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How Coal Kept My Valley Green: Forest Conservation, State Intervention, and the Transition to Fossil Fuels in Mexico

Abstract

For many nineteenth-century Westerners, including Latin Americans, deforestation represented the largest environmental threat of their time. Deforestation was associated with detrimental local effects on climate, decreased rainfall and agricultural productivity, rapid soil erosion, and worsening human physical and mental health. The onset of industrialization and the widespread adoption of steam engines, which often ran on wood, resulted in rapid and pervasive forest clearance in the last decades of the nineteenth century. In response, many conservationists and successive Mexican governments turned to fossil fuels (coal and oil) as a way of reducing overexploitation of forests while still promoting industrial growth. This approach to conservation helped to steer the country down a path of fossil-fuel dependency. By the 1940s, Mexico had made

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fossil fuels the basis of its economy and society. Ironically, such fossil fuel dependence created the conditions for explosive urban and demographic growth in the second half of the twentieth century that destroyed much of the forest the transition initially aimed to protect. The study thus insists on the decisive role that environmental concerns and state policies played in developing Mexico's modern fossil fuel energy regime, as well as the relevance of a historical perspective when considering the long-term environmental consequences of this shift.

Not ideas, but material and ideal interests, directly govern men's conduct. Yet very frequently the "world images" that have been created by "ideas" have, like switchmen, determined the tracks along which action has been pushed by the dynamic of interest.¹

—Max Weber

INTRODUCTION

In 1864 the prominent Mexican physician and chemist Leopoldo Río de la Loza wrote state authorities to denounce the massive deforestation taking place in the mountains surrounding Mexico City. Río de la Loza blamed two groups: indigenous communities and steam-powered factories. He criticized indigenous communities for their supposedly "primitive" and "wasteful" use of forest commons, such as the spring custom of setting fire to grasslands to foster regrowth that he considered detrimental to forest regeneration. Río de la Loza also attributed deforestation to the new steam-powered factories, such as textile factories and paper mills, with their insatiable appetite for wood.² Whoever the main culprit of deforestation was, for Río de la Loza the results were unequivocal: a decline in public health, an increase in drought, and spreading desertification.³ The best way to prevent a complete disaster, he argued, was for coal to replace wood as the valley's main source of energy.

This article explores how state policies and legislation of successive Mexican governments in the late nineteenth and early twentieth centuries sought to curb rapid deforestation by fostering the energy transition to fossil fuels (coal and oil) in industrializing regions of the country such as the Valley of Mexico and Monterrey. I define "energy transition" as the shift from one energy regime to another, a process during which a new energy source becomes dominant or represents more than half of total energy consumption.⁴ To track the transition,

I focus on energy consumption in key industries such as manufacturing, transportation, and, after 1890, electricity generation. For conservation-minded Mexican elites and successive Mexican governments, coal and then oil solved the twin problems of rising deforestation and rapidly increasing energy demands, both caused by industrialization. Yet in seeking to conserve forests without disrupting industrial growth, these individuals unwittingly promoted the adoption of energy and economic regimes that have had unprecedented and unforeseen environmental consequences not only for Mexico's forests, but for the world, as the country's historical carbon emissions have significantly contributed to today's climate crisis.⁵ The story of modern Mexico's forests, industrialization, and fossil fuel transition explores the relationships between ideas about nature and conservation, the role of the state as both environmental protector and industry promoter, and the relevance of an environmental history perspective when considering why and how energy transitions unfold.

The article represents a threefold scholarly contribution. First, it demonstrates the global scope of the energy transition to fossil fuels by focusing on a country in Latin America, a region that energy historians have almost completely overlooked.⁶ Scholars have often treated the transition to fossil fuels as a predominantly Western European and US process, essentially equating increased fossil fuel consumption with Western "modernization." Second, the article analyzes Mexico's transition to fossil fuels from the perspective of the state and ideas about nature and industrial civilization, a rare vantage point in energy history. The vast majority of scholarship on the topic has focused on economic and technical factors, largely ignoring how intellectual traditions and state policies have shaped those shifts.⁷ Finally, the article brings together two themes that environmental historians rarely treat in tandem—forest conservation and energy transitions—showing how they have shaped each other over time.

EARLY VIEWS ON FOREST CONSERVATION

In the 1850s, both conservative and liberal governments in Mexico took an interest in forest conservation. In 1854, during General López de Santa Anna's conservative administration, the recently created Ministry of Development (*Ministerio de Fomento*) asked mining districts nationwide for information about the extension and characteristics of the forests being logged for mining. The government agency also inquired about local regulations governing forest exploitation and reforestation efforts. In 1857 the new liberal government, despite ongoing military challenges from conservatives, sent a memorandum encouraging state governments to enact legislation protecting forests.

In typical fashion for Mexican liberals, the government not only delegated the responsibility to local authorities but also made clear that conservation measures should not interfere with the timber needs of industries and mines.⁸

Calls for forest conservation became more common in the 1860s. Key institutional actors in Mexican science, such as the Mexican Society of Geography and Statistics (*Sociedad Mexicana de Geografía y Estadística*), began publishing significant work on forest conservation.⁹ In one editorial, the editors of the *Boletín* (the society's publication) expressed alarm over rapid forest loss.¹⁰ Like Río de la Loza, they blamed factory owners and the indigenous population, who "cut and destroy their only patrimony," although they also criticized owners of large estates (*hacendados*). The journal also published the work by conservationists such as Romero Gil, who drew from Alexander von Humboldt and Mexican mining engineers to argue that forests prevented drought and fostered human health. In one article, Gil offered an overview of earlier forest legislation and called for reviving provisions from colonial forest laws, particularly those relating to coppicing (*horca y pendón*). In an effort to inspire analysis and discussion of earlier legislation, the *Boletín* reprinted an 1845 Mexican forest code, one of the first issued in independent Mexico.¹¹

A second hotbed for conservationist ideas appeared with the 1868 foundation of the Mexican Society of Natural History (*Sociedad Mexicana de Historia Natural*) and the 1869 launch of its journal, *La Naturaleza*. Around this time, discussion of fossil fuel energy, specifically coal, began creeping into the blooming discussion on forest conservation. In the first issue of *La Naturaleza*, mining engineer and founding member Pedro Monroy wrote that coal is the basis of industrial civilization, mining companies should focus on extracting coal and iron instead of gold and silver, and coal should replace wood as an energy source to reduce deforestation.¹² Monroy articulated the increasingly common idea that adopting coal would allow for unrestricted industrial growth *and simultaneously* protect forests.¹³

Up to this point, Mexican industry relied almost exclusively on wood and water to power factories, a strategy that eventually caused widespread deforestation and constrained industrial production. While the alarm with which many Mexican elites wrote about deforestation is indicative, it is nevertheless difficult to say exactly how severe deforestation was in the second half of the nineteenth century. We simply lack precise quantitative evidence regarding deforestation before 1870, given that statistics at the time was still an incipient discipline in Mexico and the government did not have the administrative and technical capacity to collect such information. After 1870, conservationists and government officials made the first attempts to quantify forest loss, but efforts remained unsystematic. Only at the beginning of the twentieth century, when the newly minted Forestry

Department created a division charged with collecting forest statistics, did more regular and reliable information become available. Despite these caveats, most sources suggest substantial deforestation in industrializing areas like the Valley of Mexico by 1880.¹⁴ Piecing together these fragmentary data, I estimate that the area immediately surrounding Mexico City—the industrial hub of the nation—experienced deforestation of about 30 km² per year by the early 1880s to keep its factories working and locomotives running, as well as to meet nonindustrial needs such as providing cooking fuel to households.¹⁵ Such pressure must have increased rapidly in the following years as industrialization expanded apace, clearing large areas of forest cover.

