand drill kit saying to myself that all that meditation stuff is silly—it's just a physical challenge. I failed to make fire every one of those times. The other key is to have the right materials. For the baseboard, willow and tulip poplar have a nice soft grain—or you can go pick up a white cedar fence post from the hardware store. For the spindle, my favorite is mullein.

I stash the mullein in my car and start up the mountain. This isn't the highest mountain in the Northeast. Mike Jones suggested I come here because it's actually the lowest mountain around where you can find alpine specialist plants, particularly capitate sedge. Beneath an overcast sky the forest at the trailhead glows with fall color: orange leaves of sugar maple, red leaves of red maple, and yellow leaves of beech, white ash, yellow birch, and hobblebush. Dark green splotches of hemlock contrast with the bright colors.

I'm sticking to the trail on this hike, so I feel a bit lost on this unfamiliar mountain. A hermit thrush lands on the ground right in front of me, then flies up to the trail marker. A red squirrel takes a drink of water from a little stream, then leaps to a tree, scurries up, and chatters at me. The yellow blazes are hard to see against the fall colors. At a stream crossing I hear blue jays and a hairy woodpecker calling, and I see a dark wet stain on a gray rock where someone recently stepped from the stream with a wet shoe. I pass a cut through the trees intended for winter skiing and hear a bird alarm in the distance.

As I ascend, the forest changes. I encounter some big red maple and ash trees over an understory of beech. Further up, sugar maple completely replaces the red maple. Hemlocks fall away and instead there are just scattered spruces.

Racing against the dimming light, my right knee starts to hurt and I hear several red squirrels chattering. Up ahead I see a wall of dark green. Suddenly, I'm in a forest dominated by red spruce

and balsam fir, with a bit of paper birch and mountain ash. The trees are small, thin, and dense. Whereas before the trail had been a soft bed of fallen leaves, now it's just bare rock with silvery flecks of mica glimmering through. Clumps of moss cling to the rocks. I hear the rapid thumping of grouse wings fleeing from my footsteps.

Then, just as suddenly, I'm back in the same deciduous forest of oranges and yellows as the leaf-covered trail continues to climb. I can see the mountain's bare summit through the trees. The sun pokes through clouds only to show that it's about to slip behind the mountain. Then I'm back in a forest of spruce and fir.

I pause at a lookout and take a picture of the view. I'm looking at the shoulder of the mountain, and there's a strange pattern. A dark green swath—shaped a bit like the Nike Swoosh—cuts across the orange mountain (fig. 7.1). What is this? I stare at the pattern trying to make sense of it. A few theories arise in my head. To test them I will have to return and walk through that forest in the distance.

DESCENDING

The sun sets, and I can see fog engulfing the barren mountaintop. I climb a bit further and reach a zone where it's mostly bare rock with scattered pockets of vegetation in little depressions here and there. The fog surrounds me, and it's ghostly quiet and still. Straining my ears, I hear what seems to be a distant saw-whet owl giving a series of shrill, rhythmic cries.

It's almost completely dark as I head down the mountain, and now it's my left knee that's hurting. Without a flashlight on I can just barely see the path. I assume I'll feel the difference in the trail beneath my feet if I step off the path, like when I used to walk to the wigwam after a long day's work in the physics lab.

Now it's really dark, and even the tiny red light of my voice recorder overwhelms the night. Am I still on the trail? I step intentionally to the side, and oh, yes, the sound of my feet on the leaf litter is completely different. It smells good here. I hear the brook bubbling and a distant barred owl. But mostly just a hush. It's moonless. Like that night I got completely lost on my way to the wigwam. At least tonight I won't have to leave the trail to get where I'm going. I can just listen to the sound of the trail and let my ears guide me down. Although there are lots more big creeks to cross on this journey.

I might be off the trail now, I don't know. I'm determined not to use my headlamp. But. It's going to take a lot longer in the dark. And. I have all these responsibilities. A life I have to get back to. Deadlines. Scheduling. Kids. Shoot, I need to make it back for their bedtime. If I were younger, I'd definitely go without a light. But I'm going to cheat a little just to make sure I'm still on the trail. As I make this decision and rummage through my gear for a light, I hear something bounding off through the woods.

I turn on the light, and I see the eyeshine of spiders reflecting back at me. The wash of light shows that I was going the right way. It was just self-doubt. Well, maybe I was a tiny bit off the trail, but mostly fine.

With the light on now, walking is much faster. But all I see is that spot. That circular spot of light. I've lost all awareness of the forest around me, of the trees, of my wide-angle vision. I'm no longer walking in the forest. I'm now walking in a spot, a circle, a cylinder—no, a little cone of light. I have no idea where I am again.

Noah, don't you remember that time we were walking at night in Black Rock Forest in New York and found a glowworm beetle? An amazing creature. The male has wings and giant antennae but is otherwise unremarkable. The wingless female looks like a glossy red, black, and yellow worm in the light. In the dark the female is a magical glow of faint blue dots. They're probably everywhere,

but you never notice them because you have to walk around in the pitch dark for them to pop out.

I try turning my light back off. Right away I stumble. All I see is the afterimage of the spot in the center of my vision—even though I was using the red light setting. That darkness seems to suck me in.

I flip my light back on. Now that I've used the light, I'm addicted to it. The trail is actually easier here—wider and flatter. But I need this light more than I did on the steep narrow trail above. I'm moving too fast now. I'm rushing along in that headlights mode. If I want to turn this light off, I'll have to completely reset. Earlier I had transitioned slowly with the sun setting through the fog and the clouds. By the time dark came, I was ready for it. Now I'm hurried and have no time. I'm not listening, I'm not feeling, I'm not smelling. I'm just moving. I have to reset. I have to reset. I have to reset.

I stop and do a few meditative breaths. As I exhale, I feel my heartbeat and use that as a cue to center myself. OK, I can do this. I start forward. I trip. I'm still hurried. I turn my light back on. I'm just trying to do too much. I've got to get home to the kids and get ready for work tomorrow and all the other things I'm trying to cram into my life. If I'm trying to do all the things I'm trying to do, I can't slow down. If I can't slow down, I can't see the woods, I can't experience it, I can't be here, I can't feel it.

Those damn hikers I met at the trailhead going up to catch the sunset. They were the ones who reminded me to bring a headlamp. I hadn't even thought of the sun setting, nor had I packed a light in my bag. At their urging I went back to the car and got this headlamp. I wish I hadn't brought it. Then I would have been forced to experience these woods.

