CHAPTER 1

Introduction

This book is about bee hunting—a fascinating open-air sport in which you find a flower patch humming with honey bees; you capture, sumptuously feed, and release a dozen or so of these bees; and then, using simple equipment but sophisticated skills, you trail these bees, step-by-step and in whatever direction they fly, back to their home. Bee hunting is a sport of infinite variety. If you start a hunt where colonies of bees living in the hives of beekeepers are fairly common, such as a suburban neighborhood or a country district with farms, then you might find yourself zeroing in on somebody's apiary. But if you start someplace wilder, say along an uninhabited road running between wooded mountains, then you'll probably find yourself following a beeline for the deep woods, homing in on the one tree out of the thousands around that is the secret residence of a wild colony of bees (fig. 1.1). Wherever this outdoor game is played, it combines almost everything that is desirable in a sport: it requires no costly equipment, can be played alone or in a group, exercises both the muscles and the brain, demands skill and persistence, builds suspense, and ends in either harmless disappointment or exhilarating triumph.

The greatest thrill in bee hunting, for most bee hunters, is to locate a wild colony of bees living in a stately tree deep in a

FIG. 1.1. Bee tree, with a knothole that serves as the nest entrance visible in the left trunk.

forest, and to sense the colony's vitality by watching the heavy traffic of its foragers zipping in and out of a picturesque knothole. Whenever I have this experience, I am reminded of the opening words of Aldo Leopold's classic tribute to nature, *A Sand County Almanac*: "There are some who can live without wild things, and some who cannot." Like most beekeepers, I love the honey bee colonies that I keep in my hives, for they are easily observed and studied. But I am *in* love with the honey bee colonies that live in the woods. They choose by themselves their tree-cavity homes, build as they see fit their beeswax combs (fig. 1.2), gather all their nourishment from flowers in the surrounding landscape, and fight without aid every predator or disease that crosses their lives. In short, these wild colonies draw fully upon the wonderful array of structural, physiological, and behavioral adaptations that constitute the biology of honey bees.

Wherever there are honey bees, there exist both managed colonies living in beekeepers' hives and wild colonies living in tree cavities, rock clefts, and the walls of buildings. While it is true that managed and wild honey bee colonies lead rather different lives—the former are manipulated to produce honey and pollinate crops, whereas the latter are left alone and can do whatever boosts their survival and reproduction—the bees in both types of colonies are virtually identical. The members of these two groups look, function, and act so similarly because the two groups have essentially the same genetic composition. This genetic similarity is a consequence of the frequent swapping of genes between the managed and wild colonies living in the same geographical area. Part of this genetic exchange between the two groups arises because the colonies living in beekeepers' hives produce swarms that escape and then lead lives in the wild, while at the same time the colonies living in natural abodes produce swarms that beekeepers collect and then install in their hives.

FIG. 1.2. The nest inside the bee tree shown in fig. 1.1. The tree trunk housing the nest has been split open, revealing the beeswax combs containing honey (above) and brood (below). On the left side of the cavity, about two-thirds of the way up, is the entrance opening. Total height of the nest is 5 feet.

The exchange of genes between managed and wild colonies also takes place in a second, more sensational way: the curious sexual behavior of honey bees. Every queen bee mates on the wing with 15–20 males drawn from the neighboring colonies living within four or so miles from her home. This shameless promiscuity of queen honey bees evolved because high genetic diversity among a queen bee's female offspring—that is, the workers in her colony—is essential to her colony's health. These days, it also has the effect of blending the genes in the managed and the wild colonies living in the same region. Incidentally, this extensive gene flow between managed and wild colonies explains why humans haven't created distinct breeds of honey bees through selective breeding, analogous to what has been done in the domestication of dogs, horses, and sheep.

It is a remarkable fact that humans have been keeping honey bees for at least 9,000 years, starting in the Middle East, and yet this insect still remains an essentially wild animal. The honey bees residing in beekeepers' hives look and behave the same as their wild counterparts. Indeed, they are all as much at home in a hollow tree as in a manufactured hive, and they are all fully capable of surviving entirely on their own.

"TO FAIR HAVEN POND—BEE HUNTING"

This little treatise is written in conscious admiration of Henry David Thoreau—not that Thoreau did much bee hunting. He did, however, write a remarkably detailed and reliable description of how it is done. I will try to do likewise, while bringing things up to date. Thoreau's guide to bee hunting is tucked away in the two-million-word journal—the daily record of things he thought, saw, and felt—that he kept from 1838, shortly after leaving Harvard College, to 1861, one year before his death. The entry of special interest to bee hunters is the one made on September 30, 1852, which begins "10 AM to Fair Haven Pond—Bee Hunting. Pratt, Rice, Hastings & myself, in