Regardless of the actual severity, Mexican elites and government officials firmly believed industrial-caused deforestation was rampant. Such perceptions led members of the Mexican press to support coal. The famous journalist Emilio Chávarri, known as “Juvenal,” published an editorial in the liberal newspaper *El Monitor Republicano* in which he described coal as the basis for transforming the country into a modern industrial nation. Juvenal asserted that the adoption of coal would allow Mexico’s forests to regenerate after centuries of mismanagement and destruction. As forests returned, Juvenal optimistically predicted, “their oxygen-filled exhalations would vivify our atmosphere” that had been impoverished by deforestation. The absence of tree cover, he lamented, had “changed the climate of deforested regions, [. . .] turning nearby settlements into sickly areas, because there is no more rain and noxious, insalubrious winds blow over them.”¹⁶ Although reflecting a preference for deploying the state to create a market for coal, Juvenal’s emphasis on adopting coal to curb deforestation may have also betrayed a distaste, common among Mexican liberals, for state intervention into the private sphere that certain forms of forest management might lead to.¹⁷

In addition to scientists and journalists, politicians with interest in forest conservation pushed for the adoption of coal. Congressman Don Manuel Fernando Soto, for instance, published an article in *Boletín* supporting the establishment of a railroad line between the Atlantic and Pacific Oceans. According to Soto, the new railroad would link northern Veracruz, the central highlands, and the coast of Guerrero, enabling the transportation of foodstuffs and raw materials to mining areas. In particular, Soto viewed the railroad as an opportunity to introduce coal into Mexico on a large scale. Replacing wood with coal, Soto argued, would decrease deforestation and make feasible the widespread adoption of steam engines, fostering industrial growth.¹⁸

Along with stemming deforestation, the Mexican intelligentsia considered coal the engine of industrial progress. In 1880, for instance, prominent Mexican statistician Emiliano Busto wrote that

coal and iron were “the heart and soul” of modern civilization and the key to future advancement. For Busto, iron and coal were providential: God had enriched the earth with them “knowing that, one day, humanity would discover that key to unlocking the future that would change the face of the earth.” Busto claimed that iron and coal were the two most important commodities that could be extracted from nature and were ubiquitous in industrial civilization. Both were present in nearly everything that human beings created from the humblest needle to the largest buildings. Thanks to coal-fueled steam power, iron had become a machine that could do the work of countless men, capable both of crushing rock and handling the most delicate fabric, all without complaint. Put simply, Busto waxed enthusiastic, iron was the perfect worker.¹⁹

According to Busto, iron was the body and coal-produced steam the soul of industrial civilization. Together they made a “sacred monster” that erased distance and divided mountains to “unite all the peoples of the world.” With coal and iron, humans overcame the limits of nature, fulfilling the biblical command to multiply and dominate the world. Machines, the “Prometheus of progress,” redeemed workers from drudgery, allowing more and more “workers of labor” (*obreros del trabajo*) to join the ranks of the “workers of the spirit” (*obreros del pensamiento*). In a prediction curiously redolent of Marxist utopia, Busto announced that through iron and coal-produced steam, humanity would be emancipated and the life of the spirit would reign supreme.²⁰

But Busto not only waxed lyrical about the spiritual benefits of adopting coal and iron; he explicitly linked national progress and power to large supplies of both. For Busto, it was clear that the nations holding humanity’s destiny in their hands were endowed with enormous deposits of these materials. Any nation that did not secure those two “elements of civilization” would be left behind, doomed to perpetual servitude to the “iron nations.” Adopting Spencerian language, Busto saw nations as superorganisms engaged with each other in a perennial struggle for survival. Busto bleakly predicted that those “southern” nations that refused to accept and adopt the formula of progress (iron and coal) would face extinction.²¹

In short, for Busto, iron and coal made nature and other energy sources such as wood and water largely irrelevant. With coal, the masculine domination of nature became reality. While geography and nature had once been destiny, iron and coal could now make deserts bloom, enabling people to create reservoirs, build tunnels, link remote places to distant markets, and erect cities almost anywhere. Wherever iron and coal existed, industrial civilization would conquer nature, accumulate vast wealth and power, and flourish. For Busto, then, the adoption of coal represented a clear break with the past; coal quite literally produced modernity. Busto’s views on coal as the

basis of modern industrial civilization were shared by the vast majority of Mexican elites.²² As one Mexican newspaper put it, coal was the “vital element of the time” (*el elemento vivificador de la época*).²³ The question was how to turn Mexico into a coal-powered nation.

COAL

By the late 1870s, the Ministry of Development believed a state policy was needed to foster coal consumption in order to protect Mexico’s forests and industry. Created on April 22, 1853, under the last administration of General Santa Anna, the Ministry of Development, Colonization, Industry, and Commerce (*Ministerio de Fomento, Colonización, Industria y Comercio*) was charged with fostering national industry through protectionist policies. (Ironically, the ministry would play a key role in attracting foreign investment in its heyday during the *Porfiriato*.) Although the ministry’s responsibilities substantially changed over time, in general they included expediting the development of the nation’s infrastructure and creating the necessary conditions for the more efficient exploitation of the country’s resources. The ministry played a key role in building Mexico’s railway network. It also collected, analyzed, and published statistical and scientific data on Mexico through its numerous annals (*anales*) and compilations (*memorias*) and promoted the development of new crops and industries. An unmistakable utilitarian bent characterized the ministry’s efforts, including its funding of scientific expeditions. The agency was the cornerstone of the modernizing project that Mexican elites undertook during the second half of the nineteenth century.²⁴

In memos sent out to state governors in 1878 and 1880, General Carlos Pacheco, the ministry’s secretary, argued that deforestation across the country had increased in recent years due to the country’s economic development. The mining boom, railway network expansion, and industrial growth, Pacheco surmised, were taking a huge toll on forests. Pacheco then repeated the conservationists’ mantra that deforestation reduced the fertility of the land, proved detrimental to human health, and led to drought. Without forests, Pacheco contended, industries and agriculture withered. The government had the responsibility to “avoid the transcendental damages” (*trascendentales perjuicios*) already evident and to prevent future generations from accusing theirs of “shortsightedness and lack of culture.” Following Pacheco’s pleas, Congress asked the executive branch to enact a new forest code, which it did in 1881, putting the ministry directly in charge of conserving and managing forests on federal land.²⁵

