Chapter 1

The Devourer of Dreams

IT CAME as a surprise: a familiar nuisance suddenly turned an unfamiliar catastrophe. Over several seasons, coffee farmers from Peru to Mexico saw more and more yellow spots appear on the leaves of their trees. In previous seasons, the rust might have caused the occasional spot, but nothing serious. Now, however, leaves engulfed with lesions fell to the ground, leaving skeletal trees alive but entirely defoliated. The disease moved into highland areas that had previously escaped the disease. In February 2013, Guatemala's *Prensa libre* interviewed smallholders whose farms had been devastated by the rust. "I never thought this would happen to me," said Mauricio Méndez, whose farm had escaped the first rust outbreak in the 1980s. A smallholder named Bartolo Chavajay "could not contain his tears in the face of his rust-infested plot." The rust had destroyed Chavajay's entire harvest—his only source of income. Without the income, he wondered how he would feed his family. Yet another farmer, Moisés Misa, worried that the disease would harm his coffee's quality, reducing the price he would receive from buyers and lowering his modest income. Over several seasons, similar scenarios played out in thousands of farms across the Americas. The rust, wrote the *Prensa libre*, devoured the hopes of farmers. Even five years later some farmers—and some countries—are still struggling to rebuild their coffee farms.[1]

This outbreak, now known as the Big Rust, was the latest episode in a much longer story. The coffee rust is caused by a fungus known scientifically as *Hemileia vastatrix*. It first entered the written record in 1869, when it was found on a remote coffee farm in Ceylon (now Sri Lanka)—then the world's third-largest coffee producer. A little more than a decade later, the rust had driven Ceylon's coffee growers to abandon coffee. Between 1870 and 1990, the rust slowly made its way around the world's coffeelands, first striking Asia and the Pacific, then Africa, and finally reaching Latin America's vast coffeelands in 1970. By 1990, it had reached virtually every major coffee-growing region in the world except Hawaii. In some places, as in Ceylon, it was a catastrophe. The rust helped drive the collapse of coffee farming in Java, an island whose name remains synonymous with coffee. As the rust made its way across the globe, however, farmers and scientists gradually learned how to adapt their farms and farming practices to the disease. Farmers were supported by a complex network of national and international organizations. By the 1990s, it seemed that the rust was just another disease. Coffee communities had adapted to the rust, much the same way that communities around the world had adapted to the influenza virus. Like the flu, the rust could be a nuisance. But properly managed, it was nothing more than that—at least in theory.

Disease, Landscape, and Society

To understand the coffee rust's tangled history, it is helpful to understand how crop epidemics work. The coffee leaf rust is much more than the fungus alone. The fungus is present in many coffee ecosystems; in some, the coffee plants have mild infections that never develop into full-blown, disruptive epidemics. So clearly the epidemic is much more than the pathogen. We need to look beyond the pathogen alone and ask, What makes the disease a disease? To answer that, we need to consider how the coffee rust fungus interacts with the rest of the coffee ecosystem. It is helpful to consider an epidemic as a *system* with three major elements: the pathogen (the fungus *H. vastatrix*), a susceptible host (in this case the coffee plant), and the appropriate environmental conditions (rainfall, temperature, sunshine, cropping patterns, etc.). These three elements—virulent pathogen, susceptible host, and environmental conditions—can be represented as a triangle (fig 1.1).[2]

Epidemics are only possible if all three elements are in place. Most obviously, if the pathogen is not present, there can be no outbreak. But while the fungus is necessary for an outbreak, it is not in itself sufficient to cause one. The fungus and the susceptible coffee plant may be present in an ecosystem, but environmental conditions—say, the temperature or the farm structure—may prevent the fungus from reproducing rapidly, so there is no outbreak. In still other cases, the fungus may be present and the environmental conditions may favor the disease, but the coffee cultivar is resistant to the rust, so there is no outbreak. Furthermore, none of the three elements is absolute; different strains of the fungus can be more or less virulent, and different coffee cultivars can be more or less resistant. The environmental conditions also favor the epidemic to a greater or lesser degree. We can use the disease triangle to understand how the host, pathogen, and environment interacted in each place to produce an outbreak.

