7

Black Gold

NO BIRDS OR INSECTS

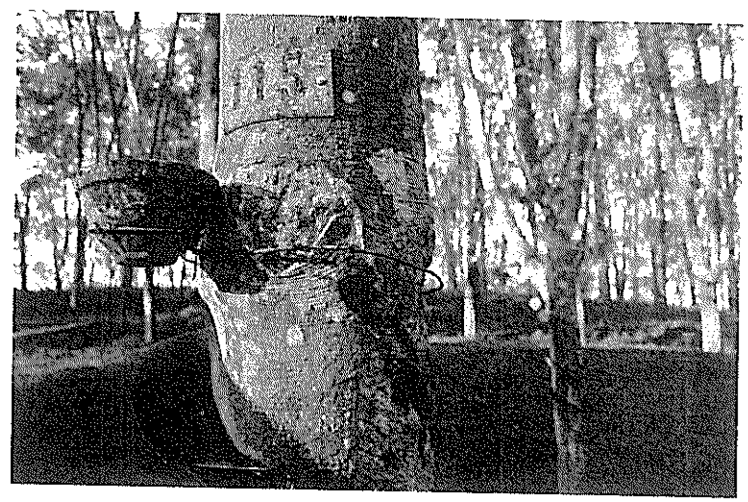
It looked like a forest but ecologists probably wouldn't call it one. It sprawled over miles of low hills outside the village of Longyin Le, at the southern tip of China, less than forty miles from the border with Laos. Prosperous by the standards of rural China, Longyin Le had houses with curtained windows and painted walls. Solar hot-water heaters and satellite dishes sprouted from the roofs on the houses beside the road. At the edge of the village the cab drove past barns and animal pens and then I was among the trees.

They were perhaps fifty feet tall and graceful to my eye, with mottled gray-green limbs and leaves that were pale on one side and glossy dark green on the other. All were of one species and all were the same age—forty-five years old, I had been told, give or take a year. That was when the government put them in the ground. With impressive thoroughness every other plant species that grew higher than my ankles had been cleared away. The effect was park-like, except that the trees, planted in rows about eight feet apart, created an almost unbroken canopy overhead. Spiraling down each trunk was a shallow incision the width of

a knife blade. Stuck to the lower edge of the incision, following it down the tree, was a flexible plastic strip perhaps three inches wide. At the bottom of each spiral was a small ceramic bowl or a place to mount one.

The trees were *Hevea brasiliensis*, the Pará rubber tree. Villagers in Longyin Le had cut the bark and attached the strips as guides. A milky, sap-like goo—*latex*, from the Latin for "liquid"—emerged from the fissure and slowly dripped along the strip until it ran into the bowl. Depending on the tree and season, latex is as much as 90 percent water. Some of the remainder consists of tiny grains of natural rubber. At first hearing, "natural rubber" may sound like something sold in pricey New Age boutiques. In fact it is a major industrial product, highly desired by high-tech manufacturers. The natural rubber in *H. brasiliensis* had lifted Longyin Le and scores of neighboring communities from destitution.

After ten or fifteen minutes of driving I left the cab and wandered about. I had come to a slope ridged by low terraces, each bearing a line of rubber trees. Beyond the crest of the slope was



Guide strips for latex and collection cups mark this rubber plantation in Xishuangbanna, China, an autonomous southern area near the Laotian border.

a sharp drop-off, and beyond that were hills, irregular as the wrinkles of a sheet thrown to the floor, their colors fading with distance in the hazy afternoon. Every living thing that I could discern was a rubber tree.

The driver was walking with me. He said he had not been to this area since he was young. The hills had been full of mammals and birds then. All had been replaced by rubber. Even the insects were still. It may have been the quietest forest I had ever walked in. Every now and then there was a quick breath of wind and the leaves rippled like tiny flags, momentarily exposing their satin tops. "There's nothing left," the driver said, visibly upset. "People want to cut and cut and plant and plant—damn them."

More than a century ago, a handful of rubber trees had come to Asia from their home in Brazil. Now the descendants of these trees carpeted sections of the Philippines, Indonesia, Malaysia, Thailand, and this part of China. Across the border *H. brasiliensis* was marching into Laos and Vietnam. A plant that before 1492 had never existed outside of the Amazon basin now dominated Southeast Asian ecosystems. Indeed, rubber reigned over such a wide area that botanists had long warned that a single potato blight–style epidemic could precipitate an ecological calamity—and, just possibly, a global economic breakdown.

In Longyin Le I wandered from house to house, talking to farmers about rubber. To a person they were thankful for the opportunities it provided. Rubber was putting food on the table, paying for children's education, building and repairing roads. Just as the potato played a critical part in helping Europe escape the Malthusian trap (though perhaps only for a time), rubber had helped bring about the Industrial Revolution, the transition from an economy based on manual labor and draft animals to one based on mechanized manufacturing. The people in Longyin Le were its latest beneficiaries. As I looked over the lush miles of birdless trees I could still hear their grateful voices. And rising like vapor were other voices, the countless men and women whose lives, for better and worse, had become entwined with this plant:

hapless slaves, visionary engineers, hungry merchants, obsessed scientists, imperial politicians. This landscape of alien trees was the creation of countless different hands in many places, and it was much older than forty-five.

"GREASE CHEMISTRY"

In May of 1526 Andrea Navagero, the Venetian ambassador to Spain, attended an entertainment in Seville staged for the royal court. Seven years earlier, Hernán Cortés, acting without the authorization of the Spanish throne, had invaded Mexico and toppled the Triple Alliance (Aztec empire). The king and queen had to decide what to do with their millions of new subjects. Some argued that they should be enslaved, because they were naturally inferior; others, that they should be converted to Christianity and made full citizens of Spain. To demonstrate the intelligence, skills, and noble demeanor of the peoples of the Triple Alliance, the antislavery faction of the Spanish church had imported a group of them to Seville. The Indians divided into teams and played a showcase version of the Mesoamerican sport of *ullamaliztli*, which the Venetian ambassador attended.

Navagero was an insatiably curious man who translated poetic and scientific classics, wrote a history of Venice, and performed biological experiments—he created a private botanical garden in 1522, among the first on the continent. He was mesmerized by *ullamaliztli*, which he seems to have thought was a performance akin to a juggling act (team sports had been played in the Roman empire but were then almost unknown in Europe). In *ullamaliztli* two squads vied to drive a ball through hoops on the opposite ends of a field—an early version of soccer, one might say, except that the ball was never supposed to touch the ground and players could hit it only with their hips, chests, and thighs. Dressed in padded breechcloths and wrist protectors like thick fingerless mittens, the players knocked a fist-sized ball back and forth "with so much dexterity that it was marvelous to see," Navagero reported, "sometimes throwing themselves completely on the ground to return the ball, and all of this done with great speed."

As fascinating to Navagero as the ball game was the ball itself. European balls were typically made of leather and stuffed with wool or feathers. These were something different. They "bounded copiously," Navagero said, ricocheting in a headlong way unlike anything he had seen before. The Indian balls, he guessed, were somehow made "from the pith of a wood that was very light." Equally puzzled was Navagero's friend Pietro Martire d'Anghiera, who saw a game at about the same time. When the Indian balls "touch the ground, even though lightly thrown, they spring into the air with the most incredible leaps," d'Anghiera wrote. "I do not understand how these heavy balls are so elastic."

The royal chronicler Gonzalo Fernández de Oviedo y Valdés fared little better. In his *General and Natural History of the Indies* (1535), the first official account of Spain's foray into the Ameri-

Europeans like German artist Christoph Weiditz were fascinated by the native ballplayers who toured Spain in the 1520s—and by the rubber ball, which was unlike anything ever seen in Europe.

cas, he tried to describe bouncing, a term not then in the Spanish language: "These balls jump much more than our hollow balls—by far—because even if they are only let slip from the hand to the ground, they rise much further than they started, and they make a jump, and then another and another, and many more, decreasing in height by itself, like hollow balls but more so." Indians made the strange, springy material of the balls, he wrote, by combining "tree roots and herbs and juices and a combination of things. . . . [A]fter [the mixture] is dried, it becomes rather spongy, not because it has holes or voids like a sponge, but because it becomes lighter, as if it were flabby and rather heavy." Wait a minute, one wants to say: how could something "become lighter" yet be "rather heavy"?

Navagero, d'Anghiera, and Oviedo had a right to be confounded: they were encountering a novel form of matter. The balls were made of rubber. In chemical terms, rubber is an *elastomer*, so named because many elastomers can stretch and bounce. No Europeans had ever seen one before.

To engineers, elastomers are hugely useful. They have tucked rubber and rubber-like substances into every nook and crack of the home and workplace: tapes, insulation, raingear, adhesives, footwear, engine belts and O-rings, medical gloves and hoses, balloons and life preservers, tires on bicycles, automobiles, trucks, and airplanes, and thousands of other products. This didn't happen immediately: careful studies of rubber didn't occur until the 1740s. The first simple laboratory experiments, in 1805, gave little hint that rubber might be useful—although the scientist, John Gough, did discover the fact, key to later understanding, that rubber heats up when stretched.* Only in the 1820s did rubber take off, with the invention of rubber galoshes.

* Gough, blind since birth, demonstrated this by touch: he pulled apart the ends of a wide rubber strip and touched it with "the edges of the lips," which are highly sensitive to heat. He also discovered that rubber shrinks when it is heated up—unlike most other substances, which increase in volume when they get hotter.

Take off for Europeans and Americans, that is; South American Indians had been using rubber for centuries. They milked rubber trees by slashing thin, V-shaped cuts on the trunk; latex dripped from the point of the V into a cup, usually a hollowed-out gourd, mounted on the bark. In a process reminiscent of making taffy, Indians extracted rubber from the latex by slowly boiling and stretching it over an intensely smoky fire of palm nuts. When the rubber was ready, they worked it into stiff pipes, dishes, and other implements. Susanna Hecht, a UCLA geographer who has worked extensively in Amazonia, believes that native people also waterproofed their hats and cloaks by impregnating the cloth with rubber. European colonists in Amazonia were manufacturing rubberized garments by the late eighteenth century, including boots made by dipping foot-shaped molds into bubbling pots of latex. A few pairs of boots made their way to the United States. Cities like Boston, Philadelphia, and Washington, D.C., were built on swamps; their streets were thick with mud and had no sidewalks. Rubber boots there were a big hit.

The epicenter of what became known as "rubber fever" was Salem, Massachusetts, north of Boston. In 1825 a young Salem entrepreneur imported five hundred pairs of rubber shoes from Brazil. Ten years later, the number of imported shoes had grown to more than 400,000, about one for every forty Americans. Villagers in tiny hamlets at the mouth of the Amazon molded thousands of shoes to the dictates of Boston merchants. Garments impregnated with rubber were modern, high-tech, exciting—a perfect urban accessory. People flocked to stores.