That same year, the ministry began funding a series of expeditions to locate domestic coal deposits with the explicit goal of reducing

deforestation through coal substitution.²⁶ The man chosen to lead such efforts was Santiago Ramírez, the foremost expert on coal in Mexico and a staunch forest conservationist. Ramírez agreed that the introduction of steam engines and the extraordinary expansion of railroads—both of which relied on wood for fuel—had resulted in rapid and widespread deforestation in Mexico. Like ministry officials and other conservationists, Ramírez considered deforestation an urgent national issue, one that posed a direct threat to Mexico's industrial development and people's health. He praised the Ministry of Development's farsightedness not only in enacting forestry laws that sought to prevent the overexploitation of forests but also in offering industry and railroads an alternative fuel to wood. As he explained, the ministry's officials realized that transitioning to fossil fuels (coal, specifically) was an essential component of any forest conservation policy, without which forest legislation would be rendered dead letter ("complying with the restrictions would be virtually impossible").²⁷

The ministry's determination to substitute coal for wood in industry and railroads led the agency to name "scientific commissions" (*comisiones exploradoras*) charged with exploring regions in the country likely to have coal deposits.²⁸ In addition to locating and analyzing coal deposits as well as describing their economic potential, the commissions' main task was to propose measures to foster coal mining in Mexico, both to protect forests and promote the country's growing industry and railroad network by providing it with cheap and abundant fuel.²⁹ Based on a number of previous reports published by private prospectors, the ministry sent commissions to several states in central, southern, and northern Mexico. These included Puebla, Tlaxcala, Oaxaca, Veracruz, San Luís Potosí, Coahuila, and Sonora. Such efforts would continue until 1895.³⁰

A year later, in 1882, the Ministry of Development began publishing a series of enormously influential reports on coal deposits in Mexico.³¹ Investors and state officials now had a clear idea of the geography and main characteristics of most of Mexico's coal deposits. Much to the disappointment of Mexico City elites, the reports found the largest coal seams in the north, especially Coahuila and Sonora, not in central Mexico, where the largest population and manufacturing centers were located. Although more centrally located states such as Oaxaca and Puebla contained some sizable deposits, these were largely located in mountainous regions difficult to access. The reports indicated that without railroad connection to those areas, extraction would not be profitable. The commissions also collected a large number of samples that allowed engineers to classify coal deposits in Mexico, a central concern for investors. The reports had almost immediate practical effects. By 1884, coal was being mined across Mexico in small quantities with Coahuila producing 30,000 tons per year, a respectable amount by Mexican standards. In the next quarter

century, Mexico's coal production would increase rapidly, reaching around two million tons by 1910.³²

The ministry's reports not only fostered coal production but also resulted in profound changes to Mexican law. As coal production increased, it became clear to state officials that Mexico needed a modern legal framework to facilitate and regulate coal extraction. A heated debate broke out between those who argued that coal deposits ultimately belonged to the nation (following the tradition of the colonial mining ordinance, *Ordenanzas de Minería*) and those who defended the preeminence of private property rights. To a degree, the controversy was rooted in confusion over the natural composition of coal and other fossil fuels. For some experts, and seemingly many laypeople, the organic origins of coal and oil made them nonmineral. Critics of this position posited that although both were organic in origin, they had been formed by geologic nonorganic processes, thus qualifying them as minerals. Most experts agreed and considered both coal and oil as "fossil fuels" (*combustibles fósiles*).³³ As such, coal and oil should fall under the old colonial tradition of state ownership that only governed minerals.³⁴

The matter was settled in 1884 when the federal government enacted a new mining code.³⁵ The code's authors were mostly interested in creating suitable conditions for Mexico's industrialization and were perfectly aware that a key component of the project was the large-scale adoption of fossil fuels for industrial power. The new code recognized coal and oil as minerals (as under colonial law) but gave private owners full property rights to surface and subsoil mineral wealth.³⁶ Thus the Mexican state relinquished its claim to being the ultimate proprietor of subsoil commodities, including coal and oil, and declared that private landowners could exploit those deposits without prior government authorization. The code also sought to stimulate coal and iron mining by exempting both from taxes for fifty years. It is important to note that scholars have often interpreted the mining code of 1884 as an attempt to attract foreign investment, overlooking its long-term effects on Mexico's energy transition to fossil fuels.³⁷ The code not only regulated the fossil fuel market; it created it. Beyond spontaneous market processes, it was lawmaking—that ultimate tool of politics and policymaking—that proved instrumental in Mexico's transition to fossil fuels. The code remained the main legal framework for the coal and oil industry until the enactment of the Constitution of 1917.³⁸

Conservationists played a particularly important role in persuading Ministry of Development officials to foster coal production. They were affiliated with key scientific organizations at the time, including the Mexican Society of Geography and Statistics and the Mexican Society of Natural History, which published the two most prestigious scientific journals of their time: *Boletín* and *La Naturaleza*. But they

also held political office, with presidents, ministers, and other high-ranking state officials sitting on the boards of their societies. For instance, Porfirio Díaz, the Mexican dictator who ruled the country between 1876 and 1911, was the honorary president of the Mexican Society of Geography and Statistics and frequently presided over the organization's meetings. While this does not mean Díaz was a conservationist, it exemplifies the access conservationists had to the most powerful members of the Mexican government.

A perfect example of these influential conservation-minded figures is Mariano Bárcena (1842–99). Bárcena was a naturalist, an engineer, and an important politician, serving as senator and governor of his native state, Jalisco. Born in 1842, Bárcena moved to Mexico City in 1865 to study art at the prestigious Academia de San Carlos. He soon dropped out and enrolled in the National Preparatory School (*Escuela Nacional Preparatoria*), the bastion of positivism in Mexico, where he studied geology and botany with Gabino Barreda, Mexico's educational reformer, and chemistry with Leopoldo Río de la Loza. Bárcena then joined the School of Engineering (*Escuela Especial de Ingenieros*), from which he graduated in 1871.³⁹ He soon became one of the most influential scientific and political figures in Mexico and a respected scholar abroad. A prolific writer, university professor, editor, and member of many prestigious scientific organizations, Bárcena was honored by Mexico's Emperor Maximilian (1864–67) with the imperial order of Guadalupe, the highest order in the country. Following the fall of Maximilian's brief empire, a succession of Mexican liberal governments named Bárcena representative of Mexico in the world fairs of Philadelphia (1876), New Orleans (1885), Paris (1889), and Buffalo (1900).⁴⁰

Bárcena was also an advocate of coal. Like other Mexican conservationists, he argued that coal would "save our mutilated forests, which are being exhausted for the production of ties, fuelwood, and industrial resins."⁴¹ Bárcena believed adopting coal was essential to stemming industry-driven deforestation while still allowing Mexico to become a modern industrial nation. It was figures such as Mariano Bárcena and Santiago Ramírez who pushed the Ministry of Development to take a leading role in Mexican forest conservation by promoting coal use.⁴²

By the turn of the twentieth century, the combined efforts of conservationists, an active state interested in preserving forests while stimulating industry, and a new legal framework had proved successful. Mexican industries, railroads, and power plants were burning hundreds of thousands of tons of coal per year, effectively initiating the economy's energy transition to fossil fuels. Coal had become an important part of the country's industrial regions. Monterrey, the second most important industrial center of the country, was particularly dependent on coal, with its main power plant, urban railroads, and largest factories burning vast amounts of it.⁴³ Monterrey was also located

