Finding the Mother Tree

What’s in it for me? An intimate trek through the forest – and the life of an influential ecologist.

Young Suzanne watched Dad and Uncle Jack as they dug into the earth. First, they cleared away the top layer of leaves, twigs, cones, and feathers, and raked them into a pile. Fungal threads, a mix of shining yellow and pure white, enmeshed the debris like a spiderweb. Next, Uncle Jack chopped into the dirt with his pickaxe, revealing a layer of dark cocoa-like humus – the substance produced by dying and decaying plants. Suzanne watched, enthusiastically chewing a piece of humus she’d picked up. She’d always loved the taste of dirt, rich and sweet. As Uncle Jack and Dad continued to dig down, they revealed further layers of earth, where tree roots were woven into an almost impenetrable tangle of umber and ochre. Finally, they reached a layer of rocks, which they coaxed out with a crowbar. The family’s dog, Jiggs, had fallen through the floor of an outhouse and was trapped underground – and now they could finally pull him free. Suzanne didn’t know it at the time, but this adventure would be a turning point in her life. It revealed the vast, rich world that existed underneath and throughout the forest – a world to which Suzanne, now a renowned ecologist, would dedicate her life. In these blinks, you’ll explore

how fungi can help trees grow; what really happens when you spray herbicides; and how a tree acts like a mother.

Murder Mystery

Tendrils of fog curled around the limbs and trunks of the trees. The needles of the firs, coated by damp mist, shone in the midafternoon light. Suzanne ran her fingers along their branches, feeling the feathery softness of the needles. Her destination was a clear-cut – a 30-hectare section of completely felled trees. This particular clear-cut belonged to the logging company she’d started working for a few weeks back. New seedlings had been planted there, and it was Suzanne’s job to assess their growth. Along the way, she spotted a Suillus mushroom, with its flat brown cap resembling a big pancake. She plucked one out of the ground and saw tiny yellow threads – mycelium – stretching from the stem down into the soil. The mushroom was merely the fruit of the fungus – the small, visible part of an organism that, underground, was vast and elaborate. As Suzanne continued toward the clear-cut, her boot suddenly slipped. In an attempt to keep her balance, she instinctively grabbed a nearby sapling, ripping it out of the ground as she fell down the slope. When she finally came to a rest, she was still holding onto the young tree. Its roots, she noticed, were coated in humus – but there was something else. The tips of the roots were glowing bright yellow, just like the Suillus mushroom she’d picked up. Curious, she began to dig into the forest floor. Every part of the soil, it seemed, was webbed with that same yellow mycelium, along with mycelium of other colors. What was their purpose? Eventually, Suzanne reached the clear-cut. The dead remains of the trees, white and weathered, jutted out of the soil like bones, while the new seedlings sprouted in neat, even rows to maximize the timber yield. Well, that was the theory, anyway. But these seedlings seemed barely alive. Pulling an especially sad-looking one from the ground, she examined its roots: coarse and black, with no

white tips. The planting job was perfect, yet something was wrong. The roots were failing to connect with the soil. Nearby, she spotted a healthy fir tree that had, by chance, sprouted from a random seed. This tree was firmly rooted in the soil, and when she examined the root tips, she was amazed. Dripping from them were bright yellow fungal threads, the same color as the Suillus mycelium. Something seemed significant about this discovery. What exactly were these mycelium doing? Were they helping or harming the seedlings – or neither? A laundry list of possibilities ran through Suzanne's head as she wrote down her analysis of the plantation: it was a failure. But what should the logging company do about it? Replant all the seedlings using the same methods? That would be the cheapest option, unless the seedlings all died again. A new solution was needed – but what?

