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FEATURE

Can Genetic Engineering Bring Back the American Chestnut?

The tree helped build industrial America before disease wiped out an estimated three billion or more of them. To revive their lost glory, we may need to embrace tinkering with nature.

By Gabriel Popkin

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Sometime in 1989, Herbert Darling got a call: A hunter told him he had come across a tall, straight American chestnut tree on Darling's property in Western New York's Zoar Valley. Darling knew that chestnuts were once among the area's most important trees. He also knew that a deadly fungus had all but wiped out the species more than a half-century earlier. When he heard the hunter's report of having seen a living chestnut whose trunk was two feet thick and rose to the height of a five-story building, he was skeptical. "I wasn't sure I believed he knew what one was," Darling says.

When Darling found the tree, it was like beholding a mythical creature. "To be so straight and perfect a specimen — it was just outstanding," he says. But Darling also saw that the tree was dying. It had been struck by the same blight that had, starting in the early 1900s, killed an estimated three billion or more of its kind, modern history's first major tree-destroying disease spread by man. If he couldn't save the tree, Darling figured, he would at least save its seeds. There was just one problem: The tree wasn't making any, because there were no other chestnut trees nearby to pollinate it.

Darling was an engineer, with an engineer's approach to solving problems. The following June, when light yellow blossoms spread over the tree's green canopy, Darling filled shotgun shells with pollen taken from the male flowers of another chestnut tree he had learned about, growing an hour and a half's drive to the north. He fired the rounds at his tree from a rented helicopter. (He ran a successful construction business and could afford the extravagance.) The effort failed. The year after that, Darling tried again. This time, he and his son hauled scaffolding up to the chestnut, at the top of a hill, and, over two weeks, pieced together an 80-foot-tall platform. Climbing to the tree's canopy, Darling brushed its blooms with worm-shaped blossoms taken from the other chestnut.

That fall, the branches of Darling's tree produced burrs covered in green spines so thick and sharp they could have been mistaken for cactuses. The harvest was modest, about 100 nuts, but Darling planted some of them and hoped. He and a friend also contacted two tree geneticists, Charles Maynard and William Powell — they go by Chuck and Bill — at the State University of New York College of Environmental Science and Forestry, in Syracuse. They had recently started a low-budget chestnut-research program there. Darling gave them some of his chestnuts and asked if the scientists could use them to bring back the species. "It seemed like something that would be fantastic to do," Darling says. "Something for the entire eastern part of the nation." A few years later, however, his own tree was dead.

Since Europeans began settling in North America, the story of the continent's forests has largely been one of loss. But Darling's offering gave rise to what many now regard as one of the most promising chances to begin revising that story — an effort that was given a lift earlier this year when the Templeton World Charity Foundation awarded Maynard and Powell's project, for most of its history a shoestring operation, more than $3 million, the largest single gift ever to their college. The geneticists' research forces conservationists to confront, in a new and sometimes discomfiting way, the prospect that repairing the natural world does not necessarily mean returning to an unblemished Eden. It may instead mean embracing a role that we've already assumed: engineers of everything, including nature.

Long and toothed, the chestnut leaf looks as if two small green saw blades have been attached back to back at the leaf's central vein. At one end, the two blades join to a stem; at the other end, they form a sharp tip, which often bends jauntily to the side. This unexpected shape cuts through the woods' muted greens and duns, stirring hikers from ambling reveries, reminding them that they move through forests that once held much mightier trees.

We can know those trees in their full glory thanks only to literature and memory. There you encounter chestnuts so abundant that in spring, the tree's creamy, threadlike flowers "like foaming waves rolled down the mountainsides," as Lucille Griffin, executive director of the American Chestnut Cooperators' Foundation, once wrote, channeling her grandfather's recollections. In fall, the tree would erupt again, this time in spiny burrs sheltering sweetness. "When chestnuts were ripe I laid up half a bushel for winter," an exuberant Thoreau writes in "Walden." "It was very exciting at that season to roam the then boundless chestnut woods of Lincoln."