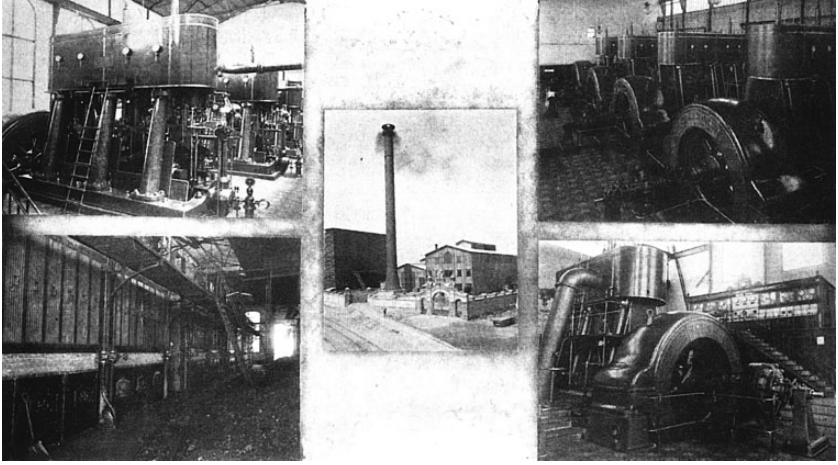


Figure 1. Nonoalco Power Station in Mexico City around 1900. Coal is visible in the bottom left image. Source: *México Ilustrado*, 1903, 152. Credit: University of California Berkeley Library.

close to Coahuila's coalfields, making dependence feasible. Not so in the case of the Valley of Mexico, located far from deposits of cheap good-quality coal. Industrial establishments, power plants, and railroads in the valley were forced to acquire coal from Coahuila or import it from abroad, keeping coal use there more limited and expensive.⁴⁴ But the adoption of coal on a large scale established a clear trend toward a fossil-fueled economy in the industrial centers of Mexico. While never becoming Mexico's main industrial fuel, coal did set the intellectual, political, and infrastructural stage for its successor: oil.

OIL

As early as 1874, Mexican intellectuals and engineers understood the potential importance of oil as a fuel.⁴⁵ Emiliano Busto, whose views on coal were discussed earlier, showed a clear understanding of oil's potential applications including power for "steam engines that are being built for this purpose [burning oil]." "What is now a utopia," he wrote regarding oil as a fuel, "will become reality one day, and perhaps sooner rather than later."⁴⁶ With the discovery of rich oil fields in northern Veracruz at the beginning of the twentieth century, Busto's predictions were confirmed.

When petroleum production surged in the Veracruz fields only a few years later, it caused significant enthusiasm among industrialists and railroad owners in Mexico.⁴⁷ While coal had stalled deforestation, the domestic scarcity of coal threatened to hinder continued industrial expansion. For decades, Mexican manufacturers complained that the lack of access to an inexpensive, reliable source of energy

increased production costs. It also made Mexican industry less competitive, both domestically and on global markets, because economies of scale were harder to achieve. Fully aware of experiments to employ petroleum as a fuel in the United States and Russia, Mexican industrialists believed that oil could solve the quest for abundant and cheap energy, this time to replace coal.⁴⁸ As the editors of the influential daily *El Economista Mexicano* stated, "Interest in oil production in Mexico has reached many manufacturing establishments in the Republic, as it has railroad owners, who realize the immense value oil could have as a fuel, as long as it can be produced in sufficient quantities to replace coal."⁴⁹ Another editorial by the same newspaper emphasized that expensive fuel was the key obstacle to continued Mexican industrialization. "For Mexico," the editorial argued, "the discovery of oil deposits and their rapid development are of special importance, because until we can find an abundant reserve of fuel, we will not be able to solve our industrial problem."⁵⁰

Carlos Díaz Dufoo, *El Economista's* chief editor and one of the most insightful observers of Mexico's industrialization process, referred to energy scarcity as Mexico's "gravest industrial problem." For Díaz Dufoo, the industrial success of countries such as Great Britain, Germany, and the United States largely depended on their abundant coal reserves. During Mexico's early industrialization, Díaz Dufoo argued, the country had relied on its extensive forests for fuel. But rapid industrial growth and the dramatic expansion of railroads had denuded vast tracts of land of its forest cover. Coal, both domestic and imported, had mitigated Mexico's deforestation crisis for a time, temporarily safeguarding the country's industrial expansion. But Mexico's limited coal deposits all but ensured that coal would never become the nation's main industrial fuel. Therefore, Díaz Dufoo believed, finding a replacement for coal—the initial replacement for wood—was indispensable. Oil seemed to be the new solution to Mexico's perennial problem of energy scarcity and industrial-driven deforestation. In the absence of vast coal reserves, oil could provide the virtually endless energy that an industrializing Mexico demanded.⁵¹

Mexico's railroad owners agreed. The country's most important railway network at the time, the Mexican National Railway (*Ferrocarriles Nacionales de México*), began its shift from coal to fuel oil as early as 1909, the same year the Mexican government gained control of the company from US interests. Tellingly, the contract obliged the British-owned oil provider to bear the expense of reconverting the locomotives back to burning coal in the event the company failed to deliver the agreed amount. Such a provision suggests not only the relative novelty of oil as a fuel source at this time, but also the reliability of coal supplies and the relative technological ease for transitioning from one fossil fuel to the other.⁵² The provision proved

unnecessary. Only twelve years later, the railway company was consuming its 1909 annual supply almost every month.⁵³ The line's fuel oil consumption only continued to grow into the 1920s.⁵⁴ Mexico's other major railway lines followed suit in the 1910s.⁵⁵

Factories in Mexico's industrial core took a similar track. San Rafael, located in the southeastern Valley of Mexico and the largest paper mill in Latin America at the time, began complementing waterpower with fuel oil in 1909.⁵⁶ Monterrey's steel plant, the first and the largest of its kind in Latin America, added fuel oil to its energy mix a few years later. It was burning 360,000 barrels of fuel oil per year by 1921, despite having relied on coal since its establishment in 1900. At this point, virtually all the largest manufacturing establishments in Mexico, many of them located in the Valley of Mexico or Monterrey, were using oil as an energy source, often as their main fuel.⁵⁷ By 1936, a few dozen textile, beer, paper, iron, and cement factories were consuming up to a million barrels of fuel oil per year in Mexico City and its hinterland alone.⁵⁸

As for electricity generation, both companies and state officials viewed thermoelectric plants as support for hydroelectricity that provided the bulk of electricity in Mexico's industrial areas. As late as 1921, only about 20 percent of Mexico City's electricity was generated by burning fuel oil or, sometimes, coal, with the rest coming from waterpower.⁵⁹ But the unreliability and seasonality of central highland rivers, aggravated by recurrent droughts in the early 1920s (which experts blamed on deforestation), made oil-powered thermoelectric plants increasingly attractive. As one newspaper put it during a particularly severe drought in 1921, the only way Mexico City could avoid a "sad spring" from lack of electricity would be by relying on fuel oil. Indeed, the situation changed dramatically over the following years.⁶⁰ By 1937, the Federal District, the administrative unit where Mexico City is located, derived 91 percent of the electricity produced within its boundaries from thermoelectric plants that burned fuel oil. Even when taking into account Necaxa, a big supplier of hydroelectricity in the region, about 55 percent of the Federal District's electricity came from fossil fuels. Monterrey and its state, Nuevo León, produced an astonishing 96 percent of their electricity with thermoelectric plants that burned fossil fuels including coal, fuel oil, and even natural gas.⁶¹