The crash was inevitable. The idea of impermeable rubber boots and clothes was more exciting than the fact. Rubber simply didn't work very well. In cold weather, the shoes became brittle; in hot weather, they melted. Boots placed in closets at the end of winter turned into black puddles by fall. The results smelled so bad that people found themselves burying their footgear in the garden. Daniel Webster, the senator and secretary of state, liked to tell the story of how he received a rubber cloak and hat as a

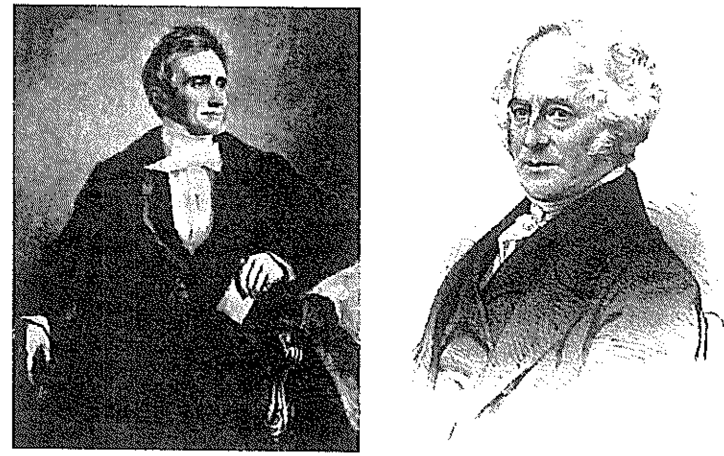
gift. He wore them on a cold evening. By the time he reached his destination the cloak had become so rigid that he stood it in the street by the front door. Supposedly he propped the hat on top. "Some decorous gentlemen among us can also remember," one critic wrote later, "that, in the nocturnal combats of their college days, a flinty India-rubber shoe, in cold weather, was a missive weapon of highly effective character." Returned goods inundated rubber dealers. Public opinion swung violently against rubber.

Just before the collapse, in 1833, a bankrupt businessman named Charles Goodyear became interested in—and obsessed by—rubber. It was typical of Goodyear's entrepreneurial acumen that he began to seek financial backing for a rubber venture just at the time investors were planning their exits from the field. A few weeks after Goodyear announced his intent to produce temperature-stable rubber he was thrown into debtor's prison. In his cell he began work, mashing bits of rubber with a rolling pin. He was untroubled by any knowledge of chemistry but boundlessly determined. For years Goodyear wandered about the northeastern United States in a cloud of penury, trailed by his hungry wife and children, dodging bailiffs and pawning heirlooms. All the while he was mixing toxic chemicals, more or less randomly, in the hope that they would make rubber more stable. The Goodyears lived in an abandoned rubber factory in Staten Island. They lived in an abandoned rubber factory in Massachusetts. They lived in a shack in a Connecticut neighborhood called Sodom Hill (the name indicated its wholesomeness). They lived in a second abandoned rubber factory in Massachusetts. Sometimes the houses had no heat or food. Two of Goodyear's children died.

Taking his cue from a dream told to him by another rubber obsessive, Goodyear began mixing rubber with sulfur. Nothing happened, he said later, until he accidentally dropped a lump of sulfur-treated rubber onto a wood stove. To his amazement, the rubber didn't melt. The surface charred, but the inner material changed into a new kind of rubber that retained its shape and elasticity at high temperatures. Goodyear threw himself into reproducing the accident, a task impeded by his inability to afford any laboratory apparatus—he had to traipse from neighbor to neighbor, asking to use their wood stoves. Sometimes the sulfur process worked, sometimes it didn't. Goodyear kept working, frustrated, hungry, haunted. When he was again thrown into debtor's prison, he wrote to acquaintances from his cell, asking for supplies "to establish an India rubber factory for myself on the spot." Eventually he borrowed money and paid the debt. A month later he was in another jail.

Along the way he befriended a young Englishman. Goodyear gave him a few of his successful samples and asked him to seek investors in Britain. By a circuitous path two thin, inch-and-a-half-long strips of Goodyear's processed rubber ended up in the fall of 1842 at the laboratory of Thomas Hancock, a Manchester engineer who had developed processes for manipulating rubber. Hancock had no idea where these bits of rubber had originated. But he quickly realized that they didn't melt in hot weather or become stiff in cold weather. The question was whether he could duplicate the accomplishment. It is unclear how much he was able to learn from Goodyear's samples. Later he claimed to have "made no analysis of these little bits" from the other man—a remarkable demonstration of incuriosity, if true. In any case Hancock was more organized and knowledgeable than Goodyear and had better equipment. For a year and a half he systematically performed hundreds of small experiments. Eventually he, too, learned that immersing rubber in melted sulfur would transform it into something that would stay stretchy in cold weather and solid in hot weather. Later he called the process "vulcanization," after the Roman god of fire. The British government granted Hancock a patent on May 21, 1844.

Three weeks later, the U.S. government awarded Goodyear *his* vulcanization patent. A glance at the patent shows that Goodyear never fully understood the process: a key ingredient, he claimed, was white lead, a metal-based pigment whose effect



Identifying the inventor of the process of vulcanization, which makes rubber usable for industrial purposes, is complex. Charles Goodyear (left) had the basic idea first, but never fully understood the process; Thomas Hancock (right) patented the process before Goodyear and understood it better, but likely derived inspiration from seeing Goodyear's initial samples.

on rubber's stability is "secondary, if anything," according to E. Bryan Coughlin, of the Silvio O. Conte National Center for Polymer Research at the University of Massachusetts. "I'm not sure, because it's not a standard treatment—maybe it has some catalytic effect." By contrast, Coughlin told me, Hancock's patent was "pretty straightforward." Hancock stirred softened rubber into sulfur heated to 240°–250° F, just above its melting point. The longer he subjected it to heat, the more elasticity it lost. "That's pretty much what I teach my students," Coughlin said.

Goodyear didn't understand the recipe for vulcanization, but he did understand that at last he had a business opportunity. Showing a previously unsuspected knack for publicity stunts, he spent $30,000 he did not have to create an entire room made of rubber for the Great Exhibition of 1851 at the Crystal Palace in London, the first world's fair. Four years later he borrowed $50,000 more to display an even more lavish rubber room at the second world's fair, the Exposition Universelle in Paris. Parisians lost their urban hauteur and gawped like rubes at Goodyear's rubber vanity table, complete with rubber-framed mirror; arranged on the top was a battalion of rubber combs and rubber-handled brushes. In the center of the rubber floor was a hard rubber desk with a rubber inkwell and rubber pens. Rubber umbrellas stood at attention in a rubber umbrella-stand in the corner of two rubber walls, each decorated with paintings on rubber canvases. For weapons fans, there was a stand of knives in rubber sheaths, swords in rubber scabbards, and rifles with rubber stocks. Except for the unpleasant rubber smell, Goodyear's exhibit was a triumph. "Napoleon III invested him with the Legion of Honor," wrote the diplomat and historian Austin Coates, "and a Paris court sent him to prison for debt." He received the medal in his cell. Goodyear was forced to sell some of his wife's possessions to pay for their trip home. He died four years later, still awash in debt.

Afterward, Americans lionized Goodyear as a visionary. Books extolled him to children as an exemplar of the can-do spirit; a major tire company named itself after him. Meanwhile, Coates noted, "Hancock received English treatment: due respect while living, fading notice when dead, and on some suitable centenary thereafter, a postage stamp."

Neither Goodyear nor Hancock had any idea *why* sulfur stabilized rubber—or why, for that matter, unadulterated rubber bounced and stretched. Nineteenth-century scientists found bouncing balls exactly as mystifying as sixteenth-century Spaniards. Stretch a thin hoop of iron: it will elongate slightly, then snap in two. A rubber band, by contrast, can stretch to three times its ordinary length, then return to its original shape. Why? And why did sulfur stop rubber from melting in the summer? "Nobody knew," Coughlin told me. "It was a huge puzzle. And it was made harder by the fact that a lot of chemists didn't really want to study it."

The last half of the nineteenth century was a heady time for

chemistry. Researchers were deciphering the underlying order of the physical world. They were placing the chemical elements into the periodic table, discovering the rules by which atoms combine into molecules, and learning that molecules could form regular crystals with structures that could be precisely identified.

Nowhere in these tidy intellectual schemes was a place for rubber. Chemists couldn't make it form crystals. Worse, many standard chemical tests on rubber produced nonsensical answers. The analyses demonstrated that each rubber molecule was made up of carbon and hydrogen atoms. No problem there. But they also indicated that the carbon and hydrogen were piled up into jumbo-sized molecules made up of tens of thousands of atoms. To most chemists, this was absurd—molecules are the fundamental building blocks of chemical compounds, and no fundamental building block should be that big.

The obvious conclusion, chemists said, is that rubber must be a *colloid:* one or more compounds finely ground up and dispersed throughout other compounds. Glue is a colloid; so are peanut butter, bacon fat, and mud. Because colloids aren't one substance but a mishmash of many different substances, they have no fundamental constituents. Looking for one would be like trying to find the molecular building blocks of a garbage heap. The chemistry of rubber was, one German researcher scoffed, *Schmierenchemie.* Literally, *Schmierenchemie* means "grease chemistry," though Coughlin told me it might be better translated as "the chemistry of the gunk on the bottom of a test tube."

Nonetheless, a few chemists ignored the disdain of their colleagues for rubber, prominent among them Hermann Staudinger, then at the Swiss Federal Institute of Technology in Zurich. A well-known researcher, he had already derived the chemical formulae for the basic flavors in coffee and pepper. (It is not unfair to charge Staudinger with inflicting instant coffee on the world.) Sometime during the First World War, he jumped into the entirely different field of rubber because of an intuitive belief that "high molecular compounds," as he called them, *did* have basic building blocks, which were fantastically large molecules. Readers familiar with stories of successful scientific mavericks will not be surprised to learn that Staudinger attracted vehement opposition, that he kept piling up evidence for his hypothesis, and that the resistance grew irrational and vituperative. When he left Zurich to work at the University of Freiburg in 1925 he was denounced by colleagues during his farewell lecture. Presumably the antagonism was heightened by Staudinger's penchant for picking fights. He once greeted the arrival of a rival's book by gluing a denunciation—"This book is not a scientific work but propaganda"—onto the cover of the copy in his university library. In the end, though, Staudinger's tale reached its denouement in the customary location: Stockholm, where he won the Nobel Prize for Chemistry in 1953.

Rubber and other elastomers, Staudinger showed, have molecules shaped like long chains.* "Long" is an accurate adjective: if a rubber molecule were as thick as a pencil, it would be as long as a football field. "Chain," too, is accurate: all rubber molecules are made up of tens of thousands of identical, repeating links, each consisting of five carbon atoms and eight hydrogen atoms. The molecules of ordinary solid substances—the copper in a wire, say—are usually distributed in orderly arrays. Rubber molecules, by contrast, are higgledy-piggledy, the chains scrambled around each other in no discernible pattern. "The classic analogy is a bowl of spaghetti," Coughlin explained to me. "But the analogy doesn't really work unless you're willing to say the noodles are a hundred yards long." Stretching a rubber band pulls the tangled molecules into alignment, lining them up in parallel like strands of spaghetti in a box. As they unkink, the molecules go from a clumped snarl to their full length, which is why rubber can

* In general, long-molecule substances are called *polymers*. Many types of polymers are familiar: fibers like silk and wool, for instance, and proteins like the gluten in bread or the albumin in egg whites. Elastomers, with their puzzling behavior, are a special type of polymer.

stretch. By contrast, the copper molecules in a wire are *already* lined up in an array, making it much harder for the material to lengthen—the difference is the difference between pulling the end of a loose, tangled string and trying to tug at a fully extended string. (The energy required to pull the chains straight is why rubber heats up when stretched.) As soon as the pressure is relaxed, the rubber molecules begin moving randomly, which naturally ensnarls them again; the rubber shrinks back to its original size.