Crashing through with monster steps, I feel so out of place in this hushed forest. I should have my light off. I should be tiptoeing. I should be barefoot—that would force me to be here. As it is, I may as well be driving my car down this trail.

When the light's off, it's not that I don't have the ability to fol-

low the trail. It's just fear. I'm afraid to move forward. What if I'm wrong about where I'm going? What if there's something dangerous out here? As if my narrow 10-degree cone of light allows me to see what's out here any better. As if whatever's out here will automatically be in my light, not in the other 350 degrees around me.

I hear my whole body pounding with every step. Thump. Thump. I hear it echo in the ground. Thump. Thump. I should slow down, but I'm still racing. Thump. Thump. I hear a mouse squeaking in the trees above. Thump. Thump. Writing this book gets me outside. Thump. Thump. But it's just one more reason to race. Thump. Thump. When all I really want to do is slow down. Thump. Thump.

SECOND VISIT

In the spring I return to Mount Cardigan, heading for the green swath that's been on my mind all winter. I have a simple quest to test my favorite theory for this pattern. Almost at my destination, I'm walking through a bright spring forest. A carpet of trout lilies, Indian cucumber, wild oats, wild sarsaparilla, and painted trillium. An understory of beech with a few scattered spruces. A canopy of red maple, sugar maple, beech, and yellow birch. A northern hardwood forest.

Suddenly, the forest shifts. It's dark. Beneath a spruce and fir canopy, I see lots of bedrock poking through the bed of needles. Moss and lichens grow on the ground amid a few scattered lowbush blueberries. A montane boreal forest.

Now, to answer the question. I dig two holes in the ground. In the hardwood forest the soil has a rich, pungent smell that reminds me a bit of the stink some millipedes give off. I dig and dig through orange dirt, little bits of debris wedging beneath my fingernails. I dig as deep as my bare hands are able and don't find what I'm looking for.

Over in the boreal forest, within a minute of digging through the thin soil, my fingers close on what feels like the tiny treasure I'm looking for. I pull it out, dust off the dirt, and inspect it up close. Yes! To be sure, I bring it over to a piece of birch bark to make a picture.

As the black flies swarm me, I'm happily content at having proven my theory. Well, I guess it's not proof, but supporting evidence. I mean, I've only dug two holes—I could have gotten lucky. If I were a real scientist, I'd need to dig many holes to make sure it wasn't dumb luck. But if I don't find what I'm looking for in the next holes, that could ruin my whole theory, and my book chapter. Better quit while I'm ahead, right?

The scientist in me says to dig at least two more holes. I begrudgingly agree. With enormous trepidation, I walk a distance and dig two more holes—one under hardwoods and one under the conifers. With my first scoop of leaf litter in the hardwood hole, I find a buried beechnut, possibly cached by a blue jay. I dig further but don't find what I'm looking for. In the conifer hole? Again I find the tiny treasures. Phew. I'm convinced. I'll stop here, leaving it to some young graduate student to dig hundreds of holes across the mountain for a full statistical analysis.

With plenty of daylight left, I head on up to the summit of Mount Cardigan, just over 3,000 feet in elevation. It's mostly an expanse of bare rock. Here and there are a few patches of vegetation clinging to crevices and sheltered spots. After a brief search in these green areas, I find the rare alpine specialist capitate sedge (fig. 7.2), along with other alpine plants like Bigelow's sedge, three-toothed cinquefoil, mountain cranberry, and crowberry.

The sun's about to set, and I sit and meditate for a bit. I stare out across the expansive landscape below. As I'm about to start down the mountain, I notice the slanting light illuminating long grooves through the bare rock. They point southward. Glacial striations. As high up as I am now, 20,000 years ago I would have still

Figure 7.2. Capitate sedge on Mount Cardigan.

been deep under the glacier. In its southward advance the glacier scoured these grooves into the bedrock (fig. 7.3).

I hike down without a light. The full moon is out. I'm more relaxed than last time, in part because my kids have become less dependent on me over these past few months. My body knows that they will be fine if I get home at 1:00 AM. I'm met on the trail by a couple wood frogs and an American toad enjoying the evening.

Suddenly, there's a little flash and a clanking sound. What was that? I take a few steps back, retracing my movements. I strike the metal tip of my hiking pole against the bedrock. That was the sound. I do it several more times, and then there's a spark. Wow. I do it again and again. I feel as ecstatic as a caveman first experi-

Figure 7.3. Glacial striations on top of Mount Cardigan.

encing flint and steel. I set my digital SLR camera down in the dirt with the shutter open for a long exposure to capture the freshly exposed fragments of iron oxidizing in tiny flames as they hurdle through the air.

Back at the trailhead, I call out to a couple of talkative barred owls. The pond, which earlier in the day had bullfrogs, now has chorusing spring peepers. I get in the car and, as I drive along the network of dirt roads, I realize I've got no maps or GPS service. The moon is still out, and I picture it hanging in the south down over the salt marsh at the mouth of the Connecticut River. If I just head toward the moon, I should make it where I want to go. Until cell signal returns I turn onto the roads that aim toward the moon. I'm

in no hurry. I still have a few hours left on my audio recording of *Zen and the Art of Motorcycle Maintenance*. So I drive off the mountain while two dueling personalities engage in a final showdown over the narrator's body.

CHASING TOADS

My knowledge of these mountains largely traces back to Mike and Liz, who, besides studying turtles, also have an affinity for the alpine. One particular evening sticks in my mind—camping with them up in the Lewis Hills of Newfoundland. After peering down into the 1,400-foot-deep canyon of Rope Cove, which led out to the Gulf of St. Lawrence, Mike, Liz, and I set up our tents near a small pond. I sat alone by the pond, wondering if we might find amphibians breeding at that elevation. The sun had just set over the canyon, trailed by a fingernail moon and Mars. I could still feel the long shadows of the barren red rocks, unable to distinguish the landscape where I sat from the images beamed to Earth by the Mars rover, except for that small pond. I sat in the spot where the clunky hooves of a moose passing at 4:00 AM the following morning would wake me for a staring contest.

Unexpectedly, my ear caught a trill that hung for a few seconds then vanished. An American toad. Or did I imagine it? Silence. I cocked my head and waited. There it was again, from north of the pond. It must have been real. I estimated that the toad was maybe a hundred feet away, probably on the far side of the pond, or possibly in a seep a bit uphill from there. I waited to hear the trill again, then stalked over toward the sound, taking my camera but leaving my GPS. Again in silence, I waited for another trill, then stalked toward it. Wait, trill, stalk. Wait, trill, stalk. I got to where the toad should have been, but the sound was coming from still

Figure 7.4. Arctic hare in the Lewis Hills of Newfoundland.

further upwind. The game continued as I made my way uphill, the toads never seeming closer.