Chestnuts were reliable. Unlike oaks, which drop acorns only during some years, chestnut trees produce a huge nut crop every fall. Chestnuts are also digestible: You can peel the skin off and eat one raw. (Try that with a tannin-laden acorn — or rather, don't.) Everything and everybody ate chestnuts: deer, squirrels, bears, birds, humans. Farmers loosed their hogs to fatten in the forest. Train cars loaded high with chestnuts rolled from the mountains to the cities around Christmastime, and yes, they really were roasted over open fires. "It is claimed that in certain districts the farmers realize more income from the sale of chestnuts than from all other farm products," William L. Bray, the first dean of the school where Maynard and Powell would later work, wrote in 1915. It was the people's tree, growing mostly wild in the forest.

It also supplied more than just food. Chestnut trees could rise to 120 feet, with as much as the first 50 feet uninterrupted by branches or knots — a lumberman's dream. While neither the most beautiful nor the strongest wood, it grew fast, especially when resprouting after being cut, and did not rot. As railroad ties and telephone poles, where durability trumped aesthetics, chestnut helped build industrial America. Thousands of barns, cabins and churches made of chestnut still stand; one author in 1915 estimated that it was America's single-most-cut tree species.

In much of the East — the tree's range extended from Mississippi to Maine, from the Atlantic Coast to the Mississippi River — the chestnut was a tree among others. But in the Appalachians, it was a tree apart. Billions of chestnuts lived on these mountains.

It's perhaps fitting that the blight first showed up in New York, the portal through which so much of the outside world has arrived in America. In 1904 a strange infection was discovered on the bark of dying chestnut trees in the Bronx Zoo. Researchers quickly determined that the blight-causing fungus, later named Cryphonectria parasitica, arrived on imported Japanese trees, as early as 1876. (There is often a time lag between when a species is introduced and when it becomes a noticeable problem.)

Soon, people in several states reported dying trees. In 1906, William A. Murrill, a mycologist at the New York Botanical Garden, published the first scientific article on the blight. The fungus, Murrill noted, causes blistery yellowish-brown infections on chestnut bark, eventually eating its way clean around the trunk. When nutrients and water can no longer flow up and down the tree's vasculature, which occupies a thin layer just below the bark, everything above the ring of death dies.

Some couldn't imagine — or didn't want others to imagine — a tree disappearing from the forest. In 1911, a Pennsylvania nursery company, the Sober Paragon Chestnut Farm, dismissed the blight as "little more than a 'scare." perpetuated by irresponsible journalists. The farm was out of business by 1913. Two years earlier, Pennsylvania had convened a chestnut-blight commission, authorized the spending of $275,000 — a vast sum at the time — and declared blanket authority to take steps to battle the affliction, which included the right to destroy trees on private property. Pathologists proposed removing all chestnut trees in a several-mile-wide swath ahead of the main infection front, to create a kind of firebreak. But the fungus proved able to leap ahead to uninfected trees, its spores borne by wind, birds, insects and people, and the plan was abandoned.

By 1940, virtually no large chestnuts were uninfected. Billions of today's dollars in value had been wiped out. Because the blight cannot survive in the soil, chestnut roots continue to send up sprouts — more than 400 million of them may still persist in the forest understory. The blight found a reservoir in oaks, however, where it lives while doing little apparent damage to its host. From there, it spreads quickly to new chestnut sprouts and knocks them back to the ground, typically long before they reach the flowering stage.

The timber industry found alternatives: oak, pine, walnut, ash. Tanning, the other major industry that relied on the chestnut tree, switched to synthetic tanning agents. For many poor farmers, there was nothing to switch to: No other native tree offered a free, dependable and abundant source of calories and protein for farmers and their animals. The chestnut blight arguably ended Appalachian subsistence farming as a common practice, forcing upon a region's worth of people a stark choice: Go into the coal mines, or move away. "With the death of the chestnut," the historian Donald Davis wrote in 2005, "an entire world did die, eliminating subsistence practices that had been viable in the Appalachian Mountains for more than four centuries."