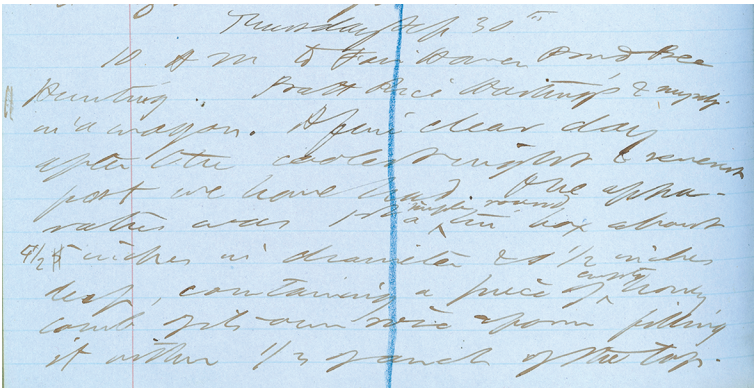


Fig. 1.3. Start of Thoreau's journal entry for Thursday, September 30, 1852. It reads as follows: "10 AM to Fair Haven Pond—Bee Hunting. Pratt, Rice, Hastings & myself in a wagon. A fine clear day after the coolest night & severest frost we have had. The apparatus was, first a simple round tin box about 4½ inches in diameter and 1½ inches deep, containing a piece of empty honey comb of its own size and form filling it within ⅓ of an inch of the top."

a wagon." (fig. 1.3). It runs over eight pages, making it one of Thoreau's longer entries for all of that year. What makes it such a trustworthy guide to the sport of bee hunting is that Thoreau does not include anything that he has been told but has not seen. There is no hearsay. Instead, Thoreau sticks to recounting what he saw and what he did on that "fine clear day" when he and the cobbler Hastings climbed on a wagon with two experienced bee hunters, Minot Pratt and Reuben Rice, and rode out to a field beside Fair Haven Pond, some two miles south of the village center in Concord, Massachusetts.

Thoreau starts by describing a bee hunter's most important piece of gear: the bee box. This is a smallish, usually wooden, two-chambered box that is immensely useful in the critical first stage of every hunt, when the bee hunter must convince a dozen or so foraging bees to quit visiting flowers and accept instead a tantalizing free lunch. The lunch counter is usually a piece of old beeswax comb filled with either diluted honey or sugar

syrup lightly scented with anise extract. The bee box used by Thoreau's company consisted of a "round tin box about 4½ inches in diameter and 1½ inches deep, containing a piece of honey comb of its own size and form" together with a wooden box that would be set atop the tin one. Thoreau tells how the bee hunters first caught several bees in the wooden box and then, after setting this box atop the tin box, gently opened an escape hatch in the wooden box's floor to allow the trapped bees to climb out and find the irresistible bait below. A few minutes later, the wooden box was lifted gently off the tin box, freeing the bees to fly home when each had taken her fill.

With a bee box in hand, one is ready to start bee hunting, and Thoreau describes how they searched for honey bees on the flowers by Fair Haven Pond, but found none there. The goldenrod flowers (*Solidago* spp.) were withered from a severe frost the previous night, and the purple aster flowers (*Aster nova-angliae*) were sparse. After eating lunch, the four men headed back to the village along Walden Road. When they reached Walden Pond they noticed fresh goldenrod and purple aster flowers on the sunny hillside sloping from the roadside down to the pond (fig. 1.4). These flowers were "resounding with the hum of bees." The team quickly captured and sent forth some dozen honey bees, each one laden with diluted honey drunk from Pratt's (or Rice's) bee box. The bees flew off in three directions, all toward places where the men knew there were colonies living in hives, not toward the forest homes of wild honey bee colonies.

Pratt was probably disappointed by where the bees were going, for he knew that a wild honey bee colony represented real treasure for its first finder. Indeed, he had told Thoreau about this earlier in the year. In the February 10, 1852, entry of his journal, where Thoreau records his discovery of a colony of bees living in a hemlock tree beside Fair Haven Pond, he also mentions that "Pratt says . . . I may get five dollars for the swarm [colony], and perhaps a good deal of honey." Thoreau,

FIG. 1.4. Worker honey bee collecting nectar and pollen from purple aster (*Aster nova-angliae*) flowers.

though, shows no disappointment about their sunny September day spent in bee hunting. Indeed, in summarizing his feelings about the day, he wrote, "I feel the richer for this experience. It taught me that even the insects in my path are not loafers, but have their special errands. Not merely and vaguely in this world, but in this hour, each is about its business. If, then, there are any sweet flowers still lingering on the hillside, it is known to the bees both of the forest and the village. The botanist should make interest with the bees if he would know when the flowers open and when they close."

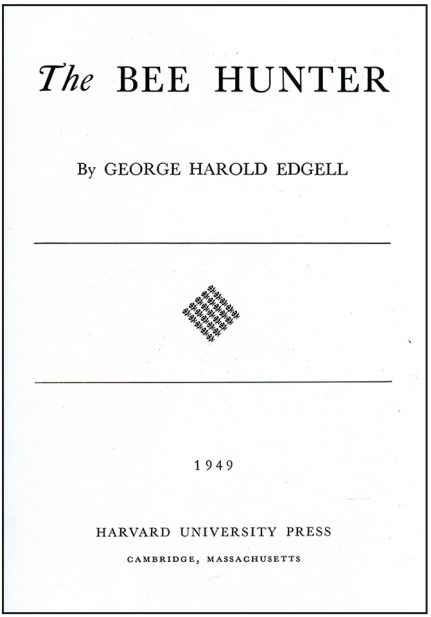
Thoreau's account of bee hunting in mid-19th-century New England depicts not just the sport, but also the author: a poet-naturalist who loved the uninhabited roads that led away from Concord, to the fields, woods, swamps, and ponds where he found the wild things that he enjoyed, preferably by himself. The bee hunter who, like Thoreau, delights in observing the ways of nature, perhaps especially in solitude, will love how the sport of bee hunting will lead him to places of quiet, natural beauty, ones that he would never discover were he not lining bees back to their unknown dwelling places.