I was carried further and further from the tents, but the stars were bright and good for navigating home. As I approached some tall grass, a low form broke the horizon nearby. It took a lazy hop and stopped to inquire about me. Gray and white spots of a shaggy milk cow, stout arms and legs, tall ears. This was my first encounter with an arctic hare (fig. 7.4). She seemed unconcerned, letting me approach to within ten feet. Then I backed away in peace to continue my toad quest. The toads had grown quite persistent and numerous by this point but seemed to be no closer.

Next I was interrupted by strange muted bursts, like a mischievous child playing with a creaking door in the grass below. It sounded like a pickerel frog to me. Though I couldn't find the culprit, I later learned that I was being mocked by a ptarmigan (fig. 7.5). Eventually, forty minutes after leaving our campsite, I arrived at a vast network of ponds on top of the hill, teaming with toads and

Figure 7.5. Rock ptarmigan takes flight in the Lewis Hills of Newfoundland.

other life. The word "moor" sprang into my head, and I expected the grave-haunting hound of the Baskervilles to leap into view.

The wind had carried the sound of the toads, and me, over half a mile. As if on cue from Arthur Conan Doyle, when I arrived a thick fog dropped down obscuring everything more than an arm's length away from my face, including the stars. If I headed toward home but veered a bit west of our tents, I might step off the vertical wall of Rope Cove. While I contemplated a life-threatening adventure back to our campsite, Mike and Liz appeared out of the fog on the edge of the moor, also drawn in by the toads.

WINDY SUMMIT

In mid-June Alder, Juno, Sydne, and I head to the Mount Washington Cog Railway, fifty miles north of Mount Cardigan. Before checking in to our hotel, we watch a video of a man unsuccessfully trying to eat cereal in gale-force winds on the summit. Now the kids are extra-excited for this adventure. We arrive at the train station in the morning and get out of the car surrounded by a bright green forest of birches, maples, aspen, and mountain ash.

It's a nice, sunny morning as we stroll into the ticket office for

our prebooked trip up the cog rail. Suddenly, the ticket lady introduces unexpected turbulence into our leisurely morning. The first problem is that it's too windy at the top of the mountain for the train to go all the way. We will only be going partway up, and we won't be allowed to walk around and photograph plants when the train stops. Do we want a refund so that we can make the two-day journey to this mountain some other time? I desperately want to get to the summit, the kids desperately want to get on the train, and the price of the tickets is painful to think about. The second problem is that I had the time wrong. Instead of leaving in a half hour, the train is leaving right now, and we need to make a decision fast.

I decide to get a refund, since the trip won't be worth it. The kids, meanwhile, are out the door bounding excitedly toward the train without tickets. Beyond them, the train tracks climb steeply up the mountainside. There beside the tracks I see the pattern I expected to see back at Mount Cardigan. As the tracks grow skinny in the distance, the bright green broadleaf forest transitions into the dark green conifer forest before the whole scene disappears in a cloud. Rather than the sharp line I saw at Mount Cardigan, the transition here is gradual, with scattered spruce and fir trees at the base becoming slowly more abundant (fig. 7.6).

Why is the Cardigan transition so sharp? A few months ago Charlie Cogbill—who knows decades more about these forests than I ever will—told me that such abrupt transitions are pretty typical. There's a sort of feedback loop, wherein the trees dominating a stand shape the environment in such a way that promotes those of its kind. Once a site begins to be dominated by spruce and fir, it doesn't linger in an intermediate state—it quickly becomes completely coniferous. Maybe, but I don't fully understand. This slope in front of me seems to be telling a different story.

I turn back to the ticketing agent. OK, just give us the tickets and we'll get on the train. We stumble onto the sold-out train car,

Figure 7.6. Vegetation transitions up the face of Mount Washington.

like a little tornado family. Sydne and I have big packs for carrying children and lots of gear for the hike I thought we'd take at the summit, Juno's carrying his own overstuffed bag, we're flustered about the rapid decision, grumpy because there are no seats together nor window seats left, and the kids are bouncing up and down with enthusiasm. The sixty other tourists on the train, wearing casual Sunday clothes, totally unencumbered by gear, quietly stare while Alder and I squeeze in next to a family from Charleston, South Carolina.

The track is so steep, almost 40 percent grade in places, that the train uses toothed wheels that mesh into a toothed rail to climb. The steam engine fires up, and we begin to clamber toward where the track disappears in the clouds.

We cross the highest elevation tributary in the watershed of the Connecticut River, and the conductor announces that, ecologically, our three-mile journey up the mountain will be equivalent to something like a 600-mile trip north (figs. 7.7–7.10). When you climb a mountain, like when you drive north, it gets colder. In the case of going north, the curvature of Earth means that the ground gets less direct sunlight to warm each square foot. In the case of going up a mountain, the thinning air makes it colder.

Out the train window, spruce and fir slowly replace the birch and maple. Historically, these conifers were the prized timber in these mountains, and loggers working at the lower slopes would often cut out all the spruce and fir while leaving behind the maple and birch. Compared to the hardwoods below, the spruce and fir now surrounding us do better on shallow, rocky, acidic soils—acidity that their fallen needles help create.

(left)
Figure 7.7. Mount Washington broadleaf forest.

(right)
Figure 7.8. Mount Washington boreal forest.

Figure 7.9. Wind-swept trees on Mount Washington.

If we were on a road trip north from the eastern deciduous forest, at this point we would be entering the boreal forest, also known as taiga. Charlie Cogbill would be quick to point out that there's a huge difference between spruce-fir forests defined by elevation and those defined by latitude. My casually conflating a montane red spruce forest with a boreal black or white spruce forest makes him shudder with disappointment. Once I get to know these systems better, I'll probably look back and shudder alongside him.

The boreal forest, which wraps around the top of the world from Canada to northern Europe to Russia, is the largest terrestrial biome on Earth (fig. 7.11). The broad, flimsy leaves of maples

Figure 7.10. Alpine tundra on Mount Washington.

and oaks have a tough time with the long, cold winters. Conifers do much better here, with waxy needles designed to withstand freezing and drought and a conical tree shape that helps shed snow. Unlike hardwood forests, these stands of conifers burn vigorously, and so fire is an important component of the boreal ecosystem. Travel to the boreal forests of Canada and you'll find cold-adapted mammals like woodland caribou, lynx, marten, snowshoe hare, and red squirrel (fig. 7.12). These replace more southern species like bobcat, fisher, cottontail, and gray squirrel.