Herb Darling met the American chestnut in his woods. Bill Powell met the tree in his lab.

Powell grew up far from the Appalachians and chestnuts. His father was in the Air Force and moved the family around: Indiana, Florida, Germany, Maryland's Eastern Shore. Despite a career spent in New York, his speech retains a Midwestern straightforwardness and a subtle but discernible Southern lilt. His unassuming manner is complemented by an unfussy sartorial style featuring jeans matched with a seemingly endless rotation of plaid shirts. His favorite interjection seems to be "wow."

Bill Powell, a State University of New York scientist, holding genetically modified American chestnut tree plantlets. Shane Lavalette for The New York Times

Powell planned to become a veterinarian until a genetics professor turned him on to the promise of a new, greener kind of agriculture based on genetically modified plants that could produce their own defenses against insects and disease. “I thought, Wow, wouldn’t it be great to make plants that could protect themselves against pests, and you wouldn't have to spray any pesticides on them?" Powell says. "Of course, the rest of the world didn't follow the same kind of thinking."

The American chestnut wasn't on Powell's mind when he arrived for graduate school at Utah State University in 1983. But he happened to join the lab of a biologist who was studying a virus that can debilitate the blight fungus. Their attempt to take advantage of the virus did not go particularly well: It did not spread from tree to tree on its own, and it had to be tailored to dozens of individual fungal types. Nevertheless, Powell was captivated by the story of a great tree brought low, and by the possibility of a scientific fix for a tragic human error. "Because of our mismanagement of moving things around the world, we imported a pathogen by accident," he says. "I thought: Wow, this is fascinating. There's a chance to bring it back."

Powell's wasn't the first attempt to undo the damage. After it became apparent that the American chestnut was doomed, the U.S. Department of Agriculture tried planting Chinese chestnut trees, a more blight-tolerant cousin, to see if the species could take the American chestnut's place. But Chinese chestnuts grow outward as much as up, more like orchard trees than timber trees. They were dwarfed in the forest by oaks and other American giants; their growth was stunted, or they simply died. Scientists also tried breeding American and Chinese chestnuts together, hoping to produce a tree with the positive traits of both. The government's effort failed and was abandoned.

Powell eventually took a job at SUNY College of Environmental Science and Forestry, where he met Chuck Maynard, a geneticist growing trees in the lab. Just a few years earlier, scientists had created the first genetically modified plant tissue — adding a gene to tobacco that conferred antibiotic resistance, for purposes of technological demonstration rather than any commercial use. Maynard had started dabbling in the new techniques, while looking for something useful to do with them. That's when Darling showed up with some seeds and a challenge: Fix the American chestnut.

In traditional plant breeding, as practiced for thousands of years, farmers (and more recently, scientists) cross varieties with desired traits; nature then mixes the genes, and people select promising mixtures for sought-after qualities — bigger, tastier fruit, or disease resistance. Typically, multiple generations are needed to yield a commercial product; the process is slow and somewhat disorderly. Darling doubted such methods would ever produce a tree as good as his wild one. "I thought we could do something better," he told me.

Genetic engineering means far more control: Specific genes can be selected for particular purposes, even if they come from unrelated species, and inserted into another organism's genome. (An organism with a gene from a different species is "transgenic." More recently, scientists have developed techniques for editing a target organism's genome directly.) The technology promised both unprecedented precision and speed. It seemed perfectly suited, Powell thought, for the American chestnut, which he calls "almost the perfect tree" — strong, tall, an abundant food source and needing only one, very specific correction: blight resistance.

Darling agreed. "We have to have engineers for everything we do" in business, he says. "It was just sort of automatic to go from construction to this."