Mutualism

Suzanne's brother, Kelly, straddled the fence separating his bull from the arena. He wore a brown cowboy hat, denim jeans, and leather chaps – a vision of the Wild West, displaced in time. This was the venerable tradition of the rodeo. Kelly tipped his hat to the referee, grasped the rope wrapped around the bull's neck, and straddled the furious animal. The gate swung open, and the bull's limbs immediately began kicking and twisting in every direction. If Kelly could stay on the bull for eight seconds, he'd win the prize money. All or nothing. The seconds ticked on, and Suzanne screamed her throat raw, her fists pumping in the air. When the seventh second came, the bull bucked violently. Kelly went flying off, landing on his shoulder with a sickening thud. Afterward, despite his newly dislocated shoulder and lack of prize money, Kelly was in good spirits. He and Suzanne shared a lighthearted chat that reminded her of the good old days, before their parents had split up and their relationship had become strained. On her way back home, Suzanne passed a squirrel, chittering as it snacked on a dark brown truffle. It had obtained the tasty morsel by excavating the ground nearby – ground that Suzanne then wanted to investigate, too. Digging through layers of clay threaded with black mycelium, she finally hit a soft spot – a truffle. Attached to one end was a thick strand of mycelium that reminded Suzanne of an umbilical cord. To her surprise, the thread ended at the root tips of a nearby Douglas fir, which the mycelium had completely surrounded. The truffle and the tree were bound up into a unified whole! That meant the relationship had to be a healthy one – the fir was thriving, and the fungus was so healthy it had sprouted a fruit, a truffle. There were other implications, too. Since the fungus was completely coating the tree's root tips, that meant any nutrients and water would have to pass through the fungus before getting to the tree. But why would the fungus willingly give those up? Or did the tree just greedily seize them? Later that day, she found the answer in a book on mushrooms she'd borrowed from the library. The fungi she'd found were called mycorrhizal. According to the book's glossary, a mycorrhizal fungus was one that formed an intimate, life-or-death relationship with a plant; neither could survive without the other. The plant gave sugars to the fungus, which the fungus needed to grow more mycelium. In turn, the fungus reached deeper into the soil, collecting water and nutrients that it then delivered back to the plant. A two-way exchange. Suzanne was shocked. The modern foresting industry was laser-focused on competitive relationships between the species in a forest – not cooperative ones. But it was starting to seem like cooperative relationships were, in fact, essential. Could these mycorrhizal fungi be the key to the mystery of her company's dying seedlings?

Executioner

Wrapping pink ribbon around the trees, Suzanne and Ray, her colleague, marked out the margins of the new clear-cut. Within its borders lay 500-year-old trees. Each one was condemned to death. The thought made Suzanne cry. She didn't object – this was part of her job. But her participation in the execution seemed heinous and brutally opposed to nature. What was she doing? The summer after helping Ray, she worked for the logging company again. But as the snow began to coat the mountains in late fall, she was laid off. It stung, but Suzanne knew it was ultimately for the best. She wanted to play a different role in the forest. First, though, she'd need to be the executioner once more. She started working for a man named Alan Vyse, who was a researcher with the British Columbia Forest Service. Suzanne hadn't done any research before, but Alan gave her the opportunity to design an experiment. She'd be investigating weeding effects in high-elevation clear-cuts. The underlying goal was to evaluate the latest government policy, something called "free to grow." It involved weeding out all other plants in an area, usually with herbicides, to eliminate any potential competitors for conifer seedlings. The native plants – every single one – were viewed as weeds to be eradicated. It was a policy that framed forests as little more than tree farms. The experiment required Suzanne to kill plants. Didn't that go against everything she stood for? Well, yes – but at the same time, investigating the free-to-grow zone would help her learn how to design experiments. She needed that foundation, the knowledge of how to be a scientist, if she were ever going to solve the mystery of those dying seedlings from the clear-cut. When Suzanne and her sister, Robyn, who was helping out, reached the clear-cut, they saw herbs and other plants running rampant. The planting companies planned to kill everything using herbicides – specifically, Roundup – which would supposedly help the spruce seeds grow. With Alan's help, Suzanne designed the experiment. In three separate plots, they would test the effects of different quantities of herbicides – one, three, and six liters – on the spruce plants. Then there'd also be a plot that used a manual cutting operation with no herbicide. And, finally, there'd be a control – all the plants in that plot would go untouched. Each treatment would be repeated ten times, so they'd be absolutely sure of the results. The results were disheartening, if not unexpected. The maximum dose of poison had been most effective at killing the rest of the plants in the plantation, leaving only the spruce seedlings behind. But, as Alan reminded Suzanne, that was all the experiment proved – namely, a big dose of poison would get rid of the weeds. It didn't say anything about whether the free-to-grow plan would actually help the seedlings survive in the long run. For that, a bigger, better experiment was needed.