Thoreau also liked to see how little money it is possible to spend, by working with one's hands and simple tools, and still complete a project. For instance, he built his cabin by Walden Pond for $28.12½, a respectably low price even in 1845, when (as Thoreau proudly records in his journal) the annual rent for a mere dormitory room at Harvard was $30.00. He achieved this economy by doing things like borrowing an axe and using it to fell young white pines and hew them into house timbers, rather than going to a sawmill and buying what he needed for his sills, corner posts, studs, and rafters. We shall see that a bee hunter who already has a watch, a magnetic compass, and some scrap lumber, and is handy with woodworking tools (or has a friend who is), can kit himself out for this sport for less than $28.12½.

BECOMING A BEE HUNTER

Like Thoreau, I learned the basics of bee hunting from an old-timer who lived in Massachusetts. His name was Dr. George Harold Edgell. He was both a distinguished professor of architectural history at Harvard University and an avid bee hunter at his summer place in New Hampshire. His obituary in the *New York Times*, on June 30, 1954, notes that over his career, he wrote four books: *A History of Architecture*, *The American Architecture of Today*, *A History of Sienese Painting*, and *The Bee Hunter* (fig. 1.5). The latter is a trim little book of 49 pages that was published by Harvard University Press in 1949.

The Bee Hunter is a gem. In it, Edgell introduces himself as a successful bee hunter of 50 years' experience. He also explains on page 1 that his main source of motivation to write this little book is the irritation he has felt in reading various books and articles on bee hunting, *all* of them written by people who must have never gone bee hunting. The telltale sign of their lack of firsthand experience is that the methods they describe could not possibly work. (It seems Edgell did not know about Thoreau's journal entry.) I think Edgell vented a bit of his


The BEE HUNTER

By GEORGE HAROLD EDGELL

1949

HARVARD UNIVERSITY PRESS

CAMBRIDGE, MASSACHUSETTS

FIG. 1.5. Title page of *The Bee Hunter*.

irritation with these fakers when he wrote, "It is time for someone who has hunted bees and found bee trees to write the facts."

Edgell further introduces himself to his readers by explaining that his interest in this sport began at the age of 10, when he was initiated "by an old Adirondacker who had sunk to driving his grandfather's mules in Newport, New Hampshire. George Smith, as I shall call him, was a character, to the youngster as fabulous as Paul Bunyan. He took his whiskey neat. He smoked and chewed at the same time and could spit without removing the pipe from his mouth. His profanity would take the bluing off a gun barrel. Withal, he was one of the kindest and most generous of men and a mighty bee hunter before the Lord, or devil if one prefers."

I discovered *The Bee Hunter* in the summer of 1978, when I returned to my family's home near Ithaca, New York, with a

PhD in biology and was on the lookout for something new to study. Ever since high school, I had been passionately interested in honey bees, and for my doctoral thesis I had enjoyed figuring out how the scout bees in honey bee swarms evaluate prospective nesting cavities, so there was no question that I'd keep going with the bees. I was feeling then, as I still do today, a strong desire to better understand how these beautiful little creatures live as wild colonies in forests, rather than as managed colonies in apiaries. Unless I could learn how *Apis mellifera* lives in its natural environment, I would never truly understand how its physiology, behavior, and social life adapt it to the natural world.

It seemed to me that one of the most profound environmental changes that beekeepers impose on their bees is the crowding of colonies in apiaries. In Europe, the original home of the honey bees we have in North America, this change started around 200 A.D., when people began to switch from *hunting* for colonies living in tree cavities to *keeping* colonies in purpose-made hives, which at first were simply hollow logs and inverted baskets. This switch made it possible to pack honey bee colonies together in apiaries, which of course makes beekeeping practical for humans. Unfortunately, living under crowded conditions can also make life hard for the bees, just as it can for us. Colonies of honey bees living jam-packed in an apiary endure greater competition for food, a higher likelihood of having their honey stolen, and an elevated risk of catching infectious diseases.

I also suspected that the difference in spacing between managed and wild colonies might be startlingly large. On the one hand, I knew that beekeepers (including me) usually space their hives just a few feet apart. On the other hand, I had just read the remarkable book by Dorothea Galton, *Survey of a Thousand Years of Beekeeping in Russia*, in which she describes how, in medieval Russia, the honey bees inhabiting trees in the forests around the city of Nizhny Novgorod had a density of

only four or five colonies per square mile, which meant that the average distance between colonies was approximately half a mile—more than 2,500 feet! I wondered, are the wild colonies living in the forests in North America also spaced so widely?

Coming back to Ithaca, which is also home to Cornell University, was exciting because I knew that close by was an ideal natural area in which to find the answer to my question. Fifteen miles southwest of Ithaca is a 4,500-acre research forest, the Arnot Forest, owned by Cornell (fig. 1.6). The rugged land adjoining the Arnot Forest, which includes the Newfield and Cliffside State Forests, is also largely forested, having been protected by New York State or abandoned by agriculture during the past one hundred years. The whole area is a natural haven for the study of wildlife, including wild honey bees. I had fallen in love with the Arnot Forest a few years before when I had installed bait hives (nest boxes mounted in trees to capture honey bee swarms) of different sizes in the forest, to determine the bees' preferred volume for a nesting cavity, and to this day it is one of my favorite outdoor haunts. Now I was eager to see if I could map the nests of the wild honey bee colonies living in the Arnot Forest and so learn about their dispersion across this vast, hilly, forested landscape.