Each of these three elements is not only biological, it is also historical. Each element changes over time, the product of interactions among human and natural forces. People have, by planting thousands or even millions of susceptible plants together, unintentionally created environments that favor rust outbreaks. They have unintentionally carried spores of the rust

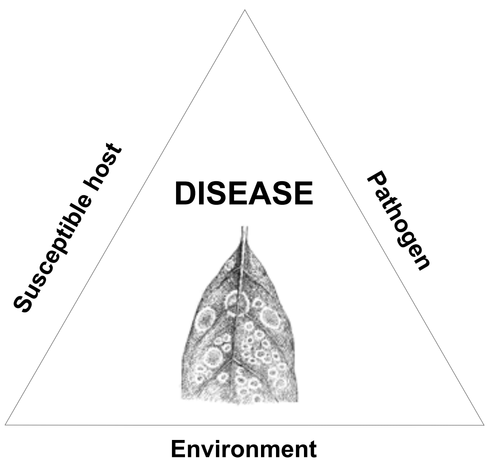

Figure 1.1. The disease triangle, showing how the pathogen, host, and environment interact to produce a disease outbreak.

farther and faster than the rust would have traveled on its own, infecting coffee zones that had previously been free of the disease. As farmers and scientists learned more about how the disease worked, they manipulated the host, pathogen, and environment to *limit* the rust. They tried to contain the pathogen through quarantines and to kill it with chemicals. They have strengthened the host by breeding rust-resistant coffee varieties. They have altered the coffee ecosystem, in places, by reducing or eliminating shade trees (fig 1.2), hoping that exposing the coffee farm to full sun would inhibit the rust.

The rust attacks the leaves of the coffee plant, but it harms the whole plant. A healthy coffee tree obtains most of its nutrition through its leaves, by photosynthesis. Nutrients allow the tree to produce new branches and buds, which in due course flower and develop into the fruit. In shaded forests, the coffee plants produce few flowers, and the leaves can provide more than enough nutrients to allow the fruit to develop properly. On the farm, farmers often manipulate the plant and the landscape to encourage the plant to produce more fruit. They reduce or eliminate shade, which encourages the plant to produce more flowers and, in turn, more fruit. They can also increase crop yields by pruning and manuring the trees. But they have to be careful not to ask too much of the tree, particularly the

PICKING COFFEE.

Figure 1.2. Coffee monoculture, nineteenth century. Dense stands of coffee like this were highly productive but also highly susceptible to diseases and pests. (In Thurber, *Coffee*, facing p. 7)

leaves. If the nutrition required by the fruit is greater than the tree can provide, the fruit may fail to develop properly; in some cases, the branches can become starved and die. So even in disease-free ecosystems, farmers have to ensure that they do not ask the tree for more nutrients than it can deliver. Sometimes they cut it close. Heavy fruit loads can cause coffee harvests to fluctuate widely from one season to the next. A heavy crop one season can draw so many nutrients that it inhibits the growth of branches and flowers the following season, leading to a lower fruit load—a pattern commonly described as biennial bearing.[3]

The rust disrupts this delicate balance. When a microscopic rust spore germinates, it sends shoots into the leaf and develops into a mycelium that colonizes the leaf and feeds off the leaf tissue. It creates a circular rust-colored lesion on the leaf, which gives the disease its name. If a leaf has just a few lesions, it can continue functioning more or less normally (see fig. 1.3). But if the conditions favor the fungus, the leaf can develop many lesions, making it difficult for it to deliver nutrients to the plant. Badly infected leaves can drop off altogether. During severe outbreaks, trees can be defoliated, depriving the tree of vital nutrients. Branches fail to develop normally and die back. The fruit, likewise, may not develop properly, or at all (see fig. 1.4). Severe rust outbreaks cause significant losses during the current season (primary losses).

The most serious effects of the rust, however, are typically felt in later seasons (secondary losses). After an outbreak, the trees may seem to recover; the next season they produce a new flush of leaves, and to a casual observer all seems well. But damaged or dead branches can no longer produce fruit. A recent study of coffee diseases and pests in Central America found that primary losses could be as high as 26 percent, while secondary losses reached 38 percent.[4] The rust exacerbated the patterns of biennial bearing; both the troughs and the peaks were lower. Once the fungus was present in the ecosystem, it was effectively impossible to eliminate. The coffee farm itself became a reservoir of infection. Farmers had to find ways of coexisting with the disease.