Experimentation

When Suzanne landed a permanent job as a silviculture researcher with the Forest Service, she immediately felt a whole new world open up before her. She was now free to ask important questions and conduct experiments that would allow her to explore her theories about the forest. With her first research grant, she would test the effects of mycorrhizal connections on the survival of conifer seedlings. Additionally, she would test whether or not native plants helped forge those mycorrhizal connections between seedlings and fungi. Designing the experiment was complicated enough, but actually executing it was even more so. In fact, it took four years and four replantings because the seedlings kept dying. The site seemed to be a black hole of death for them. Only the luxuriant grasses on each plot seemed to be doing fine. That very fact gave Suzanne a

flash of insight one day. She knew that both Douglas fir and western larch trees could only form relationships with ectomycorrhizal fungi – a specific type of fungus that wraps itself around the outside of a tree's root tips. The grasses, on the other hand, worked with arbuscular mycorrhizal fungi that penetrate the roots' cells. Could the seedlings survive only if they were paired with the right type of mycorrhizal fungus? In the fifth year of her study, Suzanne replanted again. This time, though, she placed live soil from an old-growth section of forest into one-third of the planting holes. In another third of the plantation, she placed live soil that had been radiated in a lab to kill the fungi living in it. And in the final third, she left the seedlings alone in the razed ground with no live soil. The following year, Suzanne returned to the site. And what did she find? The seedlings living in the old, fungus-filled soil were healthy – thriving, even – while the ones in the irradiated and the untouched soil were completely dead. After digging up the seedlings, Suzanne found that the dead ones had nothing attached to them – no new root tips, no fungi. But the healthy ones? A bright, dazzling rainbow of fungi were hanging off them, mycelia resplendent in all imaginable colors. Suzanne was overjoyed. She had discovered that the old-growth soil, with its many fungi, was keeping the trees healthy and thriving. Yet this was really just the tip of the iceberg. Her childhood forests were being transformed into monocultures using these relentless free-to-grow techniques. In short, there was a lot of work to be done. The day she finished taking samples from the experiment, Suzanne walked to an elder birch tree and pressed her hands against its bark. She whispered her thanks for its wisdom. In exchange, she made a promise: to learn more about the complex web of relationships in the forest, and to spread the word that the breakdown of those relationships was killing the trees. To fulfill that promise, she needed more education. It was time to head to grad school.

Fighting Words

The audience loomed in front of her, dark and menacing. Just imagine they're all cabbages, she told herself. Like Dad said to do. On this day, she was presenting the results of her master's degree experiment, in which she'd tested the effects of alder trees on pine growth. She was especially nervous because her research had revealed some uncomfortable – but vital – truths. The alder, like many other tree species, was regarded as a weed by planting companies. It was a thirsty tree that seemed to suck up all the water in a plot, leaving little for the pines. But the full story was so much more complex. True, the alders did pull water from the soil at certain times, particularly in midsummer. But they also exuded water through their roots, rerouting it to the dry surface soil. In the alder-less plots, this process didn't happen, and the topsoil remained dry – so when it rained, a lot of the water slid off the surface. This meant that, over time, the alder-dense plots actually gained water compared to those with no alders! Moreover, when the alders' leaves decomposed in the fall, they released loads of nitrogen – an essential nutrient for pines – into the soil. Cutting down the alders produced a short-term boost in nitrogen as the trees decomposed, but after the first year, that nitrogen wasn't being replaced. When the alders were allowed to remain, however, there was a sustained nitrogen boost every fall. So, as Suzanne told her audience, weeding out the alders didn't actually improve pine growth over time. The millions of dollars in treatments were, essentially, a waste of money. Needless to say, the policymakers in the Forest Service weren't happy – and they weren't yet willing to accept the information as fact. Still, it was a start. Exhausted after her speech, Suzanne joined Kelly and her research technician, Barb, down at the local pub. Kelly loped over to their table with a jug of beer in his hand. His easy, bright grin erased any of Suzanne's remaining sourness. The drinking progressed quickly, and the room was