As the cog railway reaches its steepest point, the conductor invites everyone to try standing straight up inside the climbing train—which requires leaning far forward. Out the window the

Figure 7.11. *Field Naturalist* student in spruce-fir forest.

trees shrink. They are no longer big and tree-like. They are now only a few feet high, gnarled and twisted. *Krummholz*. That's German for "twisted wood." These trees have been pounded into submission by the wind.

A little black spruce forms a bud on its highest branch, aimed up to the bright sky above, hoping to outcompete its neighbors for light. Then a cloud sets down on the mountain with a strong freezing wind. Tiny water droplets from the cloud begin to freeze on the little spruce bud. The ice formations grow bigger and bigger until, snap! The wind breaks off the ice, along with the little bud. Instead of growing upward, the spruce turns to another bud, smartly tucked along its side, to send off a horizontal branch.

We pass beyond the steepest part of the ascent and, coming up over a shoulder of the mountain, the tracks begin to level out a bit. Now we're too high for even the smallest tree to grow. It's just a low green carpet among boulders.

The vast open landscape reminds me of Iceland—that little

country up at the Arctic Circle. Iceland was the last stop on our trip around the world, and we spent just a few days gawking at puffins high on the cliffs. But it was mid-May, and Sydne and I really wanted to see the winter Northern Lights. So we booked a short trip to Iceland that January and returned with our cross-country skis hoping for a relaxing week of skiing under the aurora.

When we landed back in Iceland, we instantly felt silly for having lugged along our bulky skis, which barely fit in the rental car. We'd come from New England where there was a foot of snow on the ground, we hadn't seen the buried grass for weeks, and we didn't expect to see grass for many more weeks. We'd gone skiing

Figure 7.12. Red squirrel replaces the more familiar gray squirrel as you move north into coniferous forests.

almost every day that winter, and now here we were far north in Iceland—where there was no snow.

Yes, Iceland sits at the Arctic Circle. But it's also an island in the middle of the ocean. Water, with its great thermal mass, modulates extreme temperatures. Ocean air keeps the winters from being cold. That particular ocean happens to be extra warm due to the warm North Atlantic Current. When we told folks in Iceland about our New England winters, they were horrified at how cold it sounded. Our weather blows in from the west across a big, cold continent with no ocean to moderate it.

Though we didn't ski in Iceland, we walked on black volcanic sand beaches, gazed in wonder at swirling green auroras, and enjoyed the vast treeless landscape. This treeless landscape, like the arctic climate, was also misleading. According to historical accounts, Iceland originally supported extensive woodlands. But logging for farms and fuel, combined with grazing livestock, denuded the landscape. With the trees and vegetation gone, Iceland's thin volcanic soils washed away. Even though many farms have been abandoned, without any soils and with few seeds, the trees have yet to regrow.

On the train up Mount Washington, we've reached treeline at around 5,000 feet. On our imagined 600-mile road trip, we'd be entering the arctic tundra—perhaps in northern Labrador, although we would have run out of roads there. Permafrost in the soils excludes roots; freezing temperatures cause ice crystals in sap to kill trees; and the brief warmth in summer isn't long enough for woody tissue to grow. In the northern tundra, arctic foxes chase ptarmigan and arctic hares through dwarfed shrubs, grass, moss, and lichen.

But the analogy between driving north and going up the mountain only goes so far. It's more than just cold that prevents trees from growing on top of this mountain. The wind, the ice, and the extreme mountain weather patterns are really what hold back the

trees. Where they can find shelter from the winds, like in a crack of a big rock, some trees actually can survive up above treeline in the mountain cold.

The train pauses, engulfed by a thick fog, as the conductor talks into his radio. Then cheering erupts as he announces that we've been cleared to go to the summit. The train lurches upward. The ceiling is now undulating intensely from the strong winds above.

When the train reaches the summit, in preparation for going outside, we bundle up and I hoist my pack of gear and picnic lunches for the adventure ahead. What alpine flowers are blooming now? The Appalachian Trail (AT) crosses this summit, and Juno is excited after having hiked tiny bits of the trail in other spots up and down its length.

The first time I encountered the AT in these mountains I was in college. It was 2001, just a couple days after September 11. My *Plant Ecology* professor had taken us up into the mountains to experience how plants change along an elevation gradient. We hiked up a side trail along a ravine to a ridge where we encountered the AT.

I remember looking out from the AT down onto the vast national forest on the other side and falling in love with the view. At our feet were little red mountain cranberries clinging beneath tiny dark green leaves—the source of the lingonberry juice served in IKEA—which we popped in our mouths. Then a scraggly man with a huge reddish beard came hiking up the AT from the south. He'd been hiking since Georgia, 2,000 miles away. Had he even heard about the terrorist attacks yet? Did he know that the whole world was in a state of shock? Should we tell him?

As we exit the train, the conductor warns us to hold tight to bags and children in the wind. Outside we see what he means. It's around 40°F, and the winds are holding at around sixty miles per hour, with much higher gusts. It's enough to topple us over if we don't lean just right. One woman is actually blown over on the tracks. While the woman flails, we drag the children over the

tracks toward the shelter of the summit house, fighting to stay on our feet the whole time. Hiking now seems absurd. Juno and I enjoy a couple brief ventures into the wind. He's ecstatic about this weather, but it's too much for Alder.

After a brief stay the train gathers its travelers and heads back down the mountain. Juno and I now sit together, and we talk about the plants as we descend back down through krummholz, spruce-fir forest, and the forest mixed with maples and birches. Then Juno turns and delivers a lecture on steam trains to the passengers behind us.

Eating our peanut-butter-and-jelly sandwiches amid the sunny 70°F day back at the base of the mountain, we decide we didn't have enough time to enjoy the alpine plants. So we drive over to the other side of the mountain, where a paved road offers another route to the summit. We climb back up into the wind, stopping periodically to search for miniature alpine plants.

Once out of the car, Juno and I jump off of rocks to let the forceful gusts carry us far through the air. We pour water from our bottles toward our mouths only to have it ripped off the mountain before reaching our lips. Finally, Alder decides he wants to go play in the wind too, proclaiming simultaneously that it's "too windy" and that he wants "more wind!"