Picture a tropical mountainside, then divide it into three belts by altitude. The fungus is highly sensitive to temperature, and in the tropics, temperature is in turn heavily influenced by altitude. In the highest belt, temperatures are relatively cool. The rust fungus may be present but does not cause any significant damage to the plant. Coexistence is easy; farmers in this belt do not usually have to take any special measures to control the rust. Conversely, in the lowest and warmest belt coexistence is virtually

Figure 1.3. Coffee leaf with a few rust lesions, El Salvador. (Photo by author)

impossible. The fungus flourishes and causes such extensive damage that farmers cannot produce the crop profitably. Yields are too low, or the costs of managing the disease are too high. Those farmers typically abandon coffee cultivation. Much of our story will focus on the middle belt, the space where coexistence is possible but requires effort. Here, the rust can cause significant damage, but coffee may still be profitable if farmers can manage

Figure 1.4. Branch of rust-infected coffee tree, showing malformed coffee cherries and dieback, Costa Rica. (Photo by author)

it. The three belts lie on a continuum. The boundaries between them ebb and flow according to changing economic and ecological conditions. A sudden drop in the farm gate price of coffee, for example, may cause farmers to abandon expensive chemical control programs, which in turn would allow the disease to run its course. Conversely, a new rust-resistant coffee variety might make coffee production viable in a lowland region where the rust had previously made it impossible. Rising temperatures might trigger severe rust outbreaks in highland areas where they had previously been rare. The coffee ecosystems and the coffee economy—not to mention the rust fungus itself—are constantly changing, so coexistence with the rust is always provisional.

Themes

This story follows the global odyssey of the rust fungus from its home in the forests of southwestern Ethiopia, to its first spectacular outbreak in Ceylon, and then its spasmodic century-long journey across the global coffeelands. In each region, I move the focus outward from the fungus to consider how the coffee landscapes, societies, and economies shaped the rust outbreaks and the responses to them.[5] Histories of tropical commodities typically focus on vertical linkages, which follow the commodity from plantation to cup, from producers in the Global South to consumers in the Global North. Here, I offer a horizontal approach to the history of commodities: the rust reveals the evolving—and deepening—connections among people and landscapes across the Global South. Just as global coffee markets became more tightly connected and interdependent over the nineteenth and twentieth centuries, so too did global coffee producers.[6]

This horizontal history of coffee reveals the complex connections between coffee's life as a commodity and its life as a plant. The global coffee rust epidemic was triggered by a historically specific conjuncture of political, economic, social, technological, and environmental processes. It was, at first, a product of conquest, of empire, of liberalism, of steamships, and of migrations, both free and forced. These processes, among others, reconfigured the relations between *H. vastatrix*, the coffee plant, and the coffee landscapes in ways that favored a global epidemic. The coffee rust was not an isolated event; it was just one of a series of crop epidemics—commodity diseases—that started to break out at the same time, for many of the same reasons. The mosaic disease (a virus) wreaked havoc on global sugar production, while witches' broom and monilia decimated cacao production in places. Banana growers grappled with new global diseases like fusarium and sigatoka. These diseases could be devastating; in Central America even the powerful United Fruit Company struggled to maintain banana production in the face of fusarium and sigatoka.[7]

Commodity diseases have, in places, changed the global dynamics of commodity production. Producers in disease-free regions often had a significant advantage over producers in diseased regions, who had to contend with declining yields and the financial and logistical burdens of disease control. Even before the rust broke out, coffee growers in Asia and the Pacific struggled to compete against Brazil, whose coffeelands outproduced everyone else's. The rust outbreak simply helped consolidate Brazil's advantage. But the larger history of the rust also suggests that such regional advantages are temporary. Over time, the rust made its way around the world. Other significant diseases and pests, driven by the same forces as the rust, followed. The coffee berry borer (known as the *broca* in Spanish and Portuguese) traveled across the South Atlantic from Africa to Brazil in the 1920s and, since the 1970s, has spread through Central America. As coffee cultivation continues, farmers have to grapple with an accumulating array of local and global diseases and pests. Like the Red Queen in *Through the Looking Glass*, coffee farmers must run faster and faster just to stay in place.[8]