starting to sway around her. But just then, Kelly made a comment that took Suzanne by surprise. “You can get the cows moving,” Kelly said, “if you manage them like women.” What? Suzanne thought. What did Kelly mean by that? “The cows are the center of the herd. Their only job is to feed their calves,” he continued. Suzanne couldn’t let that stand. “Women don’t just feed babies. You’re kidding me, right?” She wanted to throttle Kelly. She pushed away her jug of beer and started shouting at him: “We can do whatever we goddamned well please!” She hardly knew what she was saying as she staggered to her feet. “Fuck you!” she screamed, stumbling out of the bar with Barb in tow. When she got home, her husband, Don, hugged her and told her she’d be fine. Kelly would get over it.

The Wood Wide Web

The carbon-transfer field data had finally arrived on her desk. Suzanne could hardly breathe as her eyes scanned the report – she had to double- and triple-check the results. They didn’t feel real. For her doctoral research, Suzanne had tested the relationships between paper birch and Douglas fir trees. What she’d found was that paper birch – once thought to be a competitor of the fir – was actually helping the fir survive. But there was more to it than that. The two were actually trading carbon back and forth via their shared mycorrhizal network. The birch was so generous with its donations that the firs were able to use the carbon to reproduce – and as the birch grew taller and produced more shade, it compensated by donating more and more carbon to neighboring firs. The trees were communicating, cooperating, and collaborating – not competing. Together, they formed an intelligent, unified system. The trees didn’t want to be separated; they needed each other. Just then, the office phone rang. It was Tiffany, Kelly’s wife. She was sobbing when she blurted out, “Suzie, listen. Kelly is dead.” The rest of Tiffany’s words rushed out like a waterfall. Suzanne could only listen, frozen, her hand clutching the edge of her desk. Kelly had left his tractor idling as he’d ducked into a barn. The tractor had slid forward and crushed him to death. Tiffany was due to give birth to their child in just three months. All of Suzanne’s senses felt dulled, numb. The last words she’d said to Kelly, drunken and angry, played again and again in her head. Brother and sister would never reconcile. Over the next months, grief consumed her. She processed it by throwing herself into her research. She was no longer afraid of sharing her discoveries with the world – grief can have that effect, making usual fears seem like nothing at all. Suzanne decided to write up her research findings about the ways that birches and firs shared carbon through fungal networks. She sent the article to the scientific journal Nature. At first, it was rejected. But, after another round of revisions, Nature decided to publish it – as an August 1997 cover story. The magazine termed Suzanne’s discovery the “wood-wide web.” Almost overnight, it made Suzanne a celebrity. For the first time, research had proven that significant amounts of carbon flow through fungal networks and are shared from tree to tree, across different species. The publicity eventually helped Suzanne secure a position at the University of British Columbia. The summer that she and her family – Don and their two young daughters, Hannah and Nava – made the move, Suzanne learned that Canadian policymakers had made a major change. They would reduce the amount of herbicides being sprayed in the forests by 50 percent. It was her research, in large part, that inspired the change.