Powell and Maynard estimated that it would take a decade to find a resistance-conferring gene, develop techniques to add it to the chestnut's genome and then get the tree to grow. "We just took a guess," Powell says. "No one had any genes that conferred resistance to a fungus. We were really starting with a blank slate."

Darling sought support from the American Chestnut Foundation, a nonprofit started in the early 1980s. Its leaders told him to get lost, basically. They were committed to crossbreeding and were wary of genetic engineering, which was already attracting opposition from environmental activists. So Darling created his own nonprofit to fund the genetic engineering work. That organization wrote its first check to Maynard and Powell, for $30,000, Powell says. (In 1990, the national organization reversed itself and accepted Darling's splinter group as its first state chapter, but some members remained skeptical or outright hostile toward genetic engineering.)

Maynard and Powell went to work. Almost immediately, their estimated timeline proved unrealistic. The first hurdle was figuring out how to grow chestnuts in the lab. Maynard tried mixing pieces of chestnut leaf with growth hormones in round, shallow plastic petri dishes, a method used to grow poplar trees. It proved impractical. Nor would new trees grow from specialized cells that develop into roots and shoots. "I'm the world's leading authority on how to kill chestnut trees," Maynard says. A University of Georgia researcher, Scott Merkle, eventually taught Maynard how to grow chestnuts from embryos, the next developmental stage after pollination.

Finding the right gene — Powell's job — also proved challenging. He spent several years studying an antimicrobial compound based on a frog gene but abandoned it over fears that the public might not accept a tree imbued with frogginess. He also looked for a blight-resistance gene in the Chinese chestnut, only to discover that numerous genes are involved in protecting the tree (at least six that they identified). Then, in 1997, a colleague returned from a scientific meeting with a listing of abstracts and presentations. Powell noticed one titled "Expression of Oxalate Oxidase in Transgenic Plants Provides Resistance to Oxalic Acid and Oxalate-Producing Fungi." From his virus research, Powell knew that the blight fungus exudes oxalic acid to kill chestnut bark and make it digestible. If the chestnut could produce its own oxalate oxidase, a specialized protein that breaks down oxalic acid, it might be able to defend itself, Powell realized. “That,” he says, “was my eureka moment.”

Many plants, it turns out, have a gene that allows them to produce oxalate oxidase. From the researcher who gave the talk, Powell got its wheat variant. A graduate student, Linda Polin McGuigan, refined a “gene gun” technique that fired the gene into chestnut embryos, hoping it would slot into the embryonic DNA. The gene lodged in the embryos temporarily, but then vanished. The team abandoned that approach and turned to a bacterium that long ago evolved a way to snip other organisms’ DNA and insert its genes. In nature, the microbe adds genes that force the host to make bacterial food; geneticists had hacked the bacterium so that it would insert any gene a scientist wanted. McGuigan got it to reliably add to chestnut embryos both the wheat gene and a marker protein that, when illuminated under a microscope, produces green light as a sign that the insertion has succeeded. (The team quickly stopped using the marker protein — nobody wants a tree that can glow.) Maynard calls the method “the most elegant thing in the world.”

Over time, Maynard and Powell built a chestnut assembly line that now stretches over several floors of an imposing, late-1960s brick-and-concrete forestry research building, as well as into a gleaming new off-campus “Biotech Accelerator” facility. The process begins with the selection of embryos that bud from genetically identical cells (most lab-created embryos don’t do this, and so are useless for creating clones) and inserting the wheat gene. The embryos, which resemble tiny clusters of pale, translucent grapes, live in agar, a puddinglike substance derived from algae, in petri dishes. To turn the embryos into trees, the researchers add growth hormones. A rack of shelves under intense fluorescent bulbs holds hundreds of cube-shaped plastic containers with miniature, rootless chestnut trees. Eventually the scientists apply rooting hormones, plant their proto-trees in pots with soil and place them in temperature-controlled growth chambers. Lab-coddled trees, unsurprisingly, fare poorly outdoors. So the researchers mate them with trees from the wild to produce hardier but still blight-resistant specimens for field testing.