We soon find three-toothed cinquefoil and Bigelow's sedge, like on top of Mount Cardigan. Then Juno and I huddle over a pincushion plant, *Diapensia*, and remark that the flowers are bigger than the leaves. A little fist-sized cluster of tiny leaves clings to the ground beneath showy white and yellow flowers. A couple feet away a few woody-stemmed plants creeping across a rock, so flat that they're hard to distinguish from the nearby lichen, support finger-thick red spikes and gray fuzzy tufts. The shape of the flowers, I suggest to Juno, is a lot like those on the big weeping willow in our yard. Same genus, but this is bearberry willow.

These dwarf plants are uniquely adapted to the alpine. The

Figure 7.13.
Tolmie's saxifrage, an alpine specialist, on Mount Rainier in Washington State.

growth form is so compact—either as mats or pincushions—that the plants seem to form a solid body, like a little animal, not unlike the stockily adapted form of the arctic hare. The leaves together create impenetrable skin protecting an interior stuffed with dead leaves and other organic matter. Each leaf itself is thick, waxy, miniature, and sometimes fuzzy. Many of the plants also grow deep taproots and turn dark red in spring and fall. These features protect them from drying winds and help them warm in the sunlight (fig. 7.13).

The diminutive size of alpine plants is about more than just hiding from the cold air. The soil below is also cold. It's so cold that the

soil microorganisms become sluggish. These are the decomposers responsible for recycling essential plant nutrients. With a lazy recycling crew, dead organic matter isn't broken down quickly—it just sits around and piles up, trapping nutrients inside. But alpine plants are used to this. Perpetually starved for nutrients, they are adapted to stay tiny, so as not to outgrow their soil resources.

Here atop Mount Washington is a vast expanse of this alpine community, but it's all above 5,000 feet in elevation. The farther north we go, these plants can be found at lower and lower elevations, until, eventually, the alpine tundra merges with the arctic tundra all the way down to sea level. So why is it that fifty miles south of here we find the same alpine plants on top of Mount Cardigan at an elevation of only 3,000 feet?

On our drive back down the mountain, we stop in the krummholz, where the kids hunker in the shelter of the twisted shrubs, picking cones off of mountain alder. Near the base, back in the boreal forest, we go for a leisurely stroll under balsam fir and red spruce along another section of the Appalachian Trail, relieved at the windless quiet.

GALÁPAGOS

In any mountainous region, elevation gradients are a driving force on plant patterns. Here in the Northeast, valleys are lush, while mountaintops are barren and hostile. But in desert areas it's often the reverse. I've been studying Galápagos giant tortoises for the past few years, although, like a true modern ecologist, I haven't actually been to the Galápagos. I've just been modeling data on my computer, trying to predict how climate change will alter future vegetation and turtles on the islands.

It's a remarkable landscape down on those volcanic islands—or so the data says. The group I'm working with, led by James Gibbs,

is particularly interested in the seasonal migrations of the tortoises between the highlands and lowlands. Up in the highlands, cool air and moist clouds produce lush greenery year round. Down at sea level the natural ecosystem is a cactus-dominated desert, with bursts of vegetation following the rainy season.

At least, Galápagos lowlands should be a cactus-dominated desert. But following the decimation of the tortoise population by explorers, the cacti, too, disappeared from much of the landscape. The cacti, it turns out, rely on tortoises to disperse their seeds—the cacti being a primary food source for the tortoises. Without tortoises woody shrubs have taken over where the cacti once were. Without cacti modern conservationists are having trouble repopulating the islands with tortoises. It's a real pickle.

In late May James came to Harvard Forest, where I am based, to present his work on Galápagos tortoises. After the seminar we went for a walk around the Forest. On the way out to the big experiments in the woods, we passed an old red pine plantation. It's a common sight around here—strange stands of uniform red pines all lined up like soldiers, with sparse vegetation below.

Neat and tidy. To me that means impoverished. But I've always had a ramshackle aesthetic and, like Pig-Pen, have always been surrounded by a cloud of entropy. I justify my disorder by claiming that ecological diversity thrives when things are messy. And the same can be said for ideas. Neatness is a hindrance to creativity.

Without the hand of foresters, such red pine forests would never grow here, and yet they're all around. What's funny is that, in fact, there is a native red pine community that does grow naturally around here. But native red pine is a community I rarely see, and it's usually protected as a special place. In this region red pine only sprouts well on exposed ridgelines along with other specialist plants—not in low, flat, shady forests like this one.

James and I wandered out to Harvard Forest's soil-warming experiment. There, underground wires have been heating the soil for

the last twenty-seven years to simulate global warming. Digging through the soil, researchers like microbiologist Serita Frey have found that warming causes complex changes in the microscopic bacteria and fungi living underground. It's easy to think that a simple gradient from cold to warm, like descending a mountain, would cause a straightforward increase in microbial activity and decomposition. But it's much more complex than that, with many interactions among different species of plants and microbes, and globally relevant impacts beyond just nutrient availability. Which microbes live in the soil determines the rate at which wood and other organic materials decay. This, in turn, affects how much carbon dioxide the soil releases back into the air—in other words, how the soil breathes. But it turns out that twenty-seven years isn't long enough for the soil communities to reach a new equilibrium, so the experiment runs on, day and night.

As James and I walked back from the soil-warming experiment, we paused to look at a tall, lone pine with a stripe running down its side. Harvard Forest sits up on a hill, and we get a lot of lightning strikes, which frequently mess with the experiments. The scar on this tree showed black around its edges a few feet off the ground. It seemed to be an old scar, and James wondered out loud whether the black was really charcoal or if it was actually a fungus. Sometimes black fungus on wood can produce a remarkable imitation of charcoal. One way to tell is to try to draw with it. If it makes a black mark on paper, it's charcoal. If not, it's fungus. I leaned over and broke off a piece of the wood. Several attempts to draw on bark and my pants ended in failure. It must be fungus.