Step one was to read up on bee hunting. A quick search of the card catalog in Mann Library—the enormous library for biology, agriculture, and applied social sciences at Cornell—revealed two books under the subject heading "Bee Hunting." Great!

The first book that I tracked down in the library's stacks was a thin paperback of 72 pages, smaller than my hand, with a title that suggested it might be, despite its size, a comprehensive handbook: *Bee Hunting: A Book of Valuable Information for Bee Hunters—Tells How to Line Bees to Trees, Etc.* Published in 1908, it was written by John R. Lockard (1858–?). It seems that Lockard was a kindly gentleman who had lived somewhere in the mountains of West Virginia, Kentucky, or Tennes-

Fig. 1.6. A view of the Arnot Forest, as seen from a lookout point along Irish Hill Road. Photo taken in early October, near the peak of the autumnal colors.

see. He explains in the preface that his book is a distillation of his knowledge of bee hunting gained during "forty years in nature's school room," and was written to "inculcate a desire for manly pastime and make [the reader's] life brighter." He definitely succeeded in both aims with me, for I finished his book feeling both keener to get out hunting and more optimistic of success. I had learned several valuable bits of the bee hunter's craft, including the importance of closely examining every tree, stump, or log when you think you are near a colony's hidden home; how a bee's flight path away from your bait can easily deviate from a direct course home unless you are making sightings in a large clearing; and what a stroke of good fortune it is to discover bees collecting water along a stream or other wet spot in the woods, for this reveals that a colony lives nearby.

However, because Mr. Lockard provides only a fuzzy description of how to zero in on a bee tree once you've deter-

mined its general direction, and because his technique for introducing bees to an irresistible free lunch involved kindling a fire, heating a flat stone, and melting a piece of honeycomb to produce aromas enticing to bees, reading his book didn't leave me feeling ready to start mapping the bee trees in the Arnot Forest. Not only did I still lack a clear sense of the mechanics of lining bees, I knew that Mr. Al Fontana, the no-nonsense manager of the Arnot Forest at the time, would throw me out of the place, probably forever, if he caught me lighting fires here and there in "his" lovely forest.

The second book I discovered that morning in Mann Library was George H. Edgell's small masterpiece, *The Bee Hunter*. Almost immediately after pulling it from the shelf, I knew I had found the handbook I'd been seeking. In 45 pages of text, one line drawing (of a bee box), and seven black-and-white photos, Edgell explains how to build a bee box, what additional pieces of paraphernalia are useful when hunting bees, which seasonal conditions favor success in bee hunting, how to establish a line to the bees' nest, how to execute a series of moves along the line to zero in on the bees' home, how it can be a major challenge ultimately to find the specific tree in which the bees are living, and, if one desires, how to "take up" (that is, cut down and extract honey from) a bee tree. I read and reread this delightful little book at least four times that day, partly the better to absorb Edgell's wonderfully detailed instructions, but also for the sheer pleasure of reading his charming writing. Consider, for example, his description of how "sparingly" one should use oil of anise when scenting a sugar syrup bait: "When I say sparingly, I mean more than the word ordinarily implies. The cork of the anise bottle rubbed on the comb and the comb then licked with the tongue will provide anise enough for one's purpose. More will make the bees quite drunk, they will refuse to suck but buzz around looking for the anise and eventually retire to the flowers to sober up." By the end of the afternoon, I knew I was ready to take action.

FIRST BEE HUNT

When I returned to Ithaca for the summer of 1978, I lived at my parents' house, but I worked at the Dyce Laboratory for Honey Bee Studies, which is part of the Department of Entomology at Cornell. With me was my close friend Kirk Visscher, who had just moved to Cornell to start his graduate studies in entomology. As was often our habit—we'd studied together at Harvard, and there I'd supervised Kirk's undergraduate thesis project—we began kicking around thoughts on important mysteries regarding honey bees that we could address through our research. Both Kirk and I had become fascinated by honey bees in high school, and we were both keen to tackle exciting questions about their behavior and social life. I shared with Kirk my question about the spacing of honey bee colonies in the wild and my plan of answering it by becoming (I hoped) a crackerjack bee hunter and locating all the colonies in the Arnot Forest. I also shared proudly my discovery of Edgell's charming little book.

By the following morning, Kirk, who is enviably intelligent and skilled at building gadgets, had read the book and built a bee box. It was inspired by the one Edgell shows in *The Bee Hunter*, but was simpler in design and thus easier to build. And it works just as well, if not perhaps better! It is such a good design that I'm still using a sturdy bee box that I built 35 years ago based on Kirk's design from that evening. We shall meet this bee box design in chapter 2.

It took Kirk and me another couple of days to assemble the rest of the equipment needed for bee hunting: an opaque cloth for covering the bee box, two squares of empty comb cut from a frame of sturdy brood comb and sized to fit loosely inside the bee box, a pint-size canning jar filled with sugar syrup "sparingly" scented with anise extract, a dropper bottle for filling the comb cells with the syrup, a small bottle of paint and a fine brush for labeling bees, a magnetic compass, a topographic

FIG. 1.7. Entrance sign for the Arnot Forest.

map of the area, a roll of plastic flagging for marking the route into (and out of) the woods, a watch, a notebook and pencils, and a toolbox or backpack for carrying everything. Also useful but not essential are a wooden crate, to serve as a stand for the bee box, and a folding chair, to make it comfortable to tend the bee box at the start of the hunt.