When a lump of pure rubber is heated up, the rubber chains vibrate and slither around each other every which way and get even more chaotically disordered; the rubber loses whatever shape it has and turns into a puddle. Vulcanization prevents this. Immersing rubber in sulfur causes a chemical reaction in which rubber molecules link themselves together with chemical "bridges" formed of sulfur atoms. So ubiquitous are the bonds that a rubber band—a loop of vulcanized rubber—is actually a single, enormous, cross-linked molecule. With the molecules anchored together, they are more resistant to change: harder to align, harder to entangle, more resistant to extremes of temperature. Rubber suddenly becomes a stable material.

The impact of vulcanization was profound, the inflatable rubber tire—key to the adoption of both the bicycle and the automobile—being the most celebrated example. But rubber also made electrification possible: try to imagine a modern building without insulation on its wiring. Or imagine dishwashers, washing machines, and clothes dryers without the belts that transmit the motion of their engines to the appliance itself. Equally important but less visible, every internal combustion engine contains many pipes and valves that channel, usually under pressure, water, oil, gasoline, and exhaust vapor. Unless the parts are manufactured perfectly, engine vibrations will cause liquids or gases to vent dangerously from the joints. Flexible rubber gaskets, washers, and O-rings almost invisibly fill the gaps. Without them, every home furnace would be at constant risk of leaking natural gas, heating oil, or coal exhaust—a potential death trap.

"Three fundamental materials were required for the Industrial Revolution," Hecht, the UCLA geographer, told me. "Steel, fossil fuels, and rubber." The rapidly industrializing nations of Europe and North America had more than adequate access to steel and fossil fuels. Which made it all the more imperative to secure a supply of rubber.

"THE BATHER IN THE BUBBLY"

In my living room hangs a portrait of either my grandmother's uncle or her great-great-uncle. Both men were named Neville Burgoyne Craig. My grandfather, who found the painting in a thrift shop, thought that the subject was the older Craig (1787–1863), founding editor of the first daily newspaper in Pittsburgh. But the late-nineteenth-century style of the painting suggests that it was the younger Craig (1847–1926), an engineer who took ship for the Amazon a week after his thirty-first birthday. He intended to make his fortune in rubber.

Craig was not planning to work directly with rubber. Instead he intended to help build a railroad to transport it. Then as now the primary source of natural rubber was latex from *Hevea brasiliensis*. Native to the Amazon basin, the tree is most abundant on the borderlands between Brazil and Bolivia. The ports nearest to this area are on the Pacific coast, across the Andes. Sending rubber to those ports would mean carrying it across the high, icy mountains. After doing that, shipping the latex to England would involve dispatching ships around the stormy southern tip of South America, a long and dangerous trip of almost twelve thousand miles. The entire route was so difficult, in fact, that the secretary of the Royal Geographical Society calculated in 1871 that it would be four times faster to ship rubber to London from the western Amazon by transporting it down the Madeira River to the Amazon itself, and thence to the Atlantic. The problem was that waterfalls and violent rapids blocked a 229-mile section of the

lower Madeira. West of this stretch were three thousand miles of navigable river in Bolivia and vast supplies of rubber and other valuable goods; east of it was the wide Amazon, and then the Atlantic. The downstream end of the impassable stretch was the Brazilian hamlet of Santo Antônio. My ancestor went to Santo Antônio to build a railroad around the rapids.

Born in Pittsburgh, Craig took his undergraduate and engineering degrees at Yale. He was a fine student who won two university mathematics prizes and was hired by the U.S. Coast and Geodetic Survey before graduation. Five years later, seeking excitement, he joined P. & T. Collins, a Philadelphia railway-construction firm, which had obtained the contract, secured by the Bolivian government, to build the Madeira railroad. The two Collins brothers seem to have believed that their considerable experience with railroads trumped their utter lack of experience with the Amazon. In January 1878 they sent out two shiploads of eager engineers and laborers from Philadelphia. Craig went in the first vessel.

As he later recounted in a memoir, winter gales plagued the journey to Amazonia. The storms wrecked the second—and, alas, much less seaworthy—ship about one hundred miles south of Jamestown, Virginia. More than eighty people drowned. Com-

Neville B. Craig

pany officers had trouble replacing the lost men—Philadelphians, shocked by the disaster, had lost their enthusiasm for the venture. Eventually Collins hired a new workforce from "the slums of several of our large eastern cities," to quote Craig's book, people "exhibiting in shape, countenance and gesture, striking evidence of the soundness of Darwin's theory." Most were immigrants from southern Italy; many had been pushed out of their homes for their anarchist beliefs. As my ancestor's snarky put-down suggests, anti-Italian prejudice was then widespread; these newly arrived Americans in consequence were desperate for work. The Collins brothers took advantage of their desperation to sign them up for lower wages than they paid the laborers on the first ship—$1.50 per day, instead of $2.00. Apparently it did not occur to the brothers that the anarchists would discover this arrangement, or that they would find it unacceptable.

Meanwhile Craig steamed up the Amazon and the Madeira to the proposed railway terminus at Santo Antônio and set to work surveying the route. He learned of the fate of the men on the second ship only when the Italians arrived as replacements. At the same time the Italians found out that they were being paid less than everyone else. Within days they went on strike. The engineers, Craig among them, constructed a cage from the steel rails for the railway and forced the strikers into it at gunpoint. Reading the memoir, I waited in vain for any recognition from Craig that imprisoning the workforce could have a negative impact on the construction schedule. Ultimately the strikers went back to work, sullenly hacking at the forest. A few weeks later "seventy-five or more" took off for Bolivia. None made it—perhaps, Craig luridly speculated, because they had "served as food to gratify the none too dainty appetites of the anthropophagous Parentintins." (The Parentintins, a nearby native group, kept potential colonists at bay by cultivating a reputation for ferocity.)

In one way the workers' flight may have been a boon: the expedition was running out of food. Like the Jamestown colonists, my ancestor's party was starving in the midst of plenty. Ten years before, the German engineer Franz Keller had surveyed the Madeira rapids with a party of Mojos Indians who so regularly feasted on turtle that he groused about the monotony; Keller preferred the pirarucu, an armored fish so big that Amazonians regularly toss huge pirarucu steaks on the barbecue, and the Amazonian manatee, a bulbous aquatic mammal whose meat, "when properly prepared, decidedly reminds one of pork."

Western Amazonia offered more—much more—than edible reptiles, fish, and mammals. Agricultural geneticists have long argued that the area around the railroad route—the Brazil-Bolivia border—was the development ground for peanuts, Brazilian broad beans (*Canavalia plagiosperma*), and two species of chili pepper (*Capsicum baccatum* and *C. pubescens*). But in recent years evidence has accumulated that the area was also the domestication site for tobacco, chocolate, peach palm (*Bactris gasipaes*, a major Amazonian tree crop), and, most important, the worldwide staple manioc (*Manihot esculenta*, also known as cassava or yuca). My ancestor nearly died from lack of food in one of the world's agricultural heartlands.

Only after five famished months did Craig learn from a local resident to fish not in the main channel, as the Americans had been doing, but in the smaller tributaries. Rather than using hooks and lines, to which Amazonian fish rarely respond, Indians sprinkled over the water a paralyzing elixir made from the tree genus *Strychnos* (the name suggests the poison). Temporarily unable to breathe, fish floated to the surface and were scooped into baskets. Craig's crew put down their fishing rods and learned to make poison. They stopped trying to grow peas and carrots in their gardens and began eating palm fruits and manioc.

What finally capsized the venture was malaria. Introduced to the coast by African slaves, probably in the seventeenth century, *Plasmodium* slowly transformed the Amazon basin into a collection of depopulated fever valleys that few foreigners wanted to enter. (I am picking up a story I began in Chapter 3.) Vulcanization brought people back. At a stroke European and American industries found themselves hungering for huge amounts of rubber. Most of it initially came from the mouth of the Amazon, near the port city of Belém do Pará. Each rubber tree produced perhaps an ounce of rubber per day, could only be milked 100 to 140 days a year, and needed to recuperate every few years. As demand grew, Belém's rubber tappers worked their trees too hard, killing many of them. Then the entire northeast coast was hit by a terrible drought in 1877–79. As many as half a million people died. Abandoning their stricken fields and tapped-out trees, burning with cholera, smallpox, tuberculosis, malaria, yellow fever, and beriberi, the starving backlanders—*flagelados*, they were called, the scourged—fled upstream on the Amazon's new steamships by the tens of thousands, hoping to make a living from rubber. Those with a little money or political clout obtained land grants or concessions from local officials; those with only ambition or ruthlessness just looked for untapped *H. brasiliensis* and set up shop. Ultimately they created about twenty-five thousand rubber estates, the Brazilian historian Roberto Santos has estimated, most of them small, employing more than 150,000 laborers overall. The throngs of migrants provided new targets for malaria. Keller, the German engineer, traveled the Madeira in 1867 and saw little malaria. Neville Craig arrived there a decade later and saw little else.

The toll was appalling. Craig landed at Santo Antônio on February 19, 1878. On March 23 the second ship arrived and the number of workers swelled to about seven hundred. Malaria had incapacitated almost half of them by the end of May. By the end of July, two-thirds of the crew were too sick to work; three weeks later, the proportion had risen to three-fourths. Some thirty-five people had died, the first of many. Only about 120 Americans, more than half of them sick, were left by January 1879. The next month, my ancestor wrote, the enterprise achieved "complete collapse." As a capstone, the railroad's British bankers, perhaps anticipating legal action, refused to pay the survivors' accumulated wages. Sick and broke, shoeless and ragged, Craig and a hundred or so others straggled down the Amazon into Belém, where they had to beg passage home. But even as they haunted the docks, financiers in Europe and the United States were already planning another shot at building the railroad—there was too much money in rubber to let the idea go.

Even in a time of crazy boom-and-bust cycles the rubber boom stood out. Brazil's rubber exports grew more than tenfold between 1856 and 1896, then quadrupled again by 1912. Ordinarily such an enormous increase would drive down prices. But instead they kept climbing. Attracted by tales of fortunes gained, speculators leaped into the market—"even the widow and parson are in for all they are worth," the *New York Times* observed—and pushed up prices higher still. How high? Meaningful figures are hard to provide, because speculation caused markets to shoot up and down erratically; in 1910, to pick an extreme example, New York rubber oscillated between $1.34 and $3.06 a pound. On top of that, the inflation, financial panics, and political instability of the era caused the currencies of Brazil, Britain, and the United States to gyrate wildly in value. Still, rubber kept going up. Its "soaring price is turning rubber manufacturers gray," the *Times* claimed on March 20, 1910. "One ounce of rubber, washed and prepared for manufacture, is worth nearly its weight in pure silver."