On our walk I told James about the book I'm writing. One of the chapters is about a barren rocky mountaintop that supports alpine plants at an elevation much lower than expected (fig. 7.14). On the flanks of the mountain, bands of spruce-fir forest slice through the hardwoods. Underneath the spruce and fir, bedrock juts up through thin soils, whereas thick soils hide the rocks of

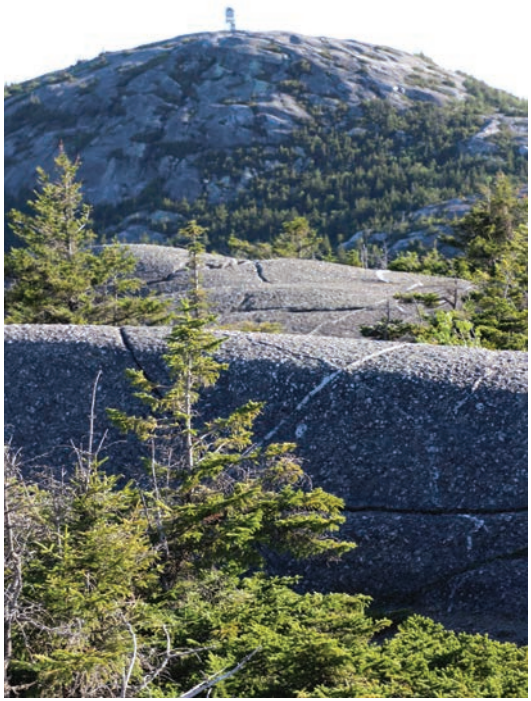


Figure 7.14. Summit of Mount Cardigan.

the neighboring hardwood forests. The little black treasures in the soil explain it all. When I discovered the treasures, I then carried them over to birch bark to make a picture, literally. Dragging them across the white bark, they produced rich black lines. Charcoal. Charcoal that had been waiting for me in the soil for 160 years (fig. 7.15).

I don't know whether it started with a lightning strike, the flick of a match, a spark of steel, or a glowing ember beneath a turning spindle of mullein, but in 1855 a massive fire burned the summit of Mount Cardigan, denuding it of trees. With no roots to stabilize the ground, the soil then washed off of the summit, exposing

Figure 7.15. Charcoal dug from the soil on Mount Cardigan, used to make line drawing on birch bark.

the bedrock below. Like in Iceland, the loss of soil changed the nature of this mountain, sending a closed subalpine forest back toward the first stages of primary succession. The top of Cardigan, devoid of protective vegetation, was now more like Mount Washington—exposed to the extremes of wind and temperature. It became a place where, despite being relatively low in elevation, only alpine specialist plants could survive the harsh conditions. And it's all because of that fire.

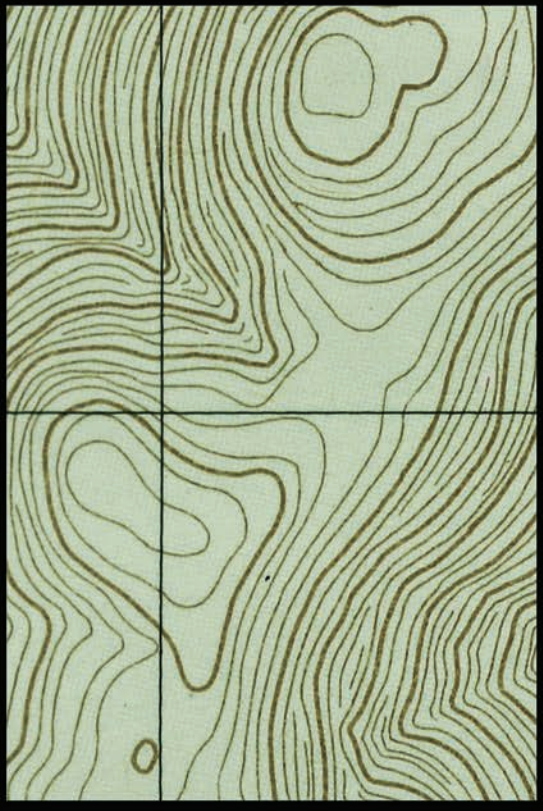
How exactly capitate sedge and the other alpine specialists arrived at this mountain still isn't clear. Maybe the summit had burned earlier and had been open for longer than we think. Maybe some seeds got stuck to mountain-hopping bird feet. Or maybe some mischievous botanist, seeing the alpine conditions, transplanted the plants for fun.

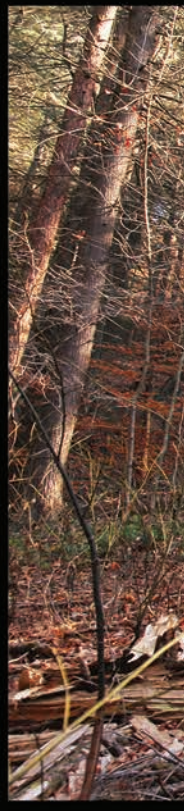
The fires that swept the summit evidently also burned down the sides of the mountain into the forests below, where the little black treasures lay in the soil. That explains the mysterious Nike Swoosh of dark green. It's a scar. Freshly burned soil makes a perfect seedbed for the conifers. Spruce and fir moved in where the old maples, beeches, and the soil beneath them were destroyed by fire.

But, we might ask, why did the fire burn where it did? Random chance? Perhaps. Or perhaps the fire is in turn a relic of centuries-old logging practices. Loggers, extracting the valuable conifers, may have artificially converted sections of the forest to hardwood-only stands. Where the weary loggers didn't reach, the conifers still stood. The hardwood stands resist fire. But the remaining conifers would have burned hot and fast, laying down a patch of burnt land that was even more favorable for future conifers and future fires.

MAJOR LESSONS FOR INTERPRETING A LANDSCAPE

- What environmental variables (e.g., elevation, moisture, temperature) define your ecoregion or ecological zone? What are the neighboring zones, and how do the species assemblages change?
- What past events—like fires, landslides, or mining operations—have left scars on your landscape?





(overleaf)
Figure 8.1. The forest is sculpted by many artists. (Inset map: USGS)

8. Disturbance

GOING UP

I feel as exhausted as Sisyphus pushing his giant boulder up the hill. My hill is a 700-foot gain in elevation up part of the small mountain behind our house. My boulder is a double stroller holding two children. The path we're on is a washed-out dirt carriage trail from the 1800s, deeply rutted in places by flowing water and definitely not intended for strollers.

This week has seen our first set of really hard frosts. Icicles cling to the moss-covered cliffs on the trailside, and ice is heaving out of the ground like winter flowers. Sitting side by side, the kids are wrapped individually in bulky layers and then together in my sleeping bag. Alder, not yet talking, is just along for the ride. But Juno, now three, is ecstatic that we'll be visiting this particular field site. He's been here a few times before; this place is a topic of frequent conversation, and a three-foot-wide slice of one of the hemlocks from here—a "tree cookie"—sits on the floor of our living room.