It is a 45-minute drive from the Dyce Lab to the entrance of the Arnot Forest (fig. 1.7), so when Kirk and I motored there in one of the lab's small fleet of green Chevy pickup trucks, we had time to discuss where we should make our first attempt at bee hunting. We decided to begin high in the forest, near its center and hence miles from any houses, to minimize the risk of engaging bees from a beekeeper's hive. It was a hot and sunny day, perfect weather for honey bees to be out foraging, so we assumed it would not be hard to find bees on flowers. It was also the middle of July, so we were making our first attempt when the summer honey flows (times of plentiful nectar) in our region were finished. Our major sources of honey in spring and early summer are the black locust, sumac, and basswood trees,

together with raspberry bushes and various herbaceous plants, such as dandelions and white clover.

Kirk and I did not yet recognize the importance of bee hunting when nectar is not available in abundance from natural sources. Only when the bees cannot find plentiful nectar in flowers will they forage enthusiastically from a square of dark, old, beeswax comb filled with sugar syrup. Evidently, taking syrup from a bee hunter's comb feels to the bees like robbing honey from another colony's nest, which is dangerous work. Robbers are often caught and killed inside the hives they are plundering. Therefore, the only times when the bees are wild about a bee hunter's bait comb are days when the weather is fair but they cannot find good, safe sources of carbohydrate, namely flowers chock-full of nectar. A warm day following a night with heavy frosts, like what Thoreau described for September 30, 1852, is ideal for bee hunting, but any fair day between spring and fall when there are flowers in bloom is worth a try (see chapter 3).

We parked atop Irish Hill, beside an old field, one of many cleared from the forest by Irish immigrants who established farms on this hill in the 1800s. They grew crops and grazed their stock on these fields until the mid-1930s, when the Federal Resettlement Administration—part of President Franklin D. Roosevelt's New Deal—helped farmers living on submarginal land, such as the thin soils on Irish Hill, move to more productive farmland. Propped on my writing desk is a rusty license plate from the last days when people lived up here. I found it in the weeds while checking a bait hive that I had mounted in a white pine behind the cellar hole of one of the long-gone farmhouses. This rectangle of disintegrating sheet steel has "NY 33" (for New York State 1933) stamped in small type at the top, and "4J79-63" (the vehicle registration number) stamped in large type below. I wonder if its owner knew, when he got this license plate back in 1933, how soon he'd be leaving his hilltop farm.

Kirk and I wandered about the site for half an hour, looking for honey bees, rather surprised that we could not find any. Finally, Kirk spotted a worker bee collecting pollen on a bush of multiflora rose (*Rosa multiflora*) and captured her in the bee box by gently maneuvering the flower bearing the bee into the open end of the box and then snapping the door shut. He then lured the bee to the box's back chamber, by letting light enter the window in the rear wall of this chamber. Finally, he locked her in the back chamber by closing the sliding divider that partitions the box into two chambers. Meanwhile, using the dropper bottle, I had filled one of the small squares of empty comb with sugar syrup and passed it to Kirk to put in the box's front chamber. Once this had been done, he gently set the bee box atop the wooden crate we'd brought along as a stand, covered the window in the back chamber, raised the sliding divider between front and back chambers (so the bee could find the comb), and put the thick cloth over the box to darken it. If the bee had seen light shining through any cracks, she would have struggled to escape at these places rather than crawl all about and bump into our syrup-filled comb.

We waited five minutes, to give her plenty of time to discover our wonderful surprise, and then Kirk opened the box's door slowly and smoothly, to avoid disturbing the bee. Our bee had indeed found the syrup (hurray!) but hadn't finished loading. Peering in, we saw her standing motionless on the comb, concentrating on the task of sucking up syrup. In about a minute, once she had filled herself to capacity, she walked out of the box into the sunlight, groomed a speck of syrup off a wingtip, probably warmed her flight muscles by shivering, and finally took flight. We crouched, the better to see her against the blue sky as she slowly circled around the bee box, gradually expanding her movements into figure eights, mostly in the eastern direction from the feeder. Of course, we tried our hardest to follow her convoluted flight, hoping to see her eventually streak

off in a beeline that would reveal the direction of her home, but we lost her from view while she was still circling. It looked like her home was more east than west, but that is about all we could say. The big questions now: Would she return for another load of the syrup bait? And would she share with her hive mates the news of her discovery?

Kirk and I waited hopefully, nervously, and patiently, reciting a key sentence from Edgell's book: "The most important quality for a successful bee hunter is patience." To help "our" bee find the comb again and to make it easier to label her if she should return, we moved the comb from its shady location just inside the bee box to a sunny spot just outside the box. After 9 minutes and 20 seconds, we heard the familiar sound of a honey bee! Then we saw her, presumably "our" bee, first approaching the comb but then darting off, next whizzing in circles around us, then poising in flight just above the comb, but finally landing and then standing atop the comb with her wings folded and her tongue extended, imbibing more of our irresistible bait. The bee was ours!