Two summers ago, Hannah Pilkey, a graduate student in Powell’s lab, showed me how that is done. She had grown a culture of the blight-causing fungus in a small plastic petri dish. In this contained form, the light-orange pathogen seemed benign, almost beautiful. It was hard to imagine it as an agent of mass death and destruction.

Pilkey knelt on the ground, marked a five-millimeter segment of a tiny sapling, made three precise incisions with a scalpel and dabbed a blob of blight onto the wounds. She sealed them with a piece of plastic film. “Just like a Band-Aid,” she said. Because this was a nonresistant “control” tree, she expected an orange infection to spread swiftly from the inoculation site and eventually encircle the small stem. She showed me trees containing the wheat gene that she had treated earlier. The infection was limited to the incision, like thin orange lips closed around a tiny mouth.

In 2013, Maynard and Powell announced their success in the journal Transgenic Research: 109 years after the American chestnut blight was discovered, they had created a version of the tree that appeared to defend itself, even when hit with a huge dose of blight fungus. To honor their first and most generous benefactor, who has poured an estimated $250,000 into the effort, the researchers had been naming their trees after him. This one was called Darling 58.

The annual meeting of the American Chestnut Foundation's New York chapter got underway in a modest hotel outside New Paltz one drizzly Saturday morning in October 2018. About 50 people had gathered for what turned out to be part scientific conference and part chestnut swap meet. At the back of a small conference room, members exchanged Ziploc bags full of nuts. The meeting was the first in 28 years not attended by Darling or Maynard; health problems kept both of them away. "We've been doing this so long, almost every year we have a moment of silence for people who've passed away," Allen Nichols, the chapter's president, told me. Still, the mood was upbeat: The transgenic tree had passed years of painstaking safety and efficacy tests.

Chapter members gave detailed updates on the status of what seemed like every large chestnut tree living in New York State. Pilkey and other graduate students presented research on how to collect and store pollen, how to grow chestnuts indoors under lights, how to pack mud onto blight infections to prolong a tree's life. Chestnuteers, many of whom pollinate and tend their own trees, peppered the young scientists with questions.

Powell took the floor, wearing what seemed to be the chapter's unofficial uniform: collared shirt tucked into jeans. His single-minded pursuit — a career of three decades organized around Herb Darling's goal of bringing back the chestnut — is rare among academic scientists, who more often do research on five-year grant cycles and then hand off promising results to others for commercialization. "He's very focused, very disciplined," Don Leopold, Powell's colleague at Environmental Science and Forestry, told me. "He has blinders on. He's not distracted by so much other stuff." When the research finally made progress, and SUNY administrators approached him about patenting his tree so the university could profit from it, Powell refused. The transgenic tree, like the original chestnut, was for the people, he said. Here, in this room, were Powell's people.

But he had a warning for them: With most of the technical obstacles overcome, the transgenic tree now faces perhaps its biggest challenge: the U.S. government. A few weeks earlier, Powell had submitted a nearly 3,000-page dossier to the Animal and Plant Health

Inspection Service, the U.S.D.A. branch responsible for approving genetically modified plants. That started the approval process for the agency: to review the application, seek public comment, produce an environmental-impact statement, ask for public comment again and issue a decision. The undertaking could take years. If the decision is no, the project could grind to a halt. (The first public-comment period has yet to open.)

The researchers planned to file additional petitions with the Food and Drug Administration, so it can examine the food safety of the transgenic nuts, and the Environmental Protection Agency, which will review the tree's environmental impact under federal pesticide law, something required for all genetically modified organisms. "This is more complicated than science!" someone in the audience said.

"It is," Powell agreed. "Science is fun. This is frustrating." ("Being regulated by three different agencies is kind of overkill," he told me later. "That really stifles innovation in environmental conservation.")