We pass a few other hikers who shoot various looks of amusement, incredulity, and the typical patronizing approval for my taking care of tiny children alone—as if I couldn't possibly be their

primary caregiver and as if being a nurturing dad couldn't possibly come naturally. Settle down, Noah, these aren't just the usual arrows of sexism: this outing is truly a bit extreme. A few raised eyebrows can be forgiven today.

We reach a particularly steep section of the road, and I'm not sure we can make it any further. Rocks are rolling downhill as my feet lose their grip and the three of us begin slipping backward. I pause. I catch my breath. Up ahead, the road levels off a bit and turns right—west. At the bend a little hiking trail drops off down along a steep cliff to the left—east.

That side trail ahead tumbles down massive formations made of impressive conglomerate rocks alongside a waterfall crashing to the base of the mountain. Below, the land is suddenly flat, and the creek gently saunters away from the pool beneath the waterfall. A few steps east of the waterfall there's a railroad, stretching long and straight along a north-south line. Cross the tracks, climb a short hill, and you find yourself under a high-voltage power line staring at low outcrops of metamorphic bedrock.

Two decades ago, miles south of here, the daily Amtrak, using that same set of tracks, would race past my dorm window on its way from Burlington, Vermont, to Washington, DC. One hundred and fifty years before, the waterfall was a popular railroad stop. At its peak of popularity in the late 1800s, vacationers would climb up the waterfall to take horse-drawn carriages to a resort hotel on the summit. But the hotel soon burned down. As legend has it, it was a band of local women who started the fire, upset that it was closer to a brothel than a hotel.

But the train tracks aren't there simply because of the tourist attractions—they follow a natural topographic line. This is the Eastern Border Fault. Standing at the power lines east of the tracks, we'd be on the Bronson Hill Island Arc, the volcanic islands that crashed into our continent 450 million years ago. But here on the west side of the tracks, we're in native North America. For to-

day we're going to stay on this continent, as our site is even farther west and even farther uphill.

I turn the stroller around and dig in my heels to drag the kids backward up the slope. The stroller inches upward as my butt falls to the ground. I scoot my heels toward my body, gathering the strength to stand up. On my feet again, I use the weight of my body as it falls against the hill to heave the stroller a few more inches up. Again and again. In this way, standing, heaving, and falling uphill, we creep upward, following the carriage horses. The kids are having a blast.

Twenty minutes later we pass the spot where this fall I came across a dead porcupine belly-up in the trail. A few yellow leaves were stuck to the quills in its side. A couple feet away more quills were pinned into the leaf litter on the ground. Brown, peanut-sized scats were scattered about. The scene was completed by oak branches, each with pencil-thick bases pruned at a sharp angle and attached green leaves nibbled at the tips. Standing over the porcupine on my way back down the mountain, I saw a woman dressed in black hiking up toward me. She carried what seemed to be a piece of blank paper, ripped from a journal, as if she was going to the top of the mountain to write a poem or a letter to a friend. I waited for her at the porcupine so that we could console each other.

"Who'd we lose here?"

"Porcupine," I responded, and, having put the pieces together, added, "Fell out of the tree while eating."

"Life is challenging and uncertain," she offered. Silently, she continued on up the trail and I down.

At last Juno, Alder, and I arrive. The road continues to the summit, but that's for another day. On the south side of the trail, we're looking at a steep slope, much too steep for a stroller—even I can see that. The children are cold, hungry, and tired, and for these last 200 feet, they want me to carry them up the slope, together. To the dismay of my vertebrae, I oblige. With Alder strapped to my front,

Figure 8.2. *Field Naturalist* students at north part of site.

Juno slung over my right shoulder, my camera hanging at my left hip, and the rest of our gear in the torn pack on my back, we stagger up. Then we collapse at the base of a large tree, and I pull out lunch.

Giant hemlocks watch over us as we eat (fig. 8.2). It's dark down here. We're in a steep ravine between two hills, cut by a tiny intermittent stream. Scattered hardwoods—sugar maple, black birch, beech—add occasional splashes of color with their bright orange and yellow fall leaves. The ground is strewn with thick trunks of fallen trees. Tucked beneath some broken branches, Juno finds a bright red partridgeberry—pea sized—attached to a small green creeping plant. He picks it and we all share the tiny fruit.

WIND

I point to a stump up the hill and tell Juno, "That's where our tree cookie came from." I first came here twelve years ago, taking *Forest Ecology* from Bill Patterson, who among other things specializes in prescribed burns like those around Maggie's Forest. Bill had been studying this spot for decades. He told our class about several big chestnut oaks that were mixed in with the hemlocks near the top of the slope when he first arrived. But from 1979 to 1981 a huge outbreak of the invasive spongy moth killed off those oaks.

A massive hemlock had been blown down the summer before Bill took our class on this field trip, and when we arrived the tree was lying with its crown uphill, to the south. The department's tool-wielding Dan Pepin came out with his chainsaw so that we could inspect the tree's growth rings. Dan started the first cut into the prostrate trunk about fifteen feet up from the base. As soon as the chainsaw was through the wood, the weight of the roots suddenly tilted the whole fifteen-foot section back up again. Dan then had to cut it back down so that we could see the rings near the bottom of the tree.

I feel a deep connection to that fallen tree because I knew the storm that blew it down. The morning it happened I had been sitting inside my old house—a tiny rental cabin—petting my cat, Annie, trying to motivate myself to go outside. A short walk through the woods down the hill from my house was a great big wetland—a giant fen. I had made a resolution to myself that I was going to go out there and try to just live off the land for a week or so. I had cleared my schedule that week, and that was the day I was supposed to leave.

But it was one of those summers where everything seemed to turn upside down. The Crocodile Hunter had been stabbed in the heart by a stingray, I had been dumped after a five-year relationship, and my landlords had burst into my house while I was gone one evening, then left me an unsettling phone message telling me

how to use a broom and threatening to evict me if I didn't do my dishes. By the end of the summer, to re-center myself, my sister had made me sit out in my yard making meditative rock spirals à la Andy Goldsworthy.

I was sitting with Annie on a little red loveseat that I had once carried on my back from a used furniture sale, gathering the energy to go out to the fen. In my bedroom a mouse that Annie had killed and lost was rotting somewhere in a pile of clothes. Pale, inch-long botfly larvae that the mouse had inhaled as tiny eggs wriggled in its flesh. The larvae emerged through the skin, crawled over to the carpet, and formed bullet-sized black pupae, which I later collected and raised into adult flies.