The newspaper was hyperventilating, but not entirely wrong. One economist recently calculated that the average London price of rubber roughly tripled between 1870 and 1910. The statistic is more remarkable than it may seem. Compare what happened to the price of rubber to what happened to the price of oil after a huge strike was discovered in Texas in 1900. World oil production doubled—and prices crashed. Crude didn't reach its 1900 price for twenty years. That rubber production went up by an order of magnitude while prices tripled is the kind of thing that makes natural-resource economists rub their eyes in bemusement. "It's pretty amazing," said Michael C. Lynch, president of Strategic Energy and Economics Research, of Winchester, Massachusetts. "No wonder people were going crazy."

The financial center of the trade was Belém. Founded in 1616 at the entrance to the world's greatest river, it had a strategic location—but little ability to take advantage of it. So much sediment washed in from the Amazon that the harbor was shallow and treacherous. Worse, the currents and winds generated by the river's vast outflow isolated the city from the rest of Brazil—incredibly, from Belém it was faster to sail to Lisbon, a distance of 3,700 miles, than to Rio de Janeiro, a distance of 2,500 miles. In consequence the city's population had never risen much above twenty-five thousand. The rubber boom allowed it to become, at last, what Amazonian dreamers had long hoped: the economic capital of a vibrantly growing realm.

Convinced they were building the Paris of the Americas, Belém's newly rich rubber elite filled the cobbled streets with sidewalk cafés, European-style strolling parks, and Beaux-Arts mansions with (a concession to the tropics) the exceptionally tall, narrow windows that promote air circulation. Social life centered around the neoclassical Teatro de Paz, where rubber barons in box seats smoked cigars and drank cachaça, the distilled sugarcane liquor that is Brazil's preferred high-alcohol beverage. Tall mango trees shaded the avenues that led to the harbor, where gangs of laborers sliced open the rubber lumps sent from upriver, looking for adulterants like stones or chunks of wood. After inspection, the rubber went into a series of immense warehouses that lined the shore like sleeping beasts. Rubber was everywhere, one visitor wrote in 1911, "on the sidewalks, in the streets, on trucks, in the great storehouses and in the air—that is, the smell of it." Indeed, the city's rubber district had such a powerful aroma that people claimed they could tell what part of the city they were in by the intensity of the odor.

Belém was the bank and insurance house of the rubber trade, but the center of rubber collection was the city of Manaus. Located almost a thousand miles inland, where two big rivers join to form the Amazon proper, it was one of the most remote urban places on earth. It was also one of the richest. Brash, sybaritic, and

imposing, the city sprawled across four hills on the north bank of the great current. Atop one hill was the cathedral, a Jesuit-built structure with a design so austere that it looks like a rebuke to the monstrosity that dominated the next hill over—the Teatro Amazonas, a preposterous fantasia of Carrara marble, Venetian chandeliers, Strasbourg tiles, Parisian mirrors, and Glasgow ironwork. Finished in 1897 and intended as an opera house, it was a financial folly: the auditorium had only 658 seats, not enough to offset the cost of importing musicians, let alone the expense of construction. Wide stone sidewalks with undulating black-and-white patterns led downhill from the theater through a jumble of brothels, rubber warehouses, and nouveau-riche mansions to the docks: two enormous platforms that rode up and down with the river on hundreds of wooden pillars. State governor Eduardo Ribeiro aggressively boosted the city, laying out streets in a modern grid, paving them with cobblestones from Portugal (the Amazon has little stone), overseeing the installation of what was then one of the globe's most advanced streetcar networks (fifteen miles of track), and directing the construction of three hospitals (one for Europeans, one for the insane, and one for everybody else). A celebrant of urban life, Ribeiro took part in everything his city had to offer, including its sybaritic whorehouses, in one of which he died amid what historian John Hemming delicately referred to as "a sexual romp."

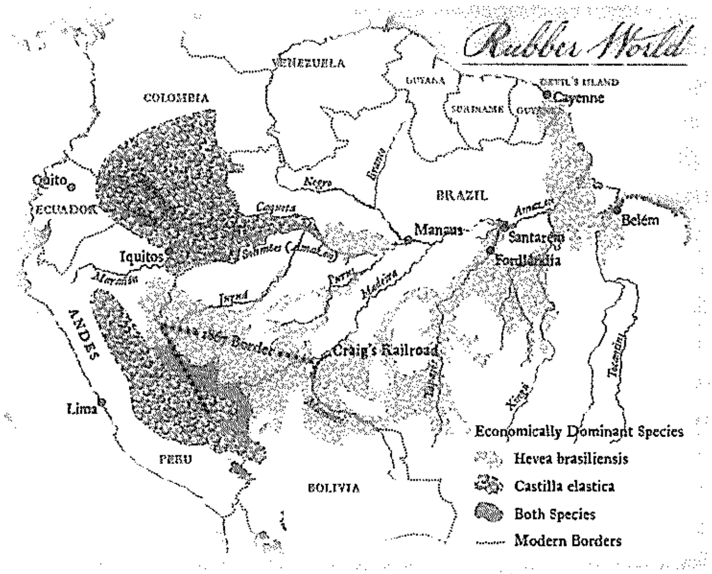
The city's many brothels were largely for the rubber tappers and field operatives who staggered into Manaus after months of labor on remote tributaries. The owners and managers had mistresses, with whom they sported in the decadent style then fashionable. "Guests once knelt to lap champagne from the bathtub of the naked beauty Sarah Lubousk from Trieste," Hemming wrote in his prodigious history of the region, *Tree of Rivers*. "The bather in the bubbly," as Hemming called her, was the mistress of Waldemar Scholtz, a recent migrant who had become the city's dominant rubber shipper—and the honorary consul from Austria. A few blocks away lived Aria Ramos, who led a celebrated double life as a carnival performer and a call girl; when she was slain in a hunting accident, her wealthy clients erected a life-size statue in the cemetery. Teeming bordellos, liquor-soaked cafés, cowboy-style barroom brawls—Manaus was the very model of a turn-of-the-century boomtown, from the warnings against the discharge of weapons on the street to the obligatory lighting of cigars with high-denomination banknotes.

So much wealth—wealth that literally *grew on trees*—in such a strategic material naturally attracted huge interest, domestic and foreign, economic and political. On the domestic side, the rubber trade came to be controlled by a baker's dozen of export houses, which in turn were dominated by Scholtz & Co., owned by the man who owned the woman in the bathtub. Like Scholtz & Co., the export houses were usually run by Europeans—intense, pallid men whose waxed moustaches and pomaded beards helped them stand apart from the beardless Indian population. Classic middlemen, they unloaded and stored the rubber that came from the interior before sending it to the mouth of the Amazon, where other European-run merchant houses shipped it to Europe and North America. The rubber itself was obtained by yet another group of corporate entities. These controlled the most critical resource in the interior: human beings.

Because latex coagulates after it is exposed to air, tappers constantly had to recut trees, tending them daily through the four-to-five-month tapping season. And they had to process the latex into crude rubber before it dried and became difficult to work with. Both tapping and processing required large amounts of care and attention. And that care and attention had to occur in remote, malarial camps—the trees couldn't be moved to more convenient, salubrious locations and the latex was too heavy to transport in its liquid state. Disease and European raids had harshly cut back the original indigenous population. Europeans had not replaced them. The ever-greater hunger for rubber was accompanied by an ever-more-desperate shortage of workers. Solutions to the labor problem emerged, many of them bestial.

At first the rubber boom seemed like a godsend—an arboreal jobs program—to the region's perpetually impoverished people. Needing workers, rubber estates hired local Indians, shipped in penniless farmers from downriver, or shanghaied hands from Bolivia. Economic theory suggests that in a labor shortage the estates would have to promise high wages and comfortable working conditions. They often did, but the promised wages were offset by stiff charges for transportation, supplies, and board. Many supposedly well-paid men were never able to work themselves out of debt; malaria, yellow fever, or beriberi felled others. To keep the labor force from finding better offers—or running away—owners stored workers onsite in barren dormitories with armed guards. Neville Craig's boss, the chief railroad engineer, visited the concessionaires who controlled the middle reaches of the Madeira. Living in three-story houses with sweeping verandas, the engineer wrote, the concessionaires were "surrounded, like medieval barons, with a retinue of Bolivian servants and their families. . . . These men are absolute masters of their peons."

In the 1890s the boom went still further upstream, into the Andean foothills—areas that until then had been regarded as useless, and so left largely to their original inhabitants, most of whom had minimal contact with Europeans. Because *H. brasiliensis* can't tolerate the cooler temperatures on the slopes, entrepreneurs focused on another species, *Castilla elastica*, which provided a less-valuable grade of rubber known as *caucho*. Although Indians tapped *Castilla* trees in Mesoamerica—the latex "emerges from *sajaduras* [the shallow cuts made when marinating meat] on the tree," one Spanish eyewitness wrote in 1574—they did not in Amazonia. The incisions, *caucheiros* (*caucho* collectors) believed, let in diseases and insects that quickly wiped out *Castilla*. Rather than futilely try to protect the trees, *caucheiros* simply cut them down, gouged off the bark, and let the latex drain into holes dug beneath the fallen trunk. Sometimes collectors could obtain several hundred pounds of latex from a single tree, thus making up in volume for *caucho*'s lower price.



Because *caucheiros* killed the trees they harvested, they naturally put a premium on being the first into a new area. The goal was to extract the most rubber in the least amount of time; every minute not at the ax was a minute when someone else was taking down irreplaceable trees. Work crews spent weeks or months trekking from tree to tree through steep, muddy, forested hills, carrying heavy loads of *caucho* from the areas they had just looted. Few people from outside the area were willing to come into the forest for this. *Caucheiros* thus turned to the people who already lived there: Indians. The situation invited abuse—and there are always people ready to take up such invitations.

Among them was Carlos Fitzcarrald, son of an immigrant to Peru who had changed his name from the hard-to-pronounce "Fitzgerald." Beginning in the late 1880s Fitzcarrald forced thousands of Indians to work the *caucho* circuit. Brazilian writer and engineer Euclides da Cunha, who surveyed part of the western Amazon at this time, learned that at one point Fitzcarrald invaded

a *Castilla*-rich area that was home to the Mashco Indians. Leading a squad of gunmen, da Cunha recounted, the *caucheiro* presented himself to the Mashco leader

> and showed him his weapons and equipment, as well as his small army, in which were mingled the varied physiognomies of the tribes he had already subdued. Then he tried to demonstrate the advantageous alternatives to the inconvenience of a disastrous battle. The sole response of the Mashco was to inquire what arrows Fitzcarrald carried. Smiling, the explorer passed him a bullet from his Winchester. The native examined it for a long time, absorbed by the small projectile. He tried to wound himself with it, dragging the bullet across his chest. Then he took one of his own arrows and, breaking it, thrust it into his own arm. Smiling and indifferent to the pain, he proudly contemplated the flowing blood which covered the point. Without another word he turned his back on the startled adventurer, returning to his village with the illusion of a superiority which in a short time would be entirely discounted.
>
> And indeed, half an hour later roughly one hundred Mashcos, including their recalcitrant chief, lay murdered, stretched out on the riverbank which to this day bears the name Playa Mashco in memory of that bloody episode.
>
> Thus they mastered this wild region. The *caucheiros* acted with feverish haste. They ransacked the surroundings, killing or enslaving everyone for a radius of several leagues. . . . The *caucheiros* would stay until the last *caucho* tree fell. They came, they ravaged and they left.