To show their tree is safe, Powell's team conducted various tests. They fed bees pollen laced with oxalate oxidase. They measured the growth of beneficial fungi in the soil. They left leaves in water and investigated their impact on tadpoles. No adverse effects were seen in any of the studies — and the tadpoles actually did slightly better on the transgenic diet than on leaves of some of the unmodified trees. The scientists sent nuts to Oak Ridge National Laboratory in Tennessee and other labs for analysis, and no differences from nuts produced by unmodified trees were detected.

Such results may reassure regulators. They will almost certainly not placate activists who oppose genetically modified organisms. John Dougherty, a retired Monsanto scientist who is consulting for Powell on a pro bono basis, calls these opponents the "antis." Environmental groups have for decades warned about unintended consequences of moving genes between distantly related species — the creation of "superweeds" that outcompete native plants, for example, or the possibility that introducing foreign genes could lead to harmful mutations in host species' DNA. They also fear companies using genetic engineering to patent and exert control over living things.

At the moment, Powell says he receives no money directly from industry sources, and he insists that donations to his lab come with "no strings attached." But Brenda Jo McManama, an organizer with a group called the Indigenous Environmental Network, points to a 2010 agreement in which Monsanto licensed two gene-modifying patents to the New York chapter of the chestnut foundation and its collaborating institutions. (Powell says that industry contributions, including from Monsanto, have amounted to less than 4 percent of his work's total funding.) McManama suspects Monsanto (acquired by Bayer in 2018) surreptitiously seeks to patent future iterations of the tree by supporting what appears to be an altruistic project. "Monsanto is evil," she says flatly.

Powell says the patents in the 2010 agreement have since expired, and by publishing the details of his tree in the scientific literature, he has ensured it can't be patented. But he realizes that will not allay all concerns. "I know some people are going to say, You're just a Monsanto shill," he says. "What can you do? You can't help that."

About five years ago, leaders at the American Chestnut Foundation concluded that they couldn't achieve their goals through crossbreeding alone and embraced Powell's genetic-engineering program. That decision has caused some rifts. In March 2019, Lois Breault-Melican, the president of the Massachusetts-Rhode Island chapter of the foundation, resigned, citing arguments made by the Global Justice Ecology Project, an anti-genetic-engineering organization based in Buffalo; her husband, Denis Melican, also left the board. The couple is particularly concerned that Powell's chestnut could prove to be a "Trojan horse" that clears the way for other commercially grown trees supercharged by genetic engineering, Denis told me.

Susan Offutt, an agricultural economist who served as chair of a National Academies of Science, Engineering and Medicine committee that produced a 2018 study of biotechnology in forests, noted that the government's regulatory process focuses on narrow questions of biological risk and almost never accounts for broader societal concerns like those raised by anti-G.M.O. activists. "What about the intrinsic value of the forest?" she asks, as an example of a question the process does not address. "Do forests have their own merit? Do we have a moral obligation to take that into account when we make decisions about intervening?"

Most scientists I spoke with see little reason to fear Powell's tree, given the profound disruptions forests have already endured: logging, mining, development and a relentless influx of tree-destroying insects and diseases, among which chestnut blight has proved to be a kind of opening act. "We're introducing new whole organisms all the time," says Gary Lovett, a forest ecologist at the Cary Institute of Ecosystem Studies in Millbrook, N.Y. The transgenic chestnut "would have less of an impact than that."

Donald Waller, a forest ecologist recently retired from the University of Wisconsin-Madison, goes further. "I sketched out a little balance with risks on one side and rewards on the other, and I just kept scratching my head over the risks" that this transgenic tree could pose to the forest, he told me. By contrast, "the side of the page under the rewards is just spilling over with ink." A blight-resistant chestnut would finally notch a victory for the embattled forest, he says. "People need hope. People need symbols."