We applied a dot of light green paint on the abdomen of our bee, which transformed her into a little friend named Green Abdomen (recorded as "G-ab" in the notebook). Fortunately, Green Abdomen was not frightened by encountering a small square of old comb that was filled with anise-scented "honey" and was sitting oddly in bright sunshine in front of a wooden box on the side of a dirt road, for she kept coming and going from the bee box, and soon she had even brought companions (fig. 1.8). Most settled quickly on the comb. We had a six-color paint set, and it was not long before we had 12 bees labeled for individual identification, each daubed with a dot of one of the six colors on abdomen or thorax. We had also begun recording data in our notebook on two things of huge interest to a bee hunter: the bees' vanishing bearings when they flew home, and their departure and return times. The latter would enable us to estimate the distance to the bees' home.

FIG. 1.8. The first bee has spread the word to her nest mates about a "free lunch" of sugar syrup.

Once the bees became accustomed to our feeder, they began to circle less and less when leaving the feeder, so it became easier for us to keep our eyes locked on a bee while she flew away. But we were just beginners, and we found it frustratingly difficult to get sightings we could trust. After about an hour of this work, we had accumulated 14 sightings of bees that flew off straight enough that we could follow them for 50 to 100 yards. The compass readings for these 14 flights home were 90°, 86°, 84°, 82°, 79°, 72°, 74°, 81°, 98°, 93°, 87°, 90°, 81°, and 92°. The average of these readings is 85°, so there could be no doubt; the home of these bees lay nearly due east.

Getting data on the busy bees' departure and return times was much easier, and we quickly learned that the length of time a bee was gone from the feeder ranged widely, from 7 minutes 50 seconds to 13 minutes 40 seconds. We noticed, however, that the four shortest "away times" were all about 8 minutes.

Knowing that these bees had flown home, unloaded their syrup, and flown back to the bee box, all in 8 minutes, meant that we could make an estimate of the distance to their home. We knew that bees fly about 15 miles per hour (hence 4 minutes per mile, or about the speed of a human sprinter), and we estimated that a bee needs about 2 minutes inside the nest to unload the droplet of syrup she has brought home; we had seen that this was how long our bees were taking to load up. Subtracting an estimated 2 minutes of unloading time from the 8 minutes of total time gone gave 6 minutes of flight time total, and therefore approximately 3 minutes of flight time for each leg of the journey. Using this estimate of 3 minutes of flight coming or going, together with the estimated flight speed of 4 minutes per mile, we calculated a flight distance to the nest of approximately three-quarters of a mile (3 minutes of flight/4 minutes per mile = ¾ mile).

Three-quarters of a mile. Yikes! Stretching out in the valley to the east, and sweeping up the hillside beyond for nearly 2 miles, was a mature hardwood forest filled with thousands of majestic sugar and red maple, beech, black and yellow birch, shagbark and pignut hickory, red and white oak, tulip poplar, and white ash trees, plus dense stands of hemlock trees on the north-facing slopes, and a sprinkling of towering white pines. These woods had been logged heavily in the late 1800s, but since then they had been left alone, and now they were packed with trees large enough to enclose a cavity of the sort a honey bee colony selects for its home. We wondered, would we ever be able to find the one tree out there that was home to Green Abdomen and her housemates?

To try to answer this question, we followed Edgell's advice about making a move down a beeline. We refilled our comb with syrup and placed it back inside the bee box. The bees were upset and acted suspiciously. One by one, though, they began landing again, so eventually it was standing room only on our matchbook-size square of comb, with each of the 15 or so bees

again fixated on filling her honey stomach with our tantalizing bait. At this point, we softly closed the door of the bee box, slipped a rubber band around it to keep the door shut, packed up our gear, and moved 100 yards in the direction the bees had flown home. This took us to the brushy edge of the old field. Edgell describes making initial moves down the beeline of 300 or 400 yards, but that seemed far too daring to us. Also, we weren't ready to plunge into the forest.

When we gently opened the bee box in the new spot, some of the bees rushed out and disappeared without circling, but several were still loading, and when they departed they did so calmly and seemed to take their bearings, for they circled slowly about the new location before they too vanished. Now we were nervous. Would any of the bees return to this new site and so make the move, or would they all return to the original spot and be lost? We noted the time, and waited, knowing that probably nobody would show up for at least 10 minutes. The wait felt endless. But after 12 minutes, we heard the wonderful, silvery tone of a honey bee returning to our comb. In a couple more minutes, other bees had also landed on the comb, including Green Abdomen. Yippeee! Kirk and I felt we were really on our way to becoming, like George Smith, "a mighty bee hunter before the Lord."

Now, however, we also had to face facts: we needed to move deeper into the woods. We scouted down the beeline and found, as expected, only unbroken forest. We recalled Edgell's somber words: "Released in the woods, a bee circles up into the trees and disappears. Sometimes it is hard to tell whether [she] goes forward or back." We soon learned, however, that we could make moves to spots in the woods where there was a gap in the canopy, usually where a big tree had fallen, and in these places we could watch the bees circle up and disappear more on one side of the opening than the others. This helped us stay on the line, and gradually we drew nearer the bee tree. As we did so, more bees buzzed around us, and we had to refill the comb

every few minutes. Also, the labeled bees were spending less and less time away between stops at the feeder.