More brutal still was Julio César Arana. The son of a Peruvian hatmaker, Arana came to exert near-total command over more than twenty-two thousand square miles on the upper Putumayo River, then claimed by both Peru and Colombia. Colombia had a heavier presence on the ground but was then convulsed by civil war. The Peruvian Arana took advantage of its inattention to push into the region, shoving aside rival *caucheiros*. Not wanting to lure laborers from other areas with high wages, he turned to indigenous people. At first they were willing to do some rubber collecting in exchange for knives, hatchets, and other trade goods. But when Arana asked for more they balked. So he enslaved them. By 1902 he had five Indian nations under his thumb. *Caucho* flowed from his land in ever-larger amounts.

Arana moved with his family to Manaus and established a reputation for quiet probity—he had the biggest library in town. Meanwhile his minions expanded his realm on the Putumayo, bribing government officials and killing his competitors. He controlled his slave force with a goon squad led by more than a hundred toughs imported from Barbados. Isolated in the forest and utterly dependent on Arana, the Barbadans executed every command they were given. No one other than Arana's agents was allowed to enter the Putumayo from outside. Twenty-three custom-built cruise boats enforced his rule.

In December 1907 two U.S. travelers stumbled into the region. Encountering a *caucheiro* whose wife had been abducted by Arana's thugs, the young men impulsively decided to help him confront the wrongdoers. Arana's private police force beat and imprisoned them in one of the company's bases, a charnel house where their guards, one of the travelers later recounted, amused themselves with "some thirteen young girls, who varied in age from nine to sixteen." Outside, the "sick and dying" lay in untended heaps "about the house and out in the adjacent woods . . . until death released them from their sufferings. Then their companions carried their cold corpses—many of them in an almost complete state of putrefaction—to the river." By claiming they were representatives of "a huge American syndicate," the tourists managed to talk their way free.

One of them vowed to expose the situation. His name was Walter Hardenburg. The son of a farmer in upstate New York, he

Julio César Arana

was a clever, restless man, self-taught as an engineer and surveyor. He had gone to the Amazon with a friend in the vague hope of seeking employment on the Madeira railroad, which a new group of Americans was trying to build. Hardenburg was not a crusader by temperament, as Hemming notes in *Tree of Rivers*, but what he saw enraged him. To document the abuses he traveled to Iquitos, Peru, on the headwaters of the Amazon. Located almost two thousand miles from the river's mouth, it is often described today as the biggest city in the world that cannot be reached by road. It was then a boomtown port like Manaus, the main difference being that it was much smaller and completely dominated by Julio César Arana. At great personal risk Hardenburg spent a year and five months in Iquitos, finding witnesses to atrocities and obtaining their notarized testimony. With the last of his money he went to England in June 1908 to stir up public opinion. The first newspaper article appeared fifteen months later.

Arana had incorporated his company in London in an attempt to go public and cash out, as software entrepreneurs would do a century later. It had a placidly respectable British board of directors whose members apparently believed Arana's lies about having clear title to the rubber land and using company profits to educate tens of thousands of Indians. The slavery was therefore a British matter. Eventually there was a parliamentary investigation and a years-long public furor. London sent an investigatory team that included Roger Casement, an Irish-born British diplomat who was a pioneering human-rights activist—he had exposed atrocities committed in the Congo by agents of Belgian king Leopold II. Casement shuttled about the Putumayo, confirming Hardenburg's charges by obtaining detailed confessions of murder and torture. In a misguided fit of nationalism, Peru defended its citizen against foreign meddling. Nonetheless Arana's empire disintegrated. He died penniless in 1952.*

Arana was by no means the only force trying to build a rubber empire in this area of unsettled borders. Political and business leaders in Europe and the United States were infuriated that a material so vital to their economies was completely controlled by foreigners. The result was what Hecht has dubbed the "scramble for the Amazon." Arguing that the southern border of its colony in Guyane actually extended into rubber country, France sent troops into the forest. Brazil did the same. A standoff ensued. King Leopold II offered to settle the dispute by taking control of the rubber himself, an offer that pleased neither

* Casement was rewarded with a knighthood. Soon after, Sir Roger quit the Foreign Office to devote himself to the cause of Irish independence. He traveled to Germany to persuade the kaiser to provide arms for an uprising. The plot was discovered and Casement arrested as a German submarine deposited him on the Irish coast. Convicted of treason, he was sentenced to death. Influential friends begged the court for mercy. Casement was unlucky enough to be gay and unwise enough to detail his sex life in diaries. Their discovery after the trial sealed his fate. He was stripped of his honors and hanged on August 3, 1916.

Julio César Arana controlled his private rubber domain in the upper Amazon with guards imported from Barbados (left). Unfamiliar with local people and utterly dependent on him, they enforced his every rule with immediate brutality. Laborers who failed to perform were given the "mark of Arana"—whipped until the skin fell off (right).

side. France, unable to maintain its force in the forest, gave up in 1900. Britain was more successful in claiming that its colony reached into rubber territory. Rather than resorting to force of arms, it deployed the Royal Geographic Society, which produced a scientific-looking survey—proof enough for the Italian foreign minister, who had been selected to mediate the dispute. British Guiana acquired some rubber land.

From Brazil's point of view, the greatest threat to its dominance of the rubber trade was the United States. The U.S. interest in Amazonia dated back to Matthew Fontaine Maury (1806–73), founder of both the U.S. Naval Observatory and modern oceanography. An ardent advocate of slavery, Maury became possessed in the 1850s by the fear that the South would lose its political clout because it was not big enough to withstand the North. In a widely circulated pamphlet, he proposed a solution: the United States should annex the Amazon basin. Ocean currents push the river's outflow into the Caribbean, where it meets the outflow from the Mississippi—proof, to Maury's mind, that the Amazon was, oceanographically speaking, part of North America, not South America. For this reason, he argued, the Amazon valley was a natural "safety valve for our Southern States." He sent two cartographers to map Amazonia for the future day when U.S. slaveholders would go "with their goods and chattels to settle and to revolutionize and to republicanize and Anglo Saxonize that valley." Southern plantation owners should resettle there, Maury argued, converting the river basin into the biggest U.S. slave state. Few planters paid attention until the South lost the Civil War. Hoping to re-create slave society in the forest, ten thousand Confederates fled to the Amazon. All but a few hundred quickly fled back. The remaining die-hards formed a sort of micro-satellite of the Confederacy in the town of Santarém, in the lower Amazon.

With Maury, Washington gave up any idea of directly annexing Amazonia. But it was willing to try to control the rubber country through a proxy: Bolivia. Bolivia and Brazil had long contested their borders. After a short war in the 1870s, Bolivia ceded part of its territory in the south, receiving as compensation title to land to its north, around the Acre River, one of the richest areas, it later turned out, for *H. brasiliensis*. Unfortunately, all the rivers in the area—the main conduits for traffic—flowed into Brazil. It was thus vastly easier to reach Acre from Brazil than from La Paz, the Bolivian capital, up eleven thousand feet in the Andes. Taking advantage of these geographical circumstances, Brazilian tappers moved illegally across the border into Acre. Bolivia, too poor to mount an effective military response, sold the rights to Acre's rubber to a U.S. syndicate. Now the Brazilian squatters would be taking money not from powerless Bolivians, but from wealthy, politically connected U.S. businessmen. The syndicate persuaded the U.S. government to send a gunboat up the Amazon. It was turned back near Manaus.

Angered by the move, the Brazilians in Acre attacked the Bolivian regional capital of Cobija on August 6, 1902: Bolivia's national day. Asleep in its barracks after a drunken holiday feast, the garrison in Cobija was captured without a shot. The Bolivian army took three months to descend from the heights of La Paz, by which time the fight was over—Acre was Brazilian, the U.S. syndicate was routed, and Cobija, formerly in the center of Acre, was now a Bolivian border town. Today almost the only trace of the battle is at the airport in Cobija, where a monument at the entrance extols the "heroes of Acre."

Victory in Acre sealed Brazil's triumph. Having beat back almost all challenges to its control over rubber, it was producing ever more of this vital elastomer and controlling most of the trade in the rubber it didn't produce. Hundreds of thousands of people were making a living from the forest. The situation was in many ways much like what environmentalists hoped for in the 1990s and 2000s when they argued that Brazilians should sustainably gather rubber and other forest products in the Amazon, rather than set up short-lived cattle ranches. But instead Brazil showed how these schemes can go awry.

WHAT WICKHAM WROUGHT

When the man from the rubber company came to the village of Ban Namma, men drifted from their homes to meet him. They hunkered down in their sandals and worn T-shirts on the bare ground in front of the village headquarters. Surrounding them was an asteroid belt of silent women and almost-silent children. The company agent had a sports coat and a glad-handing manner. He distributed cigarettes, snapping them from the pack with the expert flick of a prestidigitator. Villagers tucked them in shirt pockets or behind ears. The man from the rubber company told a joke and the men laughed. A moment later the women laughed.

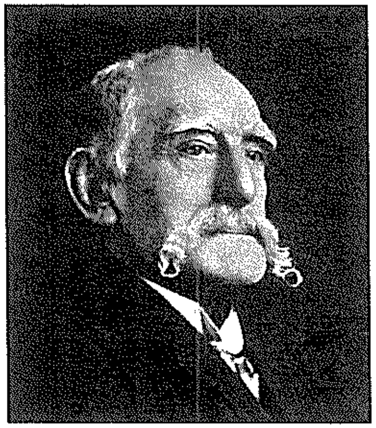
Ban Namma straggles up a hill next to the two-lane track that is the main road—often the only road—in the northwest corner of the Lao People's Democratic Republic. It is at the edge of the Golden Triangle, the intersection of the borders of Laos, Myanmar (formerly Burma), and China, a region long infamous for its opium and heroin. Some of the biggest producers were the brutish descendants of the Nationalist military officers who fled Mao Zedong's takeover of Beijing in 1949. They were joined and to some extent replaced in the 1960s by guerrillas from Communist uprisings in Myanmar. Because Beijing was subsidizing these guerrillas, its simultaneous efforts to shut down the Golden Triangle drug trade were, not surprisingly, less than successful. Eventually China tired of having criminal gangs on its border. In the 1990s it attacked them with a new weapon: corporate capitalism. Tax and tariff subsidies, some from United Nations anti-drug funds, pushed Chinese firms to create rubber plantations in the tiny, impoverished villages across the Laotian border. One of these villages was Ban Namma. The man with the cigarettes had persuaded its inhabitants to plant 1,325 acres of their land with *Hevea brasiliensis*.

The rubber man introduced himself as Mr. Chen. The venture had not been entirely successful, he told me. Rubber trees need to be planted on warm, sunny slopes that are not exposed to wind or cold and must be carefully tended for seven years before they can be tapped. In Ban Namma, Mr. Chen said, the villagers had no experience with *H. brasiliensis* and had made beginners' mistakes. They cleared land at the wrong elevation and failed to water abundantly. The promised 1,325 acres of thriving trees had become less than 500 acres of hard-pressed trees.