Conservation-minded politicians and experts were as enthusiastic about oil in the first decades of the twentieth century as their predecessors had been about coal in the late nineteenth century. For example, Salvador Alvarado, the revolutionary governor of Yucatán, fostered oil consumption in his state as the best means of protecting Yucatán's forests and agriculture.⁶² Alvarado claimed that "oil can successfully replace wood," Yucatán's "main source of fuel." Replicating nineteenth-century views on forests, Alvarado contended that adopting oil would

allow Yucatán to keep its forests, “which we must conserve to attract rainfall, the only means to irrigate our fields.” In 1939 a prominent engineer sought to convince the Mexican government of the need to increase consumption of natural gas (another fossil fuel) in the factories, power plants, and households of the Valley of Mexico on the exact same grounds.⁶³ Engineer Gustavo Treviño submitted a proposal to the Ministry of the Economy arguing that natural gas could be transported from the Gulf of Mexico to the valley more cheaply than oil. At the time, about 95 percent of Mexican natural gas, a by-product of oil extraction, was released into the atmosphere without being utilized. If the valley’s factories and power plants replaced oil with natural gas, Treviño maintained, Mexico could devote a much bigger share of its oil production to export and acquire badly needed foreign currency. Natural gas would also substitute charcoal as the main domestic fuel that had become a key driver of deforestation by then.⁶⁴ Cheaper natural gas, Treviño wrote, would thus further encourage Mexican industrialization while “solving the grave problem of deforestation, stabilizing the valley’s climate and rainfall.”⁶⁵

By the late 1930s, Mexico’s industrial sector—transportation, industry, and electricity generation—was entering the final phases of its energy transition to fossil fuels, a transition initiated by coal and finalized by oil. While much literature focuses on the emerging oil export industry, little attention has been paid to the dramatic surge in domestic use at this time. In fact, in 1937 Mexico was consuming about 40 percent of its total oil production, most of which went to fuel its core industrial regions.⁶⁶ Mexico’s industrial dependence on oil would only deepen over the next decades.⁶⁷ Although water and wood never disappeared from the energy mix in these areas, their importance as sources of energy was greatly diminished as industry shifted to burning fossil fuels.

CONCLUSION

Concerns over deforestation played a significant ideological and practical role in Mexico’s energy transition from wood to fossil fuels. While the historical record is somewhat ambiguous regarding the exact extent of deforestation in Mexico, archival sources, as well as the many reports, articles, memos, and other accounts published during this time by prominent scientists, intellectuals, and politicians, make one point very clear: curbing deforestation was of paramount importance to nineteenth-century Mexicans. Between the second half of the nineteenth century and the first decades of the twentieth, state officials and Mexican conservationists repeatedly insisted on the need for adopting new energy sources, especially fossil fuels, if regions like the Valley of Mexico were to achieve industrial progress without becoming

deforested wastelands. For these conservationists, fossil fuels would also finally solve the country's old "fuel problem" (as contemporaries called it) of energy scarcity. As industrial establishments adopted steam engines and railroads extended their iron web over Mexico, forests retreated, with disastrous consequences for the land and the people. Fossil fuels, they argued, would provide the country with cheap and abundant energy, fostering industrial growth *and* halting deforestation. Demand for substituting wood with fossil fuels received institutional backing from successive Mexican governments and agencies, as well as from important scientific organizations.

The story has numerous implications. To start, it exposes how ideas about conservation, nature, and industry have evolved over time in keeping with particular environmental circumstances. In today's age of climate change, curbing carbon emissions and industrial pollution are of central importance to current environmental policy and conservation efforts. Yet the Mexican case illustrates how environmental concerns drove successive Mexican governments to foster the consumption of fossil fuels as a way of mitigating deforestation while still promoting industrial growth. Mexican state officials and conservationists sought to solve what they viewed as the worst environmental problem of their time—deforestation—by calling for the adoption of fossil fuels on a large scale. The effects, as one might expect, were deeply contradictory. On the one hand, fossil fuel consumption did prevent large swaths of forests from being logged for fuel. My very rough estimate is that in the 1920s, the use of oil and coal may have prevented the harvest of fuelwood for railroads, industry, and power plants from a forest area of about 100,000 km² per year, or about a fifth of Mexico's total forest area at the time. But on the other hand, such efforts to make Mexico's industrialization more sustainable, in today's parlance, backfired by enabling rapid industrial and urban growth in subsequent decades. For instance, once fossil fuels became the basis of Mexico City's energy system by 1940, the city witnessed a period of massive industrialization and uncontrollable urban growth. Ironically, such fossil-fueled growth devastated some of the very forests conservationists sought to protect by promoting fossil fuels.⁶⁸ By the 1970s, Mexico City was one of the largest cities in the world and the valley in which it is located had been wholly transformed. This story repeated itself time and again in other industrializing cities across Mexico.

There was, of course, another way in which Mexico's nineteenth- and early twentieth-century's experiment with "green growth" backfired in the long run: global warming. The shift to fossil fuels to cope with deforestation, the main environmental stress of the early phase of Mexican industrialization, while vigorously pursuing rapid industrial growth resulted in large emissions of carbon dioxide during the rest of the twentieth century. Clearly, it would be absurd to expect miraculous foresight on the part of Mexican conservationists and government agencies regarding global warming; the science of

climate change and global warming was in its first stages in the late nineteenth century. More importantly, key figures in the early science of climate change like Svante Arrhenius (1859–1927), who first tried to calculate how carbon emissions could alter global temperatures, actually viewed the possibility of global warming due to the combustion of fossil fuels positively.⁶⁹ Despite such caveats, the Mexican case illustrates the enormous difficulties and often unintended consequences of implementing conservation measures in the industrial age, with its characteristic demand of permanent economic growth. Mexico's story suggests that promoting conservation and growth simultaneously, or sustainable development, as it is called today, has not been successful in the past.

But perhaps the greatest insight that Mexico's energy shift has to offer is that the transition to a fossil-fueled economy was not merely a technical or economic process but in essence *an act of politics*. Without decisive intervention from the Mexican government through state agencies, state-sponsored science, and lawmaking, the shift to fossil fuels would simply not have happened as it did, if it had happened at all. If the Mexican transition has anything to teach about past energy transitions, it is that political action, not simply a supposedly self-regulating market or technological change, ensured Mexico's switch from wood to a fossil-fueled economy. Any account of past energy transitions that fails to consider the relations between nature, politics, and energy in their fullest sense is not only incomplete but inaccurate. Past energy transitions are a good reminder that environment and society have never been two separate entities but rather co-creators of history.

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Notes

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1. Max Weber, *From Max Weber: Essays in Sociology*, ed. H. H. Gerth and C. Wright Mills (Princeton: Oxford University Press, 1958), 280.
2. Leopoldo Río de la Loza, *Escritos de Leopoldo Río de la Loza* (México: Impr. de I. Escalante, 1911), 329–34.