The Mother Tree

The sun beat down on Suzanne as she checked the time. It was still a couple of hours

until 4:00 p.m. She'd have to leave by then if she wanted to be home by midnight. Don hadn't taken well to life in Vancouver, so the family had moved to the much smaller city of Nelson, British Columbia, which was nearer to Suzanne's family. Suzanne would continue teaching in Vancouver, however – which meant a nine-hour commute home every weekend. Suddenly, a swarm of wasps emerged from a nearby hole. One of them jabbed a stinger into her, and a welt immediately began to form. Fleeing the wasps, Suzanne raced up a crest. At the top, she leaned against an old tree perched at the edge of the forest. Its branches stretched 25 meters into the air. All around its northern side lay young seedlings. When Suzanne uprooted one of them, she saw thin fungal threads hanging off of its root tips. The sight was intoxicating – material proof that the tiny seedlings were linked to the mature tree nearby. In the dry summer days, the deep-rooted old trees would draw water from the depths of the soil and lift it to the surface, transferring small amounts to the young, shallow-rooted plants. As she sat, gazing at the crescent of seedlings in front of the tree, a thought occurred to her: the oldest trees were protecting and providing for the younger trees in the forest. They were Mother Trees. Suzanne sketched out a quick drawing in her notepad: a Mother Tree as the central hub in a forest, connected to saplings and seedlings by a fungal network. The pattern that emerged looked almost like a neural network – the web of connections that exists in human brains, in which some nodes are highly connected and others less so. Whoa, she thought. What if the mycorrhizal network were even more like a neural network than that? Could trees communicate their precise thoughts and moods by transferring certain molecules through fungi? She jotted down a few calculations. The relative amounts of carbon and nitrogen transferred through mycorrhizal networks are, she realized, quite similar to the quantities of those molecules that exist in glutamate – the most abundant neurotransmitter in the human brain. Are mycorrhizal networks actually about communicating information? And a step further: Are the networks intelligent, with Mother Trees acting as the central hubs in the vast neural networks of the forest? As she stood up, a surge of gratitude for the Mother Trees coursed through Suzanne, along with a sense of kinship. They had given her the gift of these insights, and she would publish them as soon as she possibly could. At 2:00 a.m., she finally pulled into her family's driveway in Nelson. Exhausted, she still managed to make her way into Hannah's room to kiss her on the forehead. Then she went to her younger daughter Nava's room and snuggled with her under the covers. She squeezed Nava's hand, and Nava squeezed back. Suzanne herself felt like a Mother Tree – central to the lives of her two daughters, just as the large trees were to the smaller trees in the forest.

Parting Gift

Ten years had passed since she'd first accepted the teaching job at the University of British Columbia. The nine-hour commute had chewed away at her marriage; it seemed like she and Don were always quarreling. In the summer of 2012, they decided to separate. Later that year, as Suzanne headed back home to Nelson to help her daughters prepare for school, she drove by a vast expanse of gray, shriveled husks of ponderosa pine trees. They'd been decimated by an infestation of mountain pine beetle. Identifying the area's Mother Tree, bony and dead, Suzanne checked for any surviving seedlings. There were a few two-year-old ponderosas, carrying on their Mother Tree's legacy. But when Suzanne measured the soil water content in the zone, the meter read just 10 percent. How were these seedlings surviving with such little water? Could the Mother Tree, with her dying gasps, have sent her children her last reserves of water, nutrients, and food? She gazed up the slope, noticing the ponderosas that had survived the outbreak among the decimated Douglas firs. Why were those ponderosas doing

well? Could it be because the Douglas firs were connecting and communicating with them, warning them about stresses in the area? With these and other questions running through her head, Suzanne hopped in her car and headed home, absently fingering the lump in her breast she'd recently discovered. Her last mammogram had come up all clear, so she figured it was probably nothing. A few weeks later, data arrived from an experiment that had begun a year earlier. The results had Suzanne immediately rushing to write an email to her colleague, Yuan Yuan. She and Yuan Yuan had been testing fir trees under stress. They found that the firs transferred 50 percent of their total photosynthetic carbon into their roots and mycorrhizas. A further 10 percent of that carbon traveled through the fungal network that it shared with ponderosa pines. After the firs were injured, the ponderosas were able to increase their defense enzyme production – a mere 24 hours later. The discovery was a triumph. But there was worry nagging in Suzanne's mind. She'd had a biopsy taken of the lump in her breast two weeks ago, and she still hadn't heard back from the doctor's office. She was starting to fear the worst: Would she become like one of those dying Mother Trees, giving her last reserves of energy and life to ensure the survival of her children? She took the results from the fir and ponderosa study as a cue. She needed to give her daughters everything she could – all of her love – in case the worst happened. That night, she explained to them what cancer was, how she'd been tested, and how all women needed to be screened at some point. A few days later, the phone rang. It was the doctor's office, calling with bad news: Suzanne had cancer. As the doctor explained what tests she would need and what her options were, she thought, Not even Mother Trees can live forever.