Despite this kind of setback Laotian rubber was booming. For miles around Ban Namma forestland had been shaved clean at the direction of Chinese rubber firms. Young rubber trees rose like morning stubble in the cleared patches. To the far west, near the border with Burma, a big Chinese holding company, China-Lao Ruifeng Rubber, was cutting and planting almost 1,200 square miles; a second firm, Yunnan Natural Rubber, planned to convert another 650 square miles. Much more was projected, according to a 2008 report by economist Weiyi Shi for the German development agency GTZ. The area was being transformed into an organic factory, primed to pump out latex for the trucks that were already beginning to thunder down the narrow roads.

If this ecological tumult could be laid at the door of a single person, it would be Henry Alexander Wickham. Wickham's life is difficult to assess: he has been called a thief and a patriot, a major figure in industrial history and a hapless dolt whose main accomplishment was failing in business ventures on three continents. Perhaps the most accurate way to describe his role was that he was a conscious human agent of the Columbian Exchange. He was born in 1846 to a respectable London solicitor and a milliner's daughter from Wales. When the boy was four, cholera took his father's life and the family he left behind slid slowly down the social ladder. Wickham spent the rest of his life trying to climb back up. In this quest he traveled the world, wrecking his marriage and alienating his family as he tried with blind tenacity to found great plantations of tropical species. Manioc in Brazil, tobacco in Australia, bananas in Honduras, coconuts in the Conflict Islands off New Guinea—Henry Wickham failed at them all. His adventure in Brazil cost the life of his mother and his sister, who had accompanied him. The coconut plantation, on an otherwise uninhabited island, was so lonely and barren that Wickham's wife, who had endured years of privation without complaint, at last demanded that he choose between the coconuts and her. Wickham chose coconuts. They never spoke again. Nonetheless at the end of his days he was a respected man. Crowds applauded as he walked onto testimonial stages wearing a silver-buttoned coat and a nautilus-shell tie clip. His waxed moustache curved ferociously beneath his jaw like the moustache of an anime character. He was knighted at the age of seventy-four.

Wickham won the honor for smuggling seventy thousand rubber-tree seeds to England in 1876. He was acting at the behest of Clements R. Markham, a scholar-adventurer with considerable experience in tree bootlegging. As a young man, Markham had directed a British quest in the Andes for cinchona trees. Cinchona



Henry Wickham

bark was the sole source of quinine, the only effective antimalaria drug then known. Peru, Bolivia, and Ecuador, which had a monopoly, zealously guarded the supply, forbidding foreigners to take cinchona trees. Markham dispatched three near-simultaneous covert missions to the Andes, leading one himself. Hiding from the police, almost without food, he descended the mountains on foot with thousands of seedlings in special cases. All three teams obtained cinchona, which was soon thriving in India. Markham's project saved thousands of lives, not least because Ecuador, Peru, and Bolivia were running out of cinchona trees—they had killed them by stripping the bark. Riding the success to the position of director of the India Office's Geographical Department, Markham decided to repeat with rubber trees "what had already been done with such happy results for the cinchona trees." British industry's dependence on rubber was leaving the nation's prosperity in the hands of foreigners, he believed. "When it is considered that every steam vessel afloat, every railway train, and every factory on shore employing steam power, must of necessity use india-rubber," Markham argued, "it is hardly possible to over-rate the importance of securing a permanent supply." Glory would attach to those who secured that supply. In the early

1870s Markham let it be known that Britain would pay for rubber seeds. When the seeds arrived, they would be sown at the Royal Botanic Gardens, at Kew in southwest London, and the successful seedlings dispatched to Britain's Asian colonies. Two separate hopeful adventurers sent batches of rubber seed. Neither batch would sprout. Wickham became the third to try.

Rubber was Wickham's exit from his failing manioc plantation in Brazil. Cannily eliciting Markham's promise that the India Office would buy every rubber seed he sent, Wickham sought the help of his neighbors in collecting them. His plantation was located in Santarém, four hundred miles from the river's mouth, a rubber town built atop a Jesuit mission built atop a native city. It was also the biggest center of ex-Confederates in the Amazon. With the aid of Confederate families, Wickham gathered seventy thousand seeds, enough to pay for passage back to Britain for himself and his wife. (He left behind, apparently without warning, his brother and his family, as well as his widowed brother-in-law.) To judge by the frigid reception he received in London, the India Office had not expected to be billed for three-quarters of a ton of rubber seeds. Nor were they overly happy that only 2,700 germinated—evidence, suggested the environmental historian Warren Dean, that Wickham and his associates scrambled through the forest in a hot-brained hurry, grabbing seeds from the ground without consideration for their viability.

Today Wickham is reviled in Brazil. Tourist guides refer to him as the "prince of thieves," a pioneer of what has come to be called "bio-piracy"; the leading economic history of Amazonia denounces his actions as "hardly defensible in the light of international law." At a literal level this claim is untrue; Brazil then had no bio-piracy laws. Nor is there any evidence that anyone tried to stop Wickham. The British were hardly secretive—London newspapers trumpeted Markham's quest for rubber. And authorities in Santarém surely were aware that an English madman was packing up cases of rubber seeds. In any case Brazilians themselves have not hesitated to import exotic species. The nation's primary agricultural exports today are soybeans, beef, sugar, and coffee. Not one is native to the Americas.*

More important, the transport of useful species out of their home environments has been a boon to humankind. The quinine supply in the Andes was far too small for the world's needs, even if collectors had hunted down every cinchona tree. Markham's "bio-piracy" saved countless thousands in Asia and Africa from premature death. Transplanting the potato to Europe and the sweet potato to China created catastrophic social and environmental problems, as I have been at pains to argue. But it also kept millions of Europeans and Chinese from malnutrition and famine. The huge benefits of moving species outweigh the huge harms, though the balance can be closer than free-exchange advocates tend to admit. As Dean put it, "The transfer of seeds, even across national borders, even for the sake of crass profit, even in behalf of imperialism, may be counted as a foremost means of the aggrandizement of the human species."

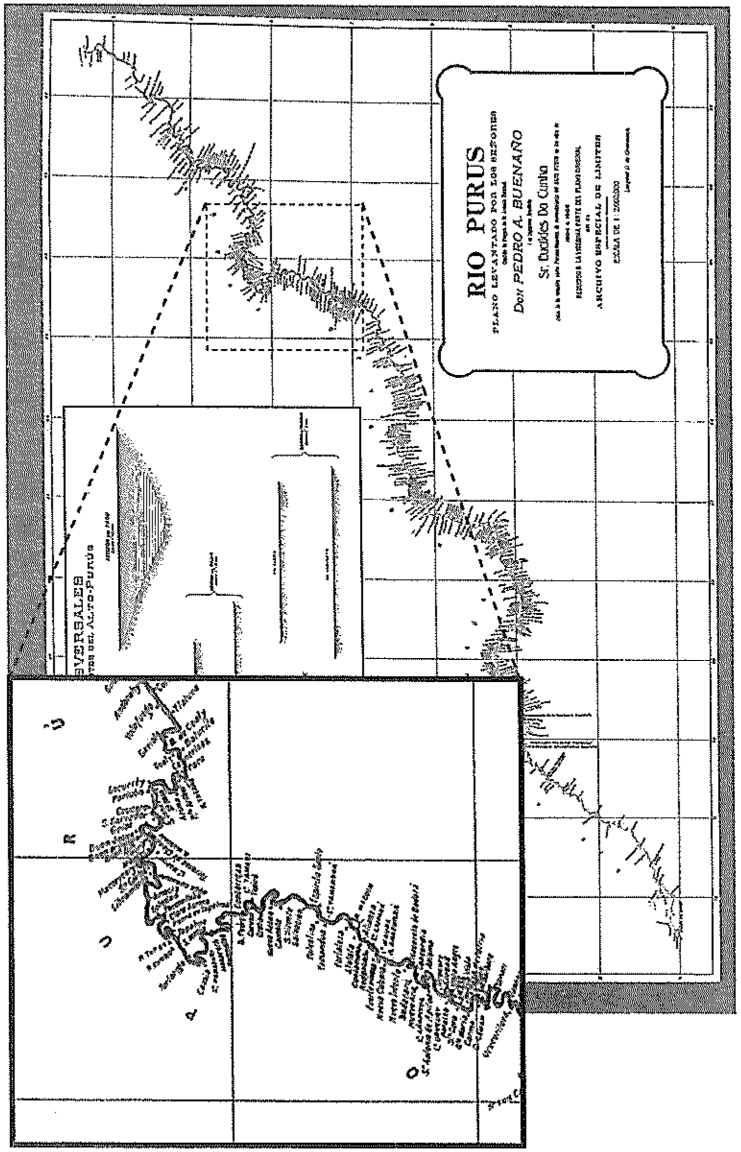
Two months after Wickham appeared in London, Kew shipped out the seedlings, most of them to Sri Lanka. Irritated with Wickham, the gardeners paid no attention to his recommendation that the trees be planted in open slopes away from marshes and riverbanks—the roots wouldn't grow properly in soggy ground. Instead they planted the seedlings in forest wetlands. Even if the plants had flourished, Sri Lanka's British colonists in 1876 were not interested in creating a new plantation industry. Two decades before, they had installed almost eight hundred square miles of coffee trees in the island's hills and imported a quarter of a million Indians to tend them. A previously unknown

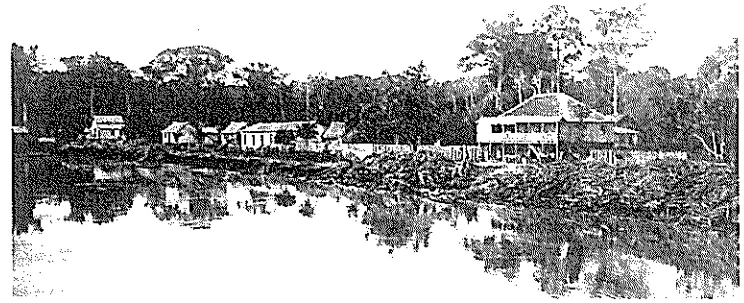
* In 1727 the Brazilian diplomat Francisco de Melo Palheta visited Cayenne, in French Guiana, to negotiate a border dispute. Somehow he obtained coffee seeds—he is said to have received them as a farewell gift from the governor's wife, whom he had seduced. Under French colonial law coffee seeds were strictly forbidden to foreigners. Melo Palheta smuggled them to Brazil, the rubber historian Warren Dean wrote, launching "a plantation industry that was the mainstay of the Brazilian economy for a century and a half."

fungus affected "two or three acres" of coffee in 1869. Three years later the director of the Sri Lanka botanical gardens was reporting that "not a single estate has quite escaped it." Wickham's seedlings arrived just as unhappy colonists were ripping out stricken coffee trees and planting tea bushes. (The coffee plague is sometimes claimed to be why the British hot beverage of choice is tea, rather than coffee.) Few were interested in replacing their new tea bushes with rubber. The same coffee disease struck Malaysia and Indonesia in the 1890s. Forced to restart there, planters tried the rubber trees that had been languishing in Sri Lanka. The fortunes quickly made in Malaysia—and Indonesia, a Dutch colony that also took some of Wickham's trees—convinced Sri Lanka to take another look. Malaysia and Sri Lanka had a thousand acres of rubber plantations in 1897. Fifteen years later, the figure had grown to more than 650,000. For the first time more rubber came from Asia than the Americas. Prices fell, and the Brazilian rubber industry was reduced to dust.