3. Richard Grove traces “desiccationist” ideas to European colonies in the Caribbean and the Indian Ocean. See Grove, *Green Imperialism: Colonial Expansion, Tropical Edens, and the Origins of Environmentalism, 1600–1860* (Cambridge: Cambridge University Press, 1995), Introduction. Dessicationist ideas among Mexican conservationists likely came from Alexander von Humboldt who attributed the aridity of the Valley of Mexico and most of the central highlands to colonial deforestation. See von Humboldt, *Ensayo político sobre el Reino de la Nueva España* (París: En casa de Rosa, gran patio del Palacio Real, 1822), 84, 399–400.
4. Energy transitions can happen in certain sectors of society but not others (e.g., in transportation but not households). In this article, I focus *exclusively* on the energy transition from wood and water to fossil fuels (coal and oil) in the industrial sector: *transportation, manufacturing, and electricity generation*. Energy transitions are *messy historical processes*, with substantial overlap between energy regimes. For example, sectors such as electricity generation still use water, although it represents only a small percentage of total electricity generated in Mexico (less than 20 percent), whereas fossil energy accounts for over 75 percent. See Roger Fouquet and Peter J. G. Pearson, “Past and Prospective Energy Transitions: Insights from History,” *Energy Policy* 50 (2012): 1–7, for a definition of energy transitions as “the switch from an economic system dependent on one or a series of energy sources and technologies to another.” Fridolin Krausmann offers a lower threshold as the starting point for Vienna’s coal phase (1865–1928) at 30 percent of total energy consumption in “A City and Its Hinterland: Vienna’s Energy Metabolism 1800–2006,” in *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, ed. S. Singh et al. (New York: Springer, 2013), 247–68. For a definition of “industrialization” as the increased use of “energy from sources that never were, or have not recently been, alive (for instance, coal, moving water, electricity and so on, rather than muscle or wood) in manufacturing, as well as in transportation and other parts of life,” see Kenneth Pomeranz, “Introduction: What Is ‘Industrialization’ and What Does It Have to Do with the ‘Pacific World’?” in *The Pacific in the Age of Early Industrialization* (Farnham: Ashgate, 2009), xiii.
5. Mexico has been among the top dozen or so emitters of carbon dioxide (CO₂) in the world for decades (Johannes Friedrich and Thomas Damassa, “The History of Carbon Dioxide Emissions | World Resources Institute,” 2016, <http://www.wri.org/blog/2014/05/history-carbon-dioxide-emissions>.) In 2012 Mexico emitted 723.85 MtCO₂-eq (million tons CO₂ equivalent). According to the US Department of Energy, Mexico’s CO₂ emissions grew at a rate of 6.5 percent per year between 1891 and 1982. See also T. A. Boden, G. Marland, and R. J. Andres, “Global, Regional, and National Fossil-Fuel CO₂ Emissions” (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, TN, 2011).
6. Among the few pioneering works on Latin America’s energy history are Mar Rubio et al., “Energy as an Indicator of Modernization in Latin America, 1890–1925,” *Economic History Review* 63, no. 3 (2010); John Soluri, “Tierras, montes y aguas: Apuntes sobre energía, medio ambiente y justicia en las Américas,” *Revista de Historia* 59–60 (2009); Luz María Uhthoff, “La industria del petróleo en México, 1911–1938: del auge exportador al abastecimiento del mercado interno. Una aproximación a su estudio,” *América Latina en la Historia Económica* 33 (June 2010). Particularly relevant to this article is Matthew Vitz, “To Save the Forests: Power, Narrative, and Environment in Mexico City’s

- Cooking Fuel Transition,” *Mexican Studies/Estudios Mexicanos* 31, no. 1 (February 2015): 125–55. The historiography on Mexican oil is vast. See, for instance, Jonathan C. Brown and Alan Knight, eds., *The Mexican Petroleum Industry in the Twentieth Century* (Austin: University of Texas Press, 1992). An environmental and labor history of Mexico’s oil industry is Myrna Santiago, *The Ecology of Oil: Environment, Labor, and the Mexican Revolution, 1900–1938* (Cambridge: Cambridge University Press, 2006). Mexico’s transition to oil, however, has received little attention. For a survey of the historiography on Latin America’s oil industry that underlines the lack of attention to consumption and dominance of studies on production, see Marcelo Bucheli, “Major Trends in the Historiography of the Latin American Oil Industry,” *Business History Review* 84, no. 2 (July 1, 2010): 339–62.
7. Ben Gales et al., “North versus South: Energy Transition and Energy Intensity in Europe over 200 Years,” *European Review of Economic History* 2 (2007): 219–53; José Jofré González, “Patrones de consumo aparente de energías modernas en América Latina, 1890–2003” (PhD diss., Universitat de Barcelona, 2012); Astrid Kander, Paolo Malanima, and Paul Warde, *Power to the People: Energy in Europe over the Past Five Centuries* (Princeton: Princeton University Press, 2013); Mar Rubio and Mauricio Folchi, “Will Small Energy Consumers Be Faster in Transition? Evidence from the Early Shift from Coal to Oil in Latin America,” n.d.; 52–75; Mar Rubio et al., “Energy as an Indicator of Modernization in Latin America, 1890–1925,” *Economic History Review* 63, no. 3 (2010). A pioneering work is Vaclav Smil, *Energy in World History* (Boulder: Westview Press, 1994). Literature overviews are Kathleen Araújo, “The Emerging Field of Energy Transitions: Progress, Challenges, and Opportunities,” *Energy Research & Social Science* (2014): 112–21, and Stefania Barca, “Energy, Property, and the Industrial Revolution Narrative,” *Ecological Economics* (2010), doi:10.1016/j.ecolecon.2010.03.012.
 8. Francisco F. de la Maza, *Código de colonización y terrenos baldíos de la República Mexicana años de 1451 a 1892* (México: Secretaría de Fomento, 1893), 662–63. Late nineteenth-century views reflected the influence of Spanish colonial legislation, particularly the Ordenanzas de Montes from 1748 and 1803. See Novísima recopilación de las leyes de España: Dividida . . . Tom. III: libros 6 and 7; libro VII, título XXIV, ley XIV and XVI; libro VII, título XXIV, ley XXII; Francisco F. de La Maza, *Código de colonización y terrenos baldíos de la República Mexicana, años de 1451 a 1892* (México: Oficina Tip. de la Secretaría de Fomento, 1893), 50–145. On Spanish forestry laws, see Luis Urteaga, “La política forestal del reformismo borbónico,” in *El bosque ilustrado: estudios sobre la política forestal española en América*, ed. Manuel Lucena Giraldo (Madrid: Instituto Nacional para la Conservación de la Naturaleza: Instituto de la Ingeniera de España, 1991), 17–43. An overview of forest conservation during the colonial period is Lane Simonian, *Defending the Land of the Jaguar: A History of Conservation in Mexico* (Austin: University of Texas Press, 1995), chapter 2.
 9. On the *Sociedad Mexicana de Geografía e Historia*, founded by government decree in Mexico City in 1833, see Raymond B. Craib, *Cartographic Mexico: A History of State Fixations and Fugitive Landscapes* (Durham: Duke University Press, 2004). See also Enrique de Olavarría y Ferrari, *La Sociedad Mexicana de Geografía y Estadística*. (México: Oficina Tip. de la Secretaría de Fomento, 1901). For the organization’s history in the early twentieth century, see Hugo Pichardo Hernández, “La Sociedad Mexicana de Geografía y Estadística y el territorio mexicano, 1902–1930,” in *El quehacer geográfico: instituciones y personajes (1876–*