Suddenly, Annie embodied the look of a wildcat poised for action, momentarily frozen with wide eyes, perked ears, and tension coiled into all of her muscles. I heard it too. Was something banging on the metal roof? Hail maybe? No, the sharp pops were farther away. Snap, pop, crackle, and then, it was a screaming train.

I've heard it said that tornados sound like trains, but this sound wasn't just *similar* to a train—there seemed to be an actual train now racing through the forest behind my house. Always having wanted to see a tornado, I burst out the door to look. I couldn't see much through the trees, and then the train was gone. When quiet returned, I excitedly, and foolishly, ran out into the forest to look for the new train tracks. But my path was blocked. The popping that had given the train a definitive chugga-chugga sound seemed to have been made by whole trees splintering.

Most trees in the tornado's path—about 300 yards across—had been destroyed. If only I'd been out in the wide-open fen, looking up at the expansive view of the hill, I would have seen a tornado go by with my own eyes. I suppose I might have been killed too.

The tornado had cut a path three miles long, going right through the center of town—an eccentric, 250-year-old rural town with a proud motto: "We're all here because we're not all there."

I made my way into town amid the din of chainsaws just in time to see the sole victim being dragged out of a collapsed barn. Although she had a sprained ankle, the goat eventually made a full recovery. A half mile away I found what seemed to be a large post from the barn that had been picked up by the storm and planted upright in the center of a field.

For the rest of the summer, I made frequent pilgrimages to the path of the tornado, mainly attracted by the plethora of exposed roots and sloughing bark that I used to make baskets. The swirling winds had toppled trees in all directions. They were like handfuls of toothpicks that Alder had tossed on the carpet. Some trees were still standing, with their tops twisted off.

In the forest where Juno, Alder, and I now sit, it wasn't the tornado itself that pulled down the hemlock but, I believe, another isolated burst of wind generated in that same storm. And now a slice of this tree sits in our house, where we occasionally count its rings. I lay a piece of tape across the surface, and Juno helps me count: one, two, three. . . . When we get to ten, I draw a short line on the tape with black marker, and we count the next ten rings. In this way we march back in time through the decades: ten, twenty, thirty. . . .

DARK AND LIGHT

As Juno, Alder, and I finish up our snack amid the hemlocks, the sun slips down behind the hill to our west. I really want to climb to the top of the ravine. But even if they had the energy to walk, or if I had the physical strength to carry them, there's not enough light or warmth left in the day.

Besides, I was just here yesterday, alone. Though homesick for the kids, I was able to reach the other half of this site (fig. 8.3). I climbed up the dark hemlock ravine. Almost near the top, I found

Figure 8.3. *Field Naturalist* student at south part of site.

a dark brown scat—smooth-sided, blunt-ended—dropped by a bobcat. I reached the crest, then walked a few more yards, descending just a bit down the other side in time to capture photos for this chapter's opening image before the sun set.

Between the two sides, the forest couldn't be more different. Dark versus light. Tall versus short. Hemlock versus oak-hickory. Surrounded by ravine walls on all sides, like sitting in a dank basement, versus admiring the view through the trees that carries on for miles across hills and sky.

There in the bright forest on the other side, the *Field Naturalist* students are huddled in groups, still discussing the mysteries I'd set them on four years ago. The obvious question is, "Why is the

bright forest so different from the dark forest?" But there are also a lot of smaller questions to stretch their minds (see fig. 8.1).

The students divide into pairs and rotate through stations. Over here an oval of moss, three feet by two feet, sticks up through the leaf litter. Why? Here a small sapling stands, dead. What happened to it? Here is a large rotting log. What stories does it tell? Here is a tangled branch on the ground. Why is it here? Off over there, where the slope of the hill turns away from us, are some understory hemlocks. What's going on with them?

HOME FOREST

While the students inspect, ponder, and debate, I lean back into the mountain, pondering the fate of the creatures that this mountain supports. On the other side of the mountain, on a north-facing slope a mile up the hill behind our house, sits the place we call The Crevice: two thirty-foot-tall blocks of conglomerate that face each other. In the winter the nooks surrounding The Crevice are home to porcupines and endangered hibernating snakes. In summer the snakes wander widely, some feasting on voles in our overgrown yard. But as fall sets in, they converge back at The Crevice. With the right timing, we can arrive to find several jet-black silky lines as thick as my wrist and longer than I am tall mingling on a carpet of bright yellow fallen birch leaves. All winter long the snakes huddle in a ball underground keeping each other warm. Without this hibernaculum they would die.

The snakes and porcupines were likely at The Crevice when Sydne and I hiked up there for our wedding ceremony—along with my ninety-year-old great aunt balancing a pumpkin on her head and Sydne's nine-year-old nephew collecting hundreds of partridgeberries to eat. The creatures were at The Crevice when we hiked up through the foot and a half of snow in the hours before

Juno was born—although not when we hiked up through the heat of summer for Alder's birth. And the snakes were certainly there in the dead of winter when we tossed the boys' placentas in. In all these hikes, from the silty lake-bottom ecology to a landscape littered with glacial boulders and stone walls, we followed the trails. But how do the snakes find their way?

While we are limited mainly to visual cues, many species of birds, turtles, snakes, salamanders, invertebrates, and others navigate by sensing Earth's magnetic field, by seeing the polarization of light in the sky, and by smelling cues in the ground. Twenty years ago researchers collected a bunch of newts from a pond. Then they put them in dark buckets surrounded by powerful magnets and drove them away in a truck, spinning them continuously. At the end of the ride, the researchers set the newts down in a laboratory twenty-five miles away from the pond. There the newts turned their noses to face the direction of home. Somehow each newt, without knowing how she got there, could sense where she was on the map in her head.

Although the snakes just hole up and sleep at The Crevice, the porcupines are after more than shelter here. Snakes don't need to eat all winter. Porcupines, on the other hand, do.

Just like the snakes, you can find porcupines foraging far and wide in fields and forests in the summer. Porcupines are perhaps my favorite local mammal. These gentle vegetarians keep to themselves, care deeply for their children, and are relatively easy to get to know. One summer after college I made friends with a local porcupine. Out on the lawn of the house we rented, the porcupine and I would lounge together, a few feet away from each other, while she picked up clover flowers with her front paws and munched them down. But to some people, porcupines are just big nasty rodents that chew things up. One day late that summer, my roommate looked out the kitchen window and saw our landlord hacking the porcupine to bits with a shovel.