Tree Medicine

Suzanne's cancer treatment required a double mastectomy. After both of her breasts were removed, she'd thought her ordeal would be over. And it would have been – if the cancer hadn't spread to her lymph nodes. But it had. Now, a new round of treatments would begin: eight chemotherapy infusions over four months. The first half would consist of administration of a drug called "Red Devil." The second half would consist of infusions of paclitaxel – a medicine that came from yew trees. She received her first dose of the cherry-colored Red Devil in the middle of winter, as snow fell on the lonely trees she could see out the window. The next day, she skied 20 kilometers; she wasn't about to let cancer make her feel weak. Along the way, she passed a clear-cut. The new pines, she noticed, had grown about a meter since the previous year. She thanked the older trees for their aid to the saplings and then asked for their help. She, too, needed healing. Meanwhile, Suzanne's grad student, Amanda, was working on kin-recognition experiments – testing how Mother Trees interacted with both kin and non-kin seedlings. The results confirmed what they'd already surmised: Mother Trees sent more carbon to the mycorrhizal fungi that belonged to their kin than to non-kin. Moreover, Mother Trees grew bigger when they were next to their children. It was a two-way relationship, like so many in the forest. But Suzanne was finding life difficult to cling to at times. The paclitaxel infusions caused extreme exhaustion, and there were times she felt she wouldn't make it. She was resolved, however, to be there for her daughters' birthdays and graduations. Gradually, Suzanne realized her doctor had been right – the yew medicine was easier to cope with than Red Devil. Soon, she could take walks in the forest again with Mary, her former neighbor – and new girlfriend. Mary always took things slowly, never hesitating to make time for a leisurely cup of creamy coffee. And she cared for the well-being of the forests as much as Suzanne did. One day, she and Mary went to find the yews resting in the shade of cedars and maples. The yews were

short and stout, their bark thick and shaggy. Suzanne found the Mother Tree, with her rows of dark green and gray needles, and tugged on the bark. Below it, the tree's flesh was purple. Finally, Suzanne's yew treatments were finished. She brought Hannah and Nava to that same grove, to visit the Mother Tree. "These are the yews that made my medicine," she told them. They hugged the gnarled tree trunks, all together, as she silently whispered her wish: May the trees watch over her daughters – all daughters – just as they'd watched over her.

Final summary

The key message in these blinks: After recovering from cancer, Suzanne began a landmark experiment she called the Mother Tree Project, which examines the structures and functions of nine different forests across British Columbia. Its goal is to determine how different webs of relationships operate within each forest, and how those relationships are affected when Mother Trees are retained. Along with ensuring that the forests remain regenerative, another important aspect of the project is to advance the emergent philosophy of complexity science. It emphasizes taking into account the multifaceted nature of the relationships that play out within the forest – and using that knowledge to improve forestry practices. Currently, Suzanne is also exploring the question of whether nitrogen from the decayed corpses of salmon is transferred into mycorrhizal fungi, from there to Mother Trees, and then from there to other trees deeper in the forest – a potentially massive web of connections. No matter the answer to that particular line of inquiry, one thing is clear: the ecosystem is not something scientists can easily separate and shove under a microscope. It is instead a unified, connected organism, a tapestry of reciprocity. For so long, foresters and others have seen the forest as a place of competition – of winner-takes-all. But diversity, regeneration, and complexity are the true values of the forest. Got feedback? We'd love to hear what you think about our content! Just drop an email to with Finding the Mother Tree as the subject line, and share your thoughts!