Powell tends to be unflappable, but skeptics of genetic engineering can fluster him. “They don’t make sense to me,” he says. “They don’t base anything on science.” Nobody complains when engineers produce better cars, or smartphones, so he wants to know what’s wrong with engineering a better tree. “It’s a tool that can help,” Powell says. “Why say, Well, we can’t use that tool? We can use a Phillips screwdriver, but we can’t use a common screwdriver, or vice versa?”

In early October 2018, I accompanied Powell to a modest field station south of Syracuse where he hopes the future of the American chestnut species is growing. The site — one of just a handful where the tree is allowed to grow — was nearly deserted. Tall plantations of pine and larch trees, products of long-abandoned research projects, leaned to the east, away from the prevailing wind, giving the area a slightly eerie feel.

Andrew Newhouse, a researcher in Powell’s lab, was already working at one of the scientists’ best trees, a wild chestnut from southern Virginia. The tree, roughly 25 feet tall, grows in a small, haphazardly arranged chestnut orchard enclosed by a 10-foot-high deer fence. Bags had been tied around the ends of some of the tree’s branches. Inner plastic bags trapped Darling 58 pollen the scientists applied in June, Newhouse explained, while outer metal mesh bags kept squirrels away from the developing burrs. The entire setup was under strict U.S.D.A. oversight; until the tree is deregulated, pollen or nuts from trees with the added gene must be quarantined inside the fences or in the researchers’ labs.

Newhouse maneuvered an extendable pole pruner around a branch; with a pull of a string, the blade snapped shut, and the bag fell. Newhouse moved quickly to the next bagged branch and repeated the procedure. Powell gathered the fallen bags and put them in a large plastic garbage bag, as if handling biohazardous material.

Back at the lab, Newhouse and Hannah Pilkey emptied the bags and quickly extracted the brown nuts from the green burrs. They took care not to get spines in their skin, an occupational hazard of chestnut research. In the past, they doted over every precious transgenic nut; this time, they finally had an abundance: more than 1,000. “We’re all doing little happy dances,” Pilkey said.

Later that afternoon, Powell took some chestnuts down the hall to Neil Patterson’s office. It was Indigenous Peoples’ Day (Columbus Day), and Patterson, the assistant director of E.S.F.’s Center for Native Peoples and the Environment, had just returned from the campus quad, where he led a native-foods demonstration. His two children and niece played on his office computer. Everyone peeled and ate a nut. “They’re still a bit green,” Powell said regretfully.

Powell's gift was multipurposed. He was disbursing seeds, hoping to use Patterson's networks to get chestnuts planted in new areas, where, in a few years, they could receive transgenic pollen. He was also engaged in a deft bit of chestnut diplomacy.

When Patterson was hired at E.S.F. in 2014, he learned that Powell was test-planting genetically engineered trees a few miles from the Onondaga Nation Resident Territory, which comprises a few mostly forested square miles south of Syracuse. If the project were to succeed, Patterson realized, the blight-resisting gene would eventually enter the land and potentially crossbreed with the remnant chestnuts there, altering a forest that was central to Onondaga identity. He also heard about fears that were driving activists, including some from Indigenous communities, to oppose transgenic organisms elsewhere. In 2015, the Yurok Tribe, for example, banned G.M.O.s from its reservation, in Northern California, because of worries about the potential for contamination in its crops and salmon fisheries.

"I realized, we had this happening here; we should at least have a dialogue," Patterson told me. At a 2015 Environmental Protection Agency meeting held at E.S.F., Powell delivered his well-rehearsed presentation to members of New York-based Native nations. When the speeches ended, Patterson recalls, several leaders said, "We should plant trees!" Their enthusiasm surprised Patterson. "I did not expect that," he says.

Later conversations revealed, however, that few of them actually remembered the role that the chestnut tree played in their traditional culture. Patterson's subsequent research taught him that the blight arrived just as the U.S. government was carrying out an extensive forced-resettlement-and-assimilation program, at a time of societal upheaval coinciding with ecological disruption. Like so much else, the Native chestnut culture of the area was lost. Patterson also found that opinions about genetic engineering varied widely. An Onondaga lacrosse-stick maker, Alfie Jacques, longed to make sticks from chestnut wood and supported the project. Others felt the risk was too great and opposed the trees.