Eventually, on our sixth move, made on our second day, we jumped the operation ahead by about 150 yards, to a large canopy opening where the forest floor fell away sharply and a huge red oak, which had grown on the edge of this drop-off, had fallen downhill. The bees moved to this site easily; a few even seemed to fly along with us as we made this move. Soon we had dozens of bees buzzing about us, and we were refilling the comb faster than ever, so we figured the tree must be near. But the bees were behaving oddly when they departed: instead of launching forward along the eastward line we had been following, they were circling away in all directions. Eventually, we realized that our bees, once they reached the top of the canopy opening, were flying north, not east, which told us that the bee tree was off to the left of the line we'd been traveling along, not farther ahead.

This was a valuable observation, for it meant that we did not have to work down the steep hillside that fell away before us; instead, we could work around on the shelf above it. It also meant that the bee tree was nearby, hence only half a mile from our starting point, not the three-quarters of a mile that we had originally estimated. And finally, it meant that now we needed to change our hunting tactics, switching from moving down a beeline to conducting a tree-to-tree search. This was a new challenge, one that felt almost hopeless because it seemed there must be hundreds of trees that we would need to inspect closely, bottom to top, to find the home address of our bees. We took heart, though, from another timeless tip from Edgell: "It is only a matter now of looking carefully enough to discover the tree." Undeniably true, but a bee tree can be exasperatingly difficult to find, as we shall see in a later chapter, when I describe one bee tree that took me three years to find. But on this day, we were beginners and we enjoyed some beginners' luck. We fanned out in the direction the departing bees were heading,

FIG. 1.9. The bee tree that the author and a fellow bee hunter, Kirk Visscher, found on their first bee hunt.

and after about an hour of going from tree to tree, scanning up and down each tree's trunk for the flash of flying bees, Kirk shouted, "Found it!" Indeed he had. Some 20 feet up the northwest side of an 18-inch diameter (at breast height) hemlock tree was a knothole with honey bees pouring in and out (fig. 1.9). At that moment, for these two novice bee hunters, there could have been no more splendid sight.

BIOLOGY BOX 1

How Abundant Are Wild Colonies of Honey Bees?

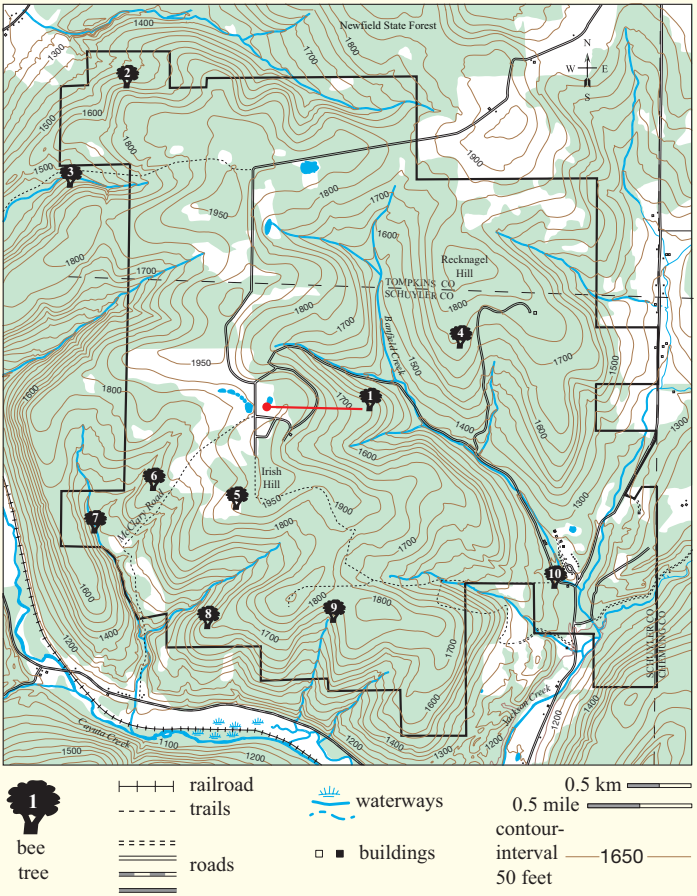
Honey bees have been living in the forests of eastern North America for some 400 years, following their introduction from Europe by English settlers starting in the 1620s, and perhaps also by Spanish settlers starting even earlier (Sheppard 1989). The hunting of the wild colonies of these bees, for their honey, probably began soon after they were brought to the New World. Already in 1720, a Mr. Paul Dudley published in the Philosophical Transactions of the Royal Society of London a letter titled "An account of a method lately found out in New-England for discovering where the bees hive in the woods, in order to get their honey." By the early 1800s, various writers, including Washington Irving (1835), were saying that bee hunting was a pleasurable and profitable pursuit for frontiersmen, since the honey obtained by plundering the nests of wild colonies was not just a treat but was also easily bartered and sold. In the journals of the Lewis and Clark Expedition, we find the following note by William Clark for Sunday, March 25, 1804, shortly after the expedition party had left St. Louis and was camped along the Kansas River: "river rose 14 Inch last night, the men find numbers of Bee Trees, & take great quantities of honey" (Moulton 2002). And in 1925, Thompson described "a most successful bee tree hunter," Lester Shaw, who lived in rural Potter County in northern Pennsylvania. He had collected over 1,700 pounds of honey from bee trees in a single season and could count by the hundreds the wild colonies he had

found. It seems clear that in the not-so-distant past there were countless skilled bee hunters with deep knowledge of the abundance of wild colonies of honey bees in North America. Unfortunately, what these hunters knew was not documented and therefore was lost when they died. So when Kirk Visscher and I began to investigate this subject in the summer of 1978, we felt we were looking, both figuratively and literally, out across new scientific terrain.