Coffee farmers—from smallholders to owners of estates—have never simply been passive victims of the disease. From the beginning, they innovated creatively and continuously in their quest to control the rust. They discovered and propagated rust-tolerant or rust-resistant coffees, some of which scientists would later use as stock for breeding programs. Well-heeled farmers bought exotic coffees at tropical nurseries in Europe's capital cities; some enterprising planters even organized collecting expeditions of their own. They experimented with virtually every chemical known or suspected to control crop diseases. They manured their farms and—depending on their situation and their particular understanding of the disease—they increased or reduced the amount of shade. They debated the causes of the rust; in Ceylon, the farmers who practiced what they called "high cultivation" blamed other farmers for the devastation caused by the rust. In Africa, European settlers sometimes blamed African farmers for infecting their farms with the rust. Debates about rust control have always been embedded in broader, intensely moralistic debates about good farming practices. Both individually and collectively, farmers searched for explanations for the outbreak and for strategies to coexist with it. Now, as then, farmers adopted whatever control methods best suited their particular situations, both economic and ecological.

Some places gradually developed administrative and scientific infrastructures to coordinate collective responses to the rust. Before World War II, these included imperial and colonial botanical gardens, ministries of agriculture, and national coffee institutes. After the war, this infrastructure grew to include multilateral research organizations—especially Portugal's Coffee Rust Research Centre (CIFC), bilateral and multilateral development organizations such as the US Agency for International Development (USAID), nongovernmental organizations, and private corporations. From the very beginning, these institutions have operated as an informal and decentralized yet powerful research network. Experts across the global coffeelands have constantly shared knowledge, technologies, and germplasm. This has been true ever since 1869, when the naturalist George Thwaites first sent samples of rust-infected leaves from Ceylon to the Royal Botanic Garden at Kew for analysis. Each contributed something to the growing global pool of knowledge about the rust, and in turn each benefited from the knowledge developed elsewhere. This openness may seem surprisingly altruistic—and it was—but it was also pragmatic. Most coffee research institutions were, and remain, small and inadequately funded. It was in their interest to share as much as they could and to learn how other communities were responding to the rust.[9]

Scientists have, from the very beginning, sought to understand the fungus and how it behaved in the field. In the 1880s, Harry Marshall Ward used the latest techniques in laboratory and field biology to demonstrate that the disease was caused by the fungus and to explain how cropping practices shaped rust outbreaks. Over the twentieth century, scientists have continued to refine and complicate our understanding of the rust's ecology in wild and cultivated ecosystems. They have also shed new light on the biology of the fungus and the genetics of rust resistance and virulence. They collected and circulated new varieties and species of coffee around the world; botanical gardens across the tropics built collections of coffee varieties, which formed the raw material for selection and breeding programs. Breeding was a long-term process that involved brute-force, large-scale systematic trial and error over years and sometimes decades. Researchers in the Dutch East Indies, for example, developed commercially viable selections of robusta. Starting in the 1960s, Portuguese researchers developed the Timor hybrid, a rust-resistant coffee that was the foundation for research. More recently, a network of researchers at the US-based World Coffee Research has been developing new F_1 hybrid coffees by blending classical breeding and selection with some of the latest biotechnologies. Scientific research is also vital to localizing tools and technologies developed elsewhere. For example, chemical fungicides have to be applied at just the right moment in the fungus's life cycle, which is shaped by local conditions. So the optimal time for spraying in Kenya, for example, is not necessarily the same as that in Costa Rica. In these ways and others, science has helped farmers around the world sustain production in the face of the rust.