Patterson understands both positions. "It's like cellphones and my kids," he told me recently, noting that his children were home from school because of the coronavirus pandemic. "One day I'm all for it; it's keeping them connected and they're learning. The next day, it's like, Let's get rid of those things." But the multiyear dialogue with Powell has softened his skepticism. Not long ago he learned that on average half the offspring of the Darling 58 trees will not have the introduced gene, meaning the original wild chestnut will also continue to grow in the forest. This tempers one major concern, Patterson said.

During our October visit, he told me that what held him back from fully supporting the transgenic program was not knowing whether Powell cared about people who would interact with the tree, or just about the tree. "I don't know what's in here for him," Patterson said, tapping his chest. Only if the relationship between people and chestnuts could be restored, he said, was it worth bringing back the tree.

To that end, he said he planned to use the nuts Powell gave him to make chestnut pudding and oil. He would take the dishes to the Onondaga territory and invite people to rediscover their ancient flavors. “Hopefully,” he said, “it will be like greeting an old friend. You just pick up right where you left off.”

The $3.2 million gift from the Templeton World Charity Foundation in January should keep Powell going as he navigates the regulatory bureaucracy and expands his focus from genetics to actual restoration across the landscape. If the government gives its blessing to his tree, Powell and American Chestnut Foundation scientists will begin allowing it to flower openly. The pollen, with its extra gene, would blow — or be brushed — onto the waiting receptacles of other trees, and transgenic chestnut destiny would unfold independently of controlled experimental settings. Assuming the gene holds up in the field as well as it does in the lab, which is no certainty, it will spread outward through the forest — an ecological point of no return that scientists long for and activists dread.

Once there’s a deregulated chestnut tree, will you be able to buy one? Yes, Newhouse says, that’s the plan. Already, the researchers are asked every week when trees will be available.

In the world that Powell, Newhouse and their colleagues inhabit, it’s easy to feel as if the entire country is waiting for their tree. But a short drive north from the research farm, through gritty downtown Syracuse, is a reminder of how profoundly both the environment and society have transformed since the American chestnut disappeared. Chestnut Heights Drive, in a town just north of Syracuse, is an unremarkable residential street with wide driveways, neat lawns and the occasional small ornamental tree dotting front yards. Timber companies are not asking for a revived chestnut. The subsistence-farming economy that was built on chestnuts is entirely gone. Almost no one has experience extracting the soft, sweet nut from the imposing burr. Most people are probably not even aware that anything is missing from the forest.

I stopped to eat a picnic dinner by Onondaga Lake, in the shade of a large white ash tree. The tree was infested by emerald ash borers; I could see the holes the insects made in the bark. It was starting to lose leaves and would probably, in a few years, die and crumble. Just to get here from my home in Maryland, I had driven past thousands of dead ash trees, bare pitchfork-shaped branches rising beside the road.

In Appalachia, companies have scraped the trees from an area larger than Delaware, to gain access to the coal beneath. The heart of coal country happens to overlap the heart of what was once chestnut country. The American Chestnut Foundation has partnered with organizations that plant trees on abandoned coal mines, and chestnuts are now growing on thousands of acres of these devastated places. Those trees are only partly blight-resistant hybrids, but they could become the parents of a new generation of trees that will someday rival the forest giants of old.

Last May, the concentration of carbon dioxide in the atmosphere hit, for the first time in human history, 414.8 parts per million. The nonwater weight of the American chestnut, like other trees, is roughly half carbon. Few things you could plant on a piece of land would suck carbon out of the air faster than a growing chestnut tree. With this in mind, an essay last year in The Wall Street Journal suggested, “Let’s farm chestnuts again.”

The new chestnut will be birthed into an old, broken world. It will have its work cut out for it.