Kirk and I had difficulty finding honey bees on flowers in the Arnot Forest in early July, so we decided to postpone further bee hunting until late August. (This was a wise decision, for reasons to be explained in chapter 3.) We knew that the dense stands of goldenrod (*Solidago* spp.) plants sprouting up beside the roads and in the abandoned fields in the Arnot Forest would start blooming in late summer. We also knew that the flowers of goldenrod, being superabundant, are the primary late-summer source of nectar and pollen for bees living in this part of New York State, so we figured that it would be easy to find worker bees buzzing around on these plants in late August. By then, though, Kirk was busy with his coursework as a new graduate student at Cornell, so I conducted the rest of the bee hunting on my own. I too would need to step back from this project, in mid-September, to return to Cambridge, Massachusetts, for the first dinner meeting of the Society of Fellows at Harvard, which was supporting my postdoctoral studies. But until then I was free to go bee hunting all day and every day. Sweet!

I hunted the wild honey bees in the Arnot Forest from August 26 to September 13. Nearly every day was hot and sunny. This gave the bees plenty of time to be out working the flowers, and it gave me an excellent opportunity to be out hunting the bees. I would arrive in the dewy fields before the sun and would continue hunting until the bees stopped visiting my bait comb at dusk. The midpoint of each day was marked by the sound of the noon whistle rising up from the Cotton-Hanlin sawmill down in the hamlet of Cayuta, a mile and a half from the forest's western boundary.

To make the most of the 19 days I had available for the task, I focused my hunting in the southern and western parts of the forest, where, in abandoned pastures and along the railroad line that skirts the forest's south boundary, I found 17 open spots where I could see in all



Map of the Arnot Forest showing the locations of the ten bee trees found there in 1978. The site of each bee tree is marked by the base of a bee-tree symbol. Red line denotes the path of the author's first bee hunt.

directions; I also found lush stands of goldenrod plants, whose shining flowers bobbed with honey bees. At each location, I could easily fill my bee box with bees to start a beeline, and I could get good readings of the vanishing bearings of the bees when they finished loading up on my sugar syrup and flew home to their nests. As shown in the figure, these beelines steered me to 10 bee tree colonies, 9 living in the Arnot Forest and 1 just outside its western boundary.

Almost certainly, the nine colonies that I found were not all of the colonies living in the Arnot Forest. After all, I did not establish beelines from flower patches located in the northern and eastern regions of the forest, which make up about 50% of its total area. I estimated, therefore, that the 9 colonies that I found inside the Arnot Forest's boundaries were only about half of the colonies living in this forest; hence there were about 18 colonies total living there in the fall of 1978. Given that the area of the Arnot Forest is almost exactly 7 square miles, this estimate of 18 colonies total meant that the abundance, or density, of the wild colonies in this forest back in 1978 was approximately 2.6 colonies per square mile; this translates to 1 colony per square kilometer.

This first estimate of the abundance of wild colonies of honey bees living in the Arnot Forest has proven to be a good general estimate for this location. Since 1978, I have made two more surveys of the colonies living in this forest. In 2002 and 2011, I located 8 and 10 colonies, respectively, living inside (or just outside) the forest's boundaries (Seeley 2003a, 2007; Seeley et al. 2015). In conducting the two additional surveys, I again covered about 50% of the Arnot Forest's total area, so my estimates of the total number of wild colonies living in the Arnot Forest in these two surveys are 16 and 20 colonies. Therefore, the estimates of the density of these wild colonies for the 2002 and 2011 surveys are 2.3 and 2.9 colonies per square mile, close to the estimate for the 1978 survey of 2.6 colonies per square mile. This consistency in the surveys' results gives me confidence that 2 or 3 colonies per square mile (or about 1 colony per square kilometer) is a reliable esti-

mate of the abundance of wild honey bee colonies living in the Arnot Forest.

This estimate of 2 or 3 wild colonies per square mile in this rugged, heavily forested region of southern New York State appears to fall at the lower end of the range of wild-colony densities that have been reported for *Apis mellifera* across its vast range, which includes Europe, the Middle East, and Africa (where it is native) and the Americas and Australia (where it is introduced). As reviewed by Hinson et al. (2015), the published estimates of wild colony densities range from 0.3 to 20 or more colonies per square mile in both natural (for example, nature preserves) and agricultural habitats. It seems clear, therefore, that bee hunters will enjoy good hunting for wild colonies everywhere on the planet where these cosmopolitan bees live. I can add that in all 10 places outside of the Arnot Forest but still in the United States where I have gone bee hunting over the last 20 years—eastern and central New York, western Pennsylvania, northern Connecticut, western Massachusetts, central Vermont, and various locations in Maine—I have had no difficulty establishing beelines that led me to wild colonies. Moreover, I have spotted wild colonies of honey bees living in trees and buildings while exploring in the following European countries: Ireland, Great Britain, Sweden, France, Switzerland, Germany, and Austria. Given the results of the studies reviewed by Hinson et al. and my personal experiences, I am confident that if you give bee hunting a try at the right time of the year (that is, whenever honey bees are foraging) and in a place with nest cavities for honey bees (wherever there are trees and buildings), then you will have success in establishing a beeline that can lead you back to a wild colony of honey bees.