Even so, science alone has seldom been a panacea, and relations between scientists and farmers have not always worked smoothly. Over the nineteenth century, scientists learned a lot about the rust but could not offer coffee farmers effective ways of controlling it. Some of the disease-control strategies they later developed did not meet the farmers' needs in other respects. In the 1970s and 1980s, scientists, backed by national coffee institutes and international research organizations, encouraged farmers to technify their farms by eliminating shade, planting high-yielding cultivars, and using fertilizers and fungicides. This technical package would, in principle, both control the rust and boost yields. But in most places only a minority of farmers adopted the full package. Others only adapted parts, or they continued farming coffee as they had done before. The package was simply not suitable for many of the region's smaller farmers, who did not have access to capital, expertise, and technology to transform their farms. Some were reluctant to give up the traditional arabica cultivars that produced the high-quality coffees for which the region was famous. Farmers were not opposed to scientific innovation in general; they readily adopted cultivars and technologies that fit well in their economic and ecological niches. Since the 1990s, scientists have paid more attention to developing rust-control strategies that are both economically and ecologically sustainable, for farmers large and small.

The rust's effects have rippled along the commodity chain—from coffee mills to roasters to consumers. According to one apocryphal story, the coffee rust outbreak in Ceylon explains why British consumers abandoned coffee for tea.[10] This is a compelling story about the power of commodity diseases. But there is no evidence to support it, and plenty to contradict it. The collapse of Ceylon's coffee industry caused barely a ripple in British consumption; any shortfalls from Ceylon could have easily been offset by imports from other sources. The most recent outbreaks in Central and South America may mark a change to this pattern, however, as this region produces most of the world's high-quality mild arabicas, which are difficult to replace with coffees produced elsewhere. This helps explain the coffee industry's growing interest in rust research and mitigation.

While the rust has not significantly reduced the global supply of coffee (to date), it has changed the global coffee trade in other ways. The Dutch developed the low-quality robusta coffee as a commercial species after 1900 because it was resistant to the rust. It has since transformed the global coffee trade, now typically accounting for between 30 and 40 percent of global coffee production. It is widely used in blended and instant coffees. And although it is typically associated with low-quality coffees, some Italian coffee aficionados argue that a little bit of robusta is an essential component of espresso blends since it helps the coffee develop its characteristic crema. The specialty coffee industry, which has long disdained robusta coffee, is now slowly starting to accept hybrid coffees that contain some robusta genes, like Colombia's Castillo coffee.[11]

The heaviest burdens of the coffee rust, like the burdens of most commodity diseases, have been borne by the producers. The rust has disrupted livelihoods and landscapes. In myriad ways, the global coffeelands bear the imprint of the rust. It has transformed coffee farming, forcing farmers to either find strategies to coexist with the disease or abandon coffee cultivation altogether. It has driven farmers and laborers out of the countryside, to seek their livelihoods elsewhere. The imprint of the rust is visible in places where farmers use chemical control or have switched to resistant varieties to keep the rust levels down. The rust has changed the economics of coffee farming; rust control has made coffee production more expensive. Farmers have to pay for the supplies, labor, and technology necessary to carry out effective programs of rust control. Still other farmers cope with the rust by cultivating coffee in complex agroforestry ecosystems, which are ecologically resilient but typically produce far less coffee and, therefore, less income. Farmers can bear these costs if the price of coffee is high enough to offset them. The rust alone does not devastate coffee farms; the combination of disease and low coffee prices does.

While this study is organized around the coffee rust, it is also about the environmental history of coffee writ large. The rust is acutely sensitive to the broader conditions in which coffee is cultivated. Small changes in the conditions can trigger larger changes in the disease. The rust epidemic allows us to do the environmental equivalent of atom smashing. Physicists explore the behavior of subatomic particles by smashing particles into atoms and seeing what happens. The results shed light on the structure and function of atoms. A rust epidemic does the same thing: it sheds light on how the coffee ecosystem functions by disrupting it. Viewed as a time lapse, global coffee frontiers have been in constant motion, expanding in some places while contracting in others. The rust opens a window into these forces, showing the complex reasons why some regions survived the epidemic while others did not. The story of the rust embodies the broader environmental challenges that coffee producers face, including climate change. As we try to make sense of climate change, which in many respects is without precedent, the history of the coffee rust can offer some insight into how farmers have adapted to other permanent, large-scale changes to their ecosystems.