Few in Manaus saw it coming—more evidence, if any were needed, of the human propensity to believe that flukes of good fortune will never come to an end. The city sank into lassitude, its opera house shuttered, its mansions abandoned. Rubber executives realized to their shock that laborers scattered across a forest the size of a continent could not produce latex nearly as efficiently as workers who moved down rows of closely packed trees. In their dismay few Amazonian businesses even tried to develop plantations. The first real chance the region had to recoup occurred in 1922, when British colonies in Asia, which had overplanted rubber, sought to control prices by forming a cartel. Among those enraged by this action were Harvey Firestone, the world's biggest tire maker, and Henry Ford, the world's biggest car maker. Firestone responded by creating a huge rubber plantation in Liberia. Ford planned one of equal size in the Amazon.

As a site he chose the Tapajós River, near Santarém, close to where Wickham had acquired his seeds. In an inauspicious debut for the project, Ford hired a Brazilian go-between who in





At the peak of the rubber boom, Brazil sent engineer and writer Euclides da Cunha to survey its disputed western border. Lining the banks of the Purus River, an upper Amazon tributary, da Cunha found hundreds of rubber-processing facilities (opposite). To stoke the fires that boiled down the latex and to fuel the steamboats that took it downstream, each plant consumed huge quantities of wood (above)—an early example of tropical forest destruction.

1927 sold him almost four thousand square miles of land up the Tapajós that happened to be owned by the go-between. To house his workers Ford built a replica of a middle-class Michigan town, complete with a hospital, schools, stores, movie theaters, Methodist churches, and wooden bungalows on tree-lined streets. On a hill was the Amazon basin's only eighteen-hole golf course. Orderly and straitlaced as Ford himself, the town was the opposite of boomtown Manaus. Wags immediately dubbed the project Fordlândia. Because Fordlândia was hilly, removing the vegetation "caused massive erosion and drainage problems," explained William I. Woods, a soil scientist and geographer at the University of Kansas. To prevent erosion, he told me, the company had to terrace the land, a "hideously expensive" process. In any case, Woods said, the soil was too sandy. Because the land was 135 miles up the Tapajós, oceangoing ships couldn't dock there during the dry season. "Even if they got rubber, they couldn't ship it out."

For Ford, the next few years were a series of unhappy surprises. Only after the first season's rubber trees died did the company find out that *H. brasiliensis* must be established at particular times of the year to thrive. Only after paying steamship bills did the company realize that it would not be possible to offset the cost of clearing all the hardwood trees on its land by selling the timber in the United States. And only after planting thousands of acres did the company learn that the Amazon has a fungus, *Microcyclus ulei,* that is partial to rubber trees. This last sentence is imprecise. The company did know that *M. ulei* existed. What it didn't grasp was that there was no way to stop it.

Microcyclus ulei causes South American leaf blight. Leaf blight begins when a spore lands on a *Hevea* leaf. Somewhat like the potato-blight spore, the minute, two-celled leaf blight spore grows a thin, rootlike tube that extends sideways, along the top of the leaf. Usually the tube is tipped by a structure called the appressorium. Executing a right-angle turn, the appressorium drills into the inner cells of the leaf. Depending on the leaf's defenses, the details of the infection process vary. In any case the fungus almost always wins, penetrating the leaf. Inside it produces spores—many, many spores—which emerge from new tubes on the bottom of the leaf. They are knocked free by raindrops or brushed off by rubbing against other leaves. Left behind are ruined, blackened leaves, which fall off the tree. Leaf blight defoliates *H. brasiliensis.* The blighted trees I have seen, with their sparse black foliage, looked as if someone had gone after them with a blowtorch. Many trees survive a bout with *M. ulei,* but their growth is stunted; a second or third episode will kill them.

M. ulei spores do not survive long after parting from their natal leaf. Thus *Hevea* trees in the wild are usually spaced widely apart; if one succumbs to leaf blight, the others are too distant to be attacked. In plantations, by contrast, trees are so close together that their upper branches are entangled. Spores hop from tree to tree like so many squirrels. Or the fungus can travel on the clothes and fingernails of plantation workers. That is what happened in Fordlândia.

Ironists will appreciate that *M. ulei* attacked just as Ford finally hired its first actual rubber expert, James R. Weir, a plant pathologist who was the ex-director of the U.S. National Fungus Collections. Weir's first action for Ford was to travel to the Indonesian island of Sumatra, home to many rubber estates. Its rubber planters had found especially productive trees and learned how to propagate them by grafting wood from these trees onto sturdy rootstock. In thirty years they had created prodigious groves of high-yielding clones. Weir purchased 2,046 grafted buds in December 1933. Like the Brazilians who failed to block Wickham, the Sumatrans who didn't stop Weir were upset about it later. Five months after his departure, Asian rubber producers formed a second, stronger cartel—and explicitly prohibited the removal of "leaves, flowers, seeds, buds, twigs, branches, roots or any living portion of the rubber plant." By then Weir had carried his precious sprouts to Brazil, where they were about to be wiped out by *M. ulei.*

M. ulei exists in many different strains; if a fungicide wipes out one, the others move in. Weir launched an emergency testing program to look for resistant trees. Meanwhile he tried to establish a new, fungus-free plantation eighty miles away on better land that was closer to the mouth of the Tapajós. He filled it with the high-producing clones from Sumatra. The fungus overran the new plantation even faster than the old. By selecting their trees exclusively for latex yield, Asian farmers had inadvertently produced varieties with even less resistance to blight. The disaster effectively ended Fordlândia, though it wasn't formally abandoned until 1945. Its fate made most Brazilians conclude that rubber plantations are not viable in the Amazon. When Ford bought land in Brazil, 92 percent of the world's natural rubber came from Asia. Five years after Fordlândia ended the figure was 95 percent.

The advent of synthetic rubber during the First World War failed to drive the Asians out of business. Despite the brilliance of industrial chemists, there is still no synthetic able to match natural rubber's resistance to fatigue and vibration. Natural rubber still claims more than 40 percent of the market, a figure that has been slowly rising. Only natural rubber can be steam-cleaned in a medical sterilizer, then thrust into a freezer—and still adhere flexibly to glass and steel. Big airplane and truck tires are almost entirely natural rubber; radial tires use natural rubber in their sidewalls, whereas the earlier bias-ply tires were entirely synthetic. High-tech manufacturers and utilities use high-performance natural-rubber hoses, gaskets, and O-rings. So do condom manufacturers—one of Brazil's few remaining natural-rubber enterprises is a condom factory in the western Amazon. With its need for materials that can withstand battle conditions the military is a major consumer—which is why the United States imposed a rubber blockade on China during the Korean War.

The blockade helped convince the Chinese of the need to grow their own *H. brasiliensis*. Alas, the nation had only a few areas warm enough for this tropical species. The biggest was Xishuangbanna (syee-schwong-ban-na, more or less), at the extreme southern tip of Yunnan Province, bordering Laos and Burma. A homeland for the Dai and Akha (Hani), two of China's minority ethnic groups, Xishuangbanna Prefecture is China's most tropical place. Although it comprises just 0.2 percent of the nation's land, it contains 25 percent of its higher plant species, 36 percent of its birds, and 22 percent of its mammals, as well as significant numbers of amphibians and freshwater fish.

A few people had dabbled in rubber there as early as 1904, but the efforts had not been sustained. In the 1960s the People's Liberation Army worked to turn the prefecture into a rubber haven. Xishuangbanna plantations were, in effect, army bases; entry was forbidden to outsiders. Outsiders included the Dai and Akha who lived nearby. As suspicious of the minorities in the mountains as the Qing, the Communists imported more than 100,000 Han

workers, many of them urban students from faraway provinces, and put them into labor gangs charged with revolutionary fervor. "China needs rubber!" they were told. "This is your chance to use your hands to help your country!" Workers were awakened every day at 3:00 a.m. and sent to clear the forest, one former Xishuangbanna laborer told anthropologist Judith Shapiro, author of *Mao's War Against Nature*.

> Every day we cut until 7:00 or 8:00 a.m., then ate a breakfast of rice gruel sent by the [Yunnan Army] Corps kitchen. We recited and studied Chairman Mao's "Three Articles" and struggled against capitalism and revisionism. Then it was back to work until lunch break, then more work until 6:00. After we washed and ate, there were more hours of study and criticism meetings.

Sneering at botanists' admonitions as counterrevolutionary, the government repeatedly planted rubber trees at altitudes where they were killed by storms and frost. Then it planted them again in the exact same place—socialism would master nature, it insisted. The frenzy laid waste to hillsides, exacerbated erosion, and destroyed streams. But it didn't actually yield much rubber. In the late 1970s the nation began its economic reforms. The educated young people fled back to their home cities, precipitating a labor shortage. Local Dai and Akha villagers were finally permitted to establish rubber farms. They were effective and efficient. Between 1976 and 2003 the area devoted to rubber expanded by a factor of ten, shrinking tropical montane forest in that time from 50.8 percent of the prefecture to 10.3 percent. The prefecture was a sea of *Hevea brasiliensis*.

Unlike the flat Amazon basin, Xishuangbanna is a mass of hills. Planting on slopes exposed the trees to sunlight and ensured that they didn't grow in pools of water, a constant risk in the Amazon because it damages the roots. In addition, according to Hu Zhouyong of the Tropical Crops Research Institute in Jinghong, the prefecture capital, the relative extremes of temperature let growers select for exceptionally robust trees that would produce more rubber in every circumstance. "Xishuangbanna is ahead of everywhere else in the world in terms of productivity," Hu said to me.

Even as burgeoning China became the world's biggest rubber consumer, its rubber producers were running out of space in Xishuangbanna—every inch of land was already taken. They looked enviously over the border at Laos; with about six million people in an area the size of the United Kingdom, it is the emptiest country in Asia. A few villages in northern Laos had begun planting as early as 1994. But the real push didn't begin until the end of the decade, when China announced its "Go Out" strategy, which pushed Chinese companies to invest abroad. The country had already changed the old military farms into private enterprises—corporations with abundant political clout. As part of Go Out, Beijing announced that it would treat rubber growing in Laos and Myanmar as an opium-replacement program, making the former military farms eligible for subsidies: up to 80 percent of the initial costs for companies to grow rubber across the border, as well as the interest on loans. In addition, it would exempt incoming rubber from most tariffs. (Which companies are receiving the money is unclear; "the subsidy distribution process," economist Weiyi Shi told me, "lacks transparency and appears to be plagued with cronyism.")

Duly incentivized, companies and smallholders flowed over the border. They hired Dai and Akha who lived in China to work with their distant relatives in Laos. Most Laotians lived in hamlets without electricity or running water; schools and hospitals were a distant dream. Seeing a chance to improve their material conditions, villagers jumped starry-eyed on the rubber bandwagon, cutting deals with firms and farms in China. "In China, they were as poor as us," one village head told me. "Now they are rich—they have motorcycles and cars—because they planted rubber. We want to have the same."