- 1964) coord. José Moncada y Patricia Gómez (México, D.F.: UNAM, Instituto de Geografía, 2009), 15–31. On Leopoldo Río de la Loza, see “Necrología de Leopoldo Río de La Loza,” *La Naturaleza* 1, no. 3 (1876): 426.
10. *Sociedad* and the *Boletín's* role in the development of nineteenth-century Mexican science cannot be overstated. See Lucero Morelos Rodríguez, *La geología mexicana en el siglo XIX: una revisión histórica de la obra de Antonio del Castillo, Santiago Ramírez y Mariano Bárcena* (Morelia, Michoacán, México; México, D.F.: Secretaría de Cultura del Estado de Michoacán; Plaza y Valdés, 2012), 116–21.
 11. Romero Gil, “Selvicultura. Destrucción de los bosques en el estado de Jalisco. Observaciones sobre los bosques, del Barón de Humboldt y un profesor de la Escuela de Minas. Ordenanzas antiguas sobre bosques y necesidad de observarlas,” *Boletín de la Sociedad Mexicana de Geografía y Estadística* 1, no. 2 (1869): 9–14. Antonio María Salonio, “Reglamento para la conservación y aumento de bosques,” *Boletín de la Sociedad Mexicana de Geografía y Estadística* 2, no. 1 [1845] (1869): 14–20.
 12. Don Pedro L. Monroy, “Observaciones sobre algunos combustibles minerales de México,” *La Naturaleza* 1, no. 1 (1869): 87–93.
 13. On the foundation of the *Sociedad de Historia Natural*, see Antonio del Castillo, “Discurso pronunciado por el señor ingeniero de minas don Antonio del Castillo, Presidente de la Sociedad, en la sesión inaugural verificada el día 6 de setiembre de 1868,” *La Naturaleza* 1, no. 1 (1870 1869): 1–5; Sociedad Mexicana de Historia Natural and Antonio del Castillo, *Estatutos de la Sociedad Mexicana de Historia Natural* (México: Imp. de la “Revista Universal,” 1869); Don Pedro L. Monroy, “Observaciones sobre algunos combustibles minerales de México,” *La Naturaleza* 1, no. 1 (1869): 87–93.
 14. See Manuel Payno, “Selvicultura,” *Boletín de La Sociedad de Geografía y Estadística de la República Mexicana*, segunda época, 2 (1870): 77–85; Ignacio Ramírez et al., “Bosques y Arbolados,” *Boletín de La Sociedad Mexicana de Geografía y Estadística*, Segunda época, 2 (1870): 14–24; Matías Romero and John Bigelow, *Railways in Mexico* (Washington, DC: W. H. Moore, 1882), 71.
 15. By deforestation, I mean forest clearing rather than wood harvesting, which affected a much larger area. I reach this rough figure (almost certainly an underestimation) by combining data from Emiliano Busto, *Estadística de la República Mexicana . . . Resumen y análisis de los informes rendidos a la Secretaría de Hacienda por los agricultores, mineros, industriales y comerciantes de la República y los agentes de México en el exterior, en respuesta a las circulares de 1° de Agosto de 1877*, 2 vols. (México: Secretaría de Hacienda, 1880), and the Department of Forestry's forest statistics: “Circulares del presente año a 1914,” noviembre 1910, AGN, Fomento, Bosques, Caja 1, Exp. 21. For a detailed discussion of the challenges of estimating deforestation and wood harvesting rates in late nineteenth-century Valley of Mexico, see Germán Vergara, “Fueling Change: The Valley of Mexico and the Quest for Energy, 1850–1930” (PhD diss., University of California, Berkeley, 2015), 54–65.
 16. Juvenal, “Boletín del Monitor. La exposición municipal. El carbón de piedra,” *El Monitor Republicano*, November 11, 1873. On *El Monitor Republicano* and the Mexican liberal press, see Charles A. Hale, *The Transformation of Liberalism in Late Nineteenth-Century Mexico* (Princeton University Press, 2014), 68–73.

17. When liberals favored forest management, they adamantly opposed infringing on private property rights. See Ignacio Ramírez et al., "Bosques y arbolados," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 2 (1870): 14–24.
18. Manuel F. Soto, "Ferrocarril y comunicación interoceánica por el centro de la República Mexicana," *Boletín de la Sociedad Mexicana de Geografía y Estadística* 2, no. 1 (1869): 505–12.
19. Emiliano Busto, *Estadística de la República Mexicana . . . Resumen y análisis de los informes rendidos a la Secretaría de Hacienda por los agricultores, mineros, industriales y comerciantes de la República y los agentes de México en el exterior, en respuesta a las circulares de 1 de agosto de 1877*. Por E. Busto (México: Secretaría de Hacienda, 1880), vol. 2, 22–27.
20. Ibid.
21. Ibid.
22. For newspapers examples, see Don Ignacio Alas, "Un discurso notable," *El Correo del Comercio*, marzo 7, 1873; "El carbón de piedra," *El Monitor Republicano*, marzo 4, 1873; "El poder del carbón," *El Minero Mexicano*, julio 31, 1873. From government officials: "Dictamen de la Comisión de Impuestos, nombrada por la Junta de Minería que el Ministerio de Hacienda convocó en su circular de 18 de Marzo de 1868," *El Minero Mexicano*, julio 31, 1873; from capitalists and private investors: Anónimo, *Datos y reflexiones sobre la industria mexicana: publicación de un industrial* (México: Imprenta de Ignacio Escalante, 1885); *Compañía explotadora de criaderos de carbón de piedra de la República Mexicana* (México: Imprenta de F. Díaz de León, 1876).
23. "Minas de carbón," *El Tiempo*, 25 de enero de 1890.
24. According to Claudia Morales Escobar, "The Ministry of Development had a marked tendency to support scientific enterprises with practical, utilitarian and, when possible, lucrative results" (my translation). See Morales Escobar, "Los proyectos geográficos de la Secretaría de Fomento, del Porfiriato a la Revolución," in *El quehacer geográfico*, 34. See also Mireya Blanco Martínez and José Omar Moncada Maya, "El Ministerio de Fomento, impulsor del estudio y el reconocimiento del territorio mexicano (1877–1898)," *Boletín del Instituto de Geografía* 74 (2011): 74–91.
25. Carlos Pacheco, *Memoria presentada al Congreso de la Unión por el Secretario de Estado y del despacho de Fomento, Colonización, Industria y Comercio de la República Mexicana, General Carlos Pacheco: corresponde á los años transcurridos de diciembre de 1877 á diciembre de 1882* (México: Oficina Tip. de la Secretaría de Fomento, 1885).
26. On the ministry's coal expeditions, see Fefer, *Los últimos años de la historia natural y los primeros días de la biología en México*, 167–70; Enrique Canudas, *Las venas de plata en la historia de México: síntesis de historia económica, Siglo XIX* (Univ. J. Autónoma de Tabasco, 2005); Blanco Martínez and Moncada Maya, "El Ministerio de Fomento, impulsor del estudio y el reconocimiento del territorio mexicano (1877–1898)."
27. Santiago Ramírez, *Noticia histórica de la riqueza minera de México y de su actual estado de explotación* (México, D.F.: Of. Tip. de la Secretaría de Fomento, 1884), 148. On Ramírez's life, see Morelos Rodríguez, *La geología mexicana en el siglo XIX*, 72–93; José Alfredo Uribe Salas and María Teresa Cortés Zavala, "Andrés del Río, Antonio del Castillo y José G. Aguilera en el desarrollo de la ciencia mexicana del siglo XIX," *Revista de Indias* 66, no. 237 (2006): 491–518.