The Story, in Brief

The story begins with a prehistory of the coffee rust, before it became legible in the mid-nineteenth century. There is no evidence of any significant outbreaks before about 1870. Nor, based on what we know of the disease, is there any reason to believe that there *were* any major outbreaks that went unrecorded. The fungus was present in the forests of southwestern

Ethiopia, the wild home of arabica coffee. But the structure of coffee production in Ethiopia likely kept any potential outbreaks in check.

The early global migrations of arabica coffee accidentally kept the rust contained to this small area. Arabica coffee was first cultivated on a large scale across the Red Sea in Yemen, on landscapes so hot and dry that the coffee plants had to be irrigated and cultivated under shade. These landscapes were singularly hostile to the development of the rust fungus, which requires water droplets on the leaves in order to germinate. Yemen's coffeelands were an ecological filter against the rust, which matters because the world's coffee farms were established by coffee seeds and plants acquired from Yemen, rather than Ethiopia. So as commercial coffee production spread globally in the seventeenth and eighteenth centuries, the rust fungus was contained in Ethiopia. There was no rust to impede the development of coffee cultivation in Africa, Asia, and the Americas—especially on intensive plantations. In the absence of the rust, coffee flourished in places where it would have otherwise been impossible.

The first wave of the rust, which lasted almost a century, was decisively shaped by European colonialism. The first outbreak was recorded in Ceylon, in 1869. Over the next century, it spread through Europe's tropical colonies in Asia, the Pacific, and Africa. These were fundamentally colonial epidemics; the rust spread through the networks of empire that linked previously isolated coffeelands ever more tightly. Spores of the fungus traveled on the wind and also stowed away on steamships, railroads, and airplanes. They were carried on the bodies of planters, laborers, and others who moved within and between the coffeelands. The fungus found purchase on the booming colonial coffee plantations, where it often found dense monocultures on which to feed and propagate. Within a decade of the first outbreak, the rust had caused the collapse of Ceylon's coffee industry and seriously harmed production across the Eastern Hemisphere. It destroyed most of East Africa's emergent coffee farms and limited global arabica production to a few highland enclaves where the fungus could be managed.

Colonial governments debated about how best to support coffee farmers, or even whether to do so. Each state emphasized some measures over others, depending on a range of considerations such as the intensity of the outbreak, the control measures available, the economic and political importance of the coffee industry, and broader ideas about the state's obligations to farmers. In Ceylon, the imperial government (grudgingly) sent Harry

Marshall Ward to study the problem. While Ward conducted brilliant and innovative experiments on the rust, he could not offer any effective means of controlling the outbreak. The government was unwilling to support any further research or to offer the planters any other support, so they were left to their own devices. In contrast, the colonial state in the Dutch East Indies was much more willing to support its coffee farmers. Researchers at the coffee experiment station in Dutch Java conducted pioneering studies on resistance and on breeding commercially viable strains of robusta coffee, which was widely adopted as a replacement for the devastated stands of arabica. But in spite of this research, effective controls remained elusive, and the rust contributed decisively to a broader decline in arabica coffee production in the Eastern Hemisphere.[12]

The second phase of the global rust epidemic, which lasted from the mid-1950s to the mid-1980s, was decisively shaped by the Cold War. Before the 1950s, coffee farmers in Latin America saw rust as a remote problem. But as the epidemic spread through West Africa, a handful of people, like the American Frederick Wellman, began to sound the alarm. In 1970, the rust was detected on a farm in Bahia, Brazil. Over the next fifteen years, farmers—along with a slew of national and transnational organizations—attempted to contain the rust as it spread inexorably across the Americas. The rust broke out in Nicaragua in 1976, and by the early 1980s, it had reached almost every corner of Latin America's coffeelands.