No one knows exactly how much *H. brasiliensis* is now in Laos; the government doesn't have the resources for surveys. According to anthropologist Yayoi Fujita of the University of Chicago, in 2003 rubber covered about a third of a square mile in Sing District, next to the border. Three years later it covered seventeen square miles there. Similar growth has occurred in many other districts. The Laotian government estimated that rubber covered seven hundred square miles of the nation by 2010, eight times more than it covered just four years before. And the pace of clearing will only accelerate, along with the effects of that clearing.*

"To harvest a couple thousand square miles of rubber, you need a couple hundred thousand workers," Klaus Goldnick, a regional planner in the northern provincial capital of Luang Namtha, said to me. "The whole province has only 120,000 people. The only solution is to bring in Chinese workers." He said, "Many people here live off the forest. When the forest is gone, it will be difficult for them to survive." He said, "Foreign companies are paying a concession fee"—about $1.50 per tree—"to the government. The more trees, the more fees."

Most of the first plantations were created by villagers who knocked down a few acres on their own or worked with equally small plantations in China. Later the bigger Chinese operations moved in, among them the former state farms. Because rubber trees take seven years to mature, companies naturally want to make long-term arrangements with the people who plant and tend them. I was allowed to look at one of the resultant contracts, between the Chinese firm Huipeng Rubber and three hamlets in Luang Namtha Province.

* Jefferson Fox of the East-West Center in Hawaii, who is working with colleagues to evaluate rubber's impact in Southeast Asia, notes that Vietnam plans to increase its companies' rubber area by 1,500 square miles—a quarter of that in southern Laos. In January 2009 Fox visited big plantations in southern Laos, he told me, "from which smallholders had been removed from their land in order to grant land concessions to Vietnamese investors."

Written in both Chinese and Lao, the contract consisted of twenty-four numbered paragraphs. Three were boilerplate: legal descriptions of Huipeng and the villages. Eighteen explained the rights and privileges of the company. One listed the villagers' rights and privileges. In the confusion of the moment, I may have got the numbers slightly wrong—the papers were shown to me while a village head and the rubber agent were telling me their views, each in a different language. But it was impossible to miss that Huipeng's executives had affirmed the contract with their signatures whereas the villagers had affirmed it by rolling their thumbprints onto the page. Each village would plant a certain amount of its land with rubber, the contract explained. Huipeng would in return improve both the roads within the village and the highway to it. But the firm could then sell its rights to the land at its own discretion and hire anybody it wanted to tend the trees, including people from China. Some 70 percent of the proceeds from rubber would go to the villages, "depending on the effective results of the planting"—a big loophole, it seemed to me. Contracts of this sort between companies and villages are common in China (the tobacco plots I visited in the Fujianese hill village in Chapter 5 were governed by one). But such arrangements seemed less benign in Luang Namtha. To my eye the contract looked like the kind of document that emerges when one party has a lawyer looking after its interests and the other party doesn't know what a lawyer is.

In Ban Songma, the next settlement down the road, the village leader who negotiated the contract was about thirty years old. On the day we met he wore a white T-shirt and soccer shorts with a Munich logo. Beside him stood his wife, holding a baby girl wrapped in a faded Hello Kitty blanket. I asked him the name of the rubber company, how much land the village was supposed to provide to it, and the split of the proceeds. He couldn't answer these questions. This was not because he was stupid—he was obviously a shrewd, sparky man—but because the questions were beyond his frame of reference. To be a modern economic agent

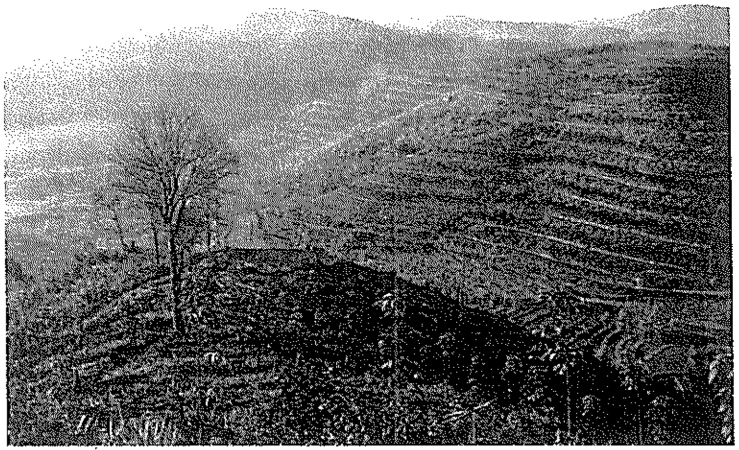
requires a huge set of habits, assumptions, and expectations. Few of them had been needed in Ban Songma even ten years before. Indeed, they may have been counterproductive. Venturing onto the clawed ground of global capitalism, the village head was as out of his element as Neville Craig was on the Madeira River. That he wanted the fruits of capitalism—Chinese motorbikes and Japanese televisions and nylon shorts emblazoned with the logos of European sports teams—didn't make the likelihood of a happy outcome any greater.

Already Huipeng had imported Chinese workers to plant the seedlings. The village head didn't know whether he and his neighbors would be taught how to graft trees themselves, or to tap latex, or to do the initial processing for rubber. But he did know that people who worked for the Chinese ended up with motorbikes, which liberated them from hours of walking up and down the steep hills. The baby in the Hello Kitty blanket will grow up knowing more than her father about the whirling new world Ban Songma is entering. Huipeng's contract will be in force for forty years. It will be interesting to see at its end how that child regards the deal that her father signed.

THE END OF THE WORLD

The morning had been clear and bright, an ominous sign. On the pedestrian bridge that leads to the Xishuangbanna Tropical Botanical Garden I could see the faintest swirl of fog on the hills. Researchers had drawn their office curtains on the building's sunny side. Founded in 1959, the garden grew up with Xishuangbanna's rubber industry. Its scores of scientists monitored the impact of the refashioning of the regional ecosystem and didn't like what they saw. "We all hate rubber," one researcher told me. "But then we're all ecologists here."

Although the Golden Triangle receives as much as one hundred inches of rain a year, three-quarters of it falls between May



Almost every bit of Xishuangbanna that can support rubber trees has been cleared and planted (top), a change that is profoundly altering the environment—the region's morning mists are vanishing, along with its water supply. With China's rubber companies running out of suitable land in China itself, they have moved across the border to northern Laos (above, a freshly logged hillside).

and October. The rest of the year the forest survives largely on dew from morning fog. "Back in the 1980s and 1990s there was still fog at lunchtime," XTBG ecologist Tang Jianwei told me. "Now it's gone by eleven." The "very obvious" change, he said, is a symptom of a profoundly altered hydrological regime.

Rubber is to blame, Tang said. *H. brasiliensis* usually sheds its leaves in January and new leaves begin budding in late March. The absence of leaves means that the forest has fewer surfaces to retain dew, which reduces water absorption during the dry season. Surface runoff rises by a factor of three—which in turn jacks up soil erosion by a remarkable factor of forty-five. Worse, the new leaves' most intense growth occurs in April, at the dry season's hottest, driest point. To propel growth, the roots suck up water from three to six feet below the surface. Tapping begins as the new leaves appear and continues until they fall. To replace the lost latex, the roots suck up still more water from the ground. How much water? Tang did some rough estimates with pen and paper. Half a kilogram of latex a day, twenty days a month tapping, 180 trees to the acre . . . good latex is 60 to 70 percent water . . . 4,400 pounds of water a year per acre. Rubber producers are effectively putting all the water in the hills into trucks and driving it away. "A lot of smaller streams are drying up," he said. "Villages have had to move because there's no drinking water." Now spread this impact across Laos and Thailand, he said. It would be a slow-motion remaking of a huge area. "It's not easy to tell what the effects would be," Tang said.

Beginning to heed ecologists' worries, Xishuangbanna effectively banned new rubber planting in 2006 by freezing all land rotation. The scheme is unlikely to have much effect. To begin with, as Shi notes, it seems to violate China's newly reformed land laws. But even if Xishuangbanna farmers were to stop planting *H. brasiliensis* tomorrow, its area would keep rising—on their own, rubber trees are invading the remaining forest.

Hillside rubber plantations surround Tang's office in the botanical garden. Because trees are grafted from the wood of high-yielding specimens, the great majority of the rubber trees in Southeast Asia are clones. And the majority of the trees used to create those clones descended from the few sprouts that survived from Henry Wickham's original expedition—a slice of a slice of a slice. These are the trees that Weir brought to Fordlândia, the varieties so highly susceptible to *M. ulei*. The trees make a canopy of green so unbroken that Beijing legally describes rubber plantations as "forests"; locals can fill fallow farmland with rubber and fulfill government conservation dictates. As the area of rubber increases, it becomes an increasingly inviting target for pests. "That's the lesson of biology," Tang said. "Diseases always come in. Sooner or later, they find a way."

For a century, isolation—the isolation of Southeast Asia from Brazil, of Southeast Asian nations from each other—has spared the rubber plantations. But the world is knitting itself together ever more closely. There are still no direct flights between Amazonia and Southeast Asia, but they will come. And in April 2008 the governments of Cambodia, China, Laos, Myanmar, and Thailand opened a brand-new highway that for the first time links all of these nations and connects them to Malaysia and Singapore. Trucks will be able to zoom in three days from Singapore to Kunming, the capital of Yunnan Province. If and when *M. ulei* arrives from Brazil, this will provide transportation. "In ten or twenty years, Xishuangbanna's trees could be wiped out," Tang said. "So would everyone else's trees, probably."

The disaster would take a long time to repair. The industrial revolution, one recalls, depends on three raw materials: steel, fossil fuels, and rubber. If one member of that triad suddenly vanished, it would have unwelcome effects. Imagine transportation networks without tires, electric power plants without gaskets and seals, hospitals without sterile rubber hoses and gloves. Industrial civilization could face such disruption worldwide that organizations from the United Nations to the U.S. Department of Defense list *Microcyclus ulei* as a potential biological weapon. Synthetic rubber will be deployed to replace it, but only as an imperfect replacement. "I sure as hell wouldn't want to be in a 747 about to land on synthetic tires," the director of the U.S. National Defense Stockpile Center has said.

Breeders are working on new, resistant plants, but progress is slow. "All control measures against this disease have been unsuccessful," stated the *Annals of Botany* in 2007. Even the most modern techniques "have failed to prevent large losses and dieback of trees." Asian scientists pulled some more trees from Brazil in 1981 to increase plantations' genetic diversity. These are being evaluated and cross-bred with more productive plants. Researchers in France announced in 2006 that they had fully resistant clones. But few plantation owners want to take up these varieties, which are new and therefore risky. Every ecologist I spoke with in Brazil, China, and Laos believed that Asia was almost as unprepared for leaf blight today as it was fifty years ago.

When I visited Xishuangbanna, I wore the same shoes that I had worn a few months before in Brazil. Because the spores are fragile, I was pretty sure I wouldn't cause an epidemic. Still, I sprayed my shoes with fungicide. At the border neither the Chinese nor the Laotian customs officials batted an eye at the two Brazilian visas in my passport, or the entry stamps that said I had passed through Manaus, epicenter of leaf blight. I wanted to do my work, so I didn't say anything.

Someday, though, there will be a problem. The cycle of the Columbian Exchange will be complete, taking away what it once gave. Trees will die fast. The epidemic will cover an area large enough to be visible from space: black-leaved splotches scattered from the tip of China to the end of Indonesia. There will be a major international mobilization of resources to fight the outbreak. And planters will suddenly be aware that they are living in the Homogenocene, an era in which Asia and the Americas are increasingly alike.