This epidemic and the responses to it were shaped by Cold War politics. This included international trade agreements, especially the International Coffee Agreement, which were, in part, designed to forestall rural unrest. The United States—particularly through the US Department of Agriculture (USDA) and the USAID—assumed a significant role in shaping coffee cultivation generally, and responses to the rust specifically. It helped finance the Coffee Rust Research Centre in Portugal and the Center for Tropical Agricultural Research (CATIE) in Costa Rica. During these decades, the national coffee industries across Latin America were arguably as strong as they had ever been. National coffee institutes conducted research and offered coffee farmers financial and technical support. Organizations like Brazil's Instituto Brasileiro do Café, Colombia's CENICAFÉ, and Costa Rica's ICAFÉ conducted innovative research on breeding, chemical control, and other facets of the disease. In many places, the rust epidemic triggered a Green Revolution–style modernization of coffee farming. Scientists and government bureaucrats encouraged farmers to switch to higher-yielding dwarf coffees. The higher productivity—along with heavy application of fertilizers and fungicides—more than offset any losses caused by the rust. Farmers were also encouraged to reduce or eliminate shade on the assumption that full sunlight was inimical to the rust. Still, many farmers across the Americas only partially technified their farms, for example choosing to use chemical control but continuing to plant traditional arabicas.

In Latin America, the rust caused panic before it arrived. But when it did arrive, it did not produce a wholesale collapse of coffee production as it had elsewhere. Some individual farmers suffered, at times catastrophically. But collectively, the coffeelands of Latin America did not see significant declines in production. The coordinated scientific and institutional responses played a part in controlling the fungus. But there was also a strong element of geographical luck: most of Latin America's coffeelands were in comparatively cool, high-altitude landscapes with distinct dry seasons, where the rust either was not a significant problem or could easily be managed. By the end of the 1980s, the rust had been domesticated virtually everywhere in the Americas. Farmers had adapted to it and treated it as just another disease. As long as farmers in susceptible areas kept spraying and fertilizing their farms, it seemed that the rust no longer presented a significant threat.

A third phase—the neoliberal phase—of the coffee rust began around 2008. A new series of devastating rust outbreaks, known as the Big Rust, began in Colombia, spread to Central America in 2012, and ultimately encompassed a vast area bounded by Puerto Rico, Mexico, and Peru. Unlike the previous rust epidemics, the Big Rust was not triggered by the migration of a pathogen to an area that had previously been free of the disease. Rather, it was fueled in part by a complex set of changing weather patterns that favored the fungus. It was also caused by fundamental changes in the economic and institutional context of global coffee production, which once again made the coffeelands vulnerable to outbreaks. The collapse of the International Coffee Agreement's price stabilization system in 1989 triggered a new, highly volatile cycle of booms and busts. During the busts, farmers economized by cutting back or delaying measures that had previously kept the rust in check. Farmers were, in many cases, more poorly equipped to respond than they had been a generation before. In the 1980s and 1990s, many of the public institutions that had previously provided essential research, credit, and extension to coffee farmers fell victim to austerity programs.

The Big Rust has been far more devastating than the initial outbreak of the 1970s and 1980s, and recovery has been much slower. In many respects, Colombia's coffee industry responded quickly and effectively; its national research institute, CENICAFÉ, rolled out new resistant varieties and advised farmers on other disease-control measures. The National Federation of Coffee Growers effectively lobbied the government for financial support for afflicted farmers. But even in this best-case scenario, it took five years for Colombian coffee production to recover to pre-rust levels. Elsewhere in Latin America, few states could emulate the Colombian model. In places like Mexico, the epidemic encouraged farmers to mobilize and demand more resources from the state. Out of necessity, the private sector—especially the specialty coffee industry—started to offer technical and financial support to some farmers. They are now financing new research organizations, such as World Coffee Research. Or, like Starbucks, they are conducting their own research. While these private-sector initiatives are important, their reach remains limited; they can help only a small portion of afflicted farmers. New technologies, such as systemic fungicides and F_1 coffees, also help in the fight against rust. But fundamentally, the main obstacles to managing the rust remain organizational and financial as much as technical.

The Big Rust is a bellwether event, foreshadowing the kinds of adaptations that coffee farmers will need to make in the face of climate change. While it remains unclear whether or not the Big Rust was caused by long-term climate change, unusual weather patterns certainly played a critical role. As researchers and farmers adapt to the rust and to the other environmental challenges facing coffee production, their paradigms are gradually shifting. Before the 1990s, most rust-control efforts focused on increasing productivity. The assumption was that increased production would offset the costs incurred by disease control. Now, even in conventional coffee production, control programs focus more on ecological and economic sustainability. Both the ecological and economic challenges must be addressed if coffee is to have a long-term future.