28. Ramírez, *Noticia histórica de la riqueza minera de México y de su actual estado de explotación*, 149. See also Santiago Ramírez, “Informe que el ingeniero de minas Santiago Ramírez rinde á la Secretaria de Fomento, como resultado de su exploración á los distritos de Matamoros Izúcar, Chiautla y Acatlán en el Estado de Puebla, y del estudio de sus criaderos de carbón mineral,” *Anales del Ministerio de Fomento de la República Mexicana* 7 (1882): 8–9.
29. Ramírez, “Informe que el ingeniero de minas Santiago Ramírez rinde á la Secretaria de Fomento, como resultado de su exploración á los distritos de Matamoros Izúcar, Chiautla y Acatlán en el Estado de Puebla, y del estudio de sus criaderos de carbón mineral,” 8–9.
30. The ministry also built coal docks in Veracruz, Mexico’s largest port, to import large quantities of coal. See “Obras en puerto de Veracruz. Se comisiona al ingeniero Lorenzo Pérez Castro para que forme el proyecto y presupuesto de un mueble para descarga de carbón mineral,” 1881, Fomento, puertos y faros, Veracruz, caja 11, exp. 562, Archivo General de la Nación.
31. There are dozens of reports. For examples, see Santiago Ramírez, “El poder calorífico de los combustibles minerales por el ingeniero de minas Santiago Ramírez,” *Anales del Ministerio de Fomento de la República Mexicana* 7 (1882): 129–35; “Informe que rinde a la Secretaría de Fomento el ingeniero de minas que subscribe, sobre su exploración en la municipalidad de Tlaquiltenango, perteneciente al distrito de Tetecala del Estado de Morelos para el reconocimiento de unos supuestos criaderos de carbón,” *Anales Del Ministerio de Fomento de La República Mexicana* 7 (1882): 114–28.
32. Historical figures for coal production in Mexico are notoriously unreliable. The general upward trend in production after the 1880s, however, is unmistakable. See Departamento de Minas, *El carbón mineral en México. Recopilación formada con los informes, artículos, folletos, etc., pub. hasta la fecha sobre la materia* (México: Departamento Universitario y de Bellas Artes, Dirección de Talleres Gráficos, 1921); John Birkinbine and Henry E. Birkinbine, *Industrial Progress of Mexico* (Philadelphia, 1909); Frederick E. Seward, *The Coal Trade: A Compendium of Valuable Information Relative to Coal Production, Prices, Transportation, etc. at Home and Abroad. . .* ([New York]: [publisher not identified], 1904).
33. Santiago Ramírez described coal as a fossil fuel: “among the bitumens, which according to the classification adopted by most mineralogists, *are fossil fuels*, oil is the most important.” (“[e]ntre los betunes, que según la clasificación adoptada por la mayor parte de los mineralogistas, forman parte de los combustibles fósiles, ocupa un lugar preferente el petróleo”). See Ramírez, *Noticia histórica de la riqueza minera de México y de su actual estado de explotación*, 147, 208. This view became the norm among the most important legal scholars in Mexico twenty years later (Academia Mexicana de Jurisprudencia y Legislación, *Estudios jurídicos: petróleo y carbón de piedra* (México, D.F.: Librería de la vida, de Ch. Bouret, 1905).
34. Mariano Bárcena, “El proyecto de Código de Minería. Dictamen del representante de los Estados de Jalisco y México,” *El Minero Mexicano*, October 30, 1884; Juvenal, “Un importante fallo de la Corte. El carbón de piedra.,” *El Monitor Republicano*, Jueves, de agosto de 1882, 3a época, 184; Manuel Lizardi, “Opinión que al Sr. Ingeniero D. Francisco Glennie presenta en consulta el licenciado Manuel Lizardi,” *Anales del Ministerio de Fomento de la República Mexicana* 7 (1882): 164; Santiago Ramírez, “El dominio radical de los criaderos de carbón. Estudio minero-legal por el ingeniero de minas Santiago Ramírez,”

- Anales del Ministerio de Fomento de la República Mexicana* 7 (1882): 136–47; “Observaciones a la consulta del Sr. lic. D. Crispiniano del Castillo hechas por el ingeniero de minas Santiago Ramírez”; “La previa indemnización en los denuncios de minas,” *El Minero Mexicano*, July 20, 1882, Tomo 9, no. 21.
35. “Decretos referentes a minería expedidos en el año de 1884,” 1884, Fomento, Minas y Petróleo, caja 70, legajo 5, exps. 11 y 13, Archivo General de la Nación.
 36. For oil (called “bitumen and juices from the earth”) classified as a mineral under colonial law, see *Reales ordenanzas para la direccion, régimen y gobierno del importante Cuerpo de la Minería de Nueva España, y de su Real Tribunal General. de orden de Su Magestad.* (Madrid, 1783), 75.
 37. For instance, Juan Carlos Moreno-Brid and Jaime Ros, *Development and Growth in the Mexican Economy: A Historical Perspective* (Oxford: Oxford University Press, 2009), 54–55.
 38. *Código de Minería de la República Mexicana* (México: Impr. y Lit. de I. Paz, 1885), 47.
 39. Positivism was a dominant philosophy among late nineteenth-century Mexican elites. See Hale, *The Transformation of Liberalism in Late Nineteenth-Century Mexico*, chapter 5.
 40. Bárcena’s work is vast, spanning forty years and several disciplines. An example of his early work on conservation is Mariano Bárcena, “Dictámen sobre la repoblación vegetal del Valle de México,” *La Naturaleza* 1, no. 6 (1870): 245–51. On Mariano Bárcena’s life, see Santiago Ramírez, *Elogio fúnebre del profesor Don Mariano de la Bárcena, secretario perpetuo de la Academia de Ciencias Exactas, Físicas y Naturales* (México: Oficina Tip. de la Secretaría de Fomento, 1901).
 41. Mariano Bárcena, “El Proyecto de Código de Minería. Dictámen del representante de los Estados de Jalisco y México,” *El Minero Mexicano*, October 30, 1884.
 42. “Conservación de bosques” 1880, Archivo Histórico del Distrito Federal, San Ángel, Tierras, Montes, exp. 90, 1880; Mariano Bárcena, “Los criaderos de carbón,” *El Minero Mexicano*, marzo 3, 1881. Bárcena took part in drafting the final version of the 1884 mining code as the representative of Mexico’s state of Jalisco. See “Decretos referentes a minería expedidos en el año de 1884,” 1884, Fomento, minas y petróleo, caja 70, legajo 5, exps. 11 y 13, Archivo General de la Nación.
 43. On the city’s main power plant, which consumed about 130,000 tons of coal annually by the early 1890s, see Compañía de luz eléctrica de Monterrey, “Informe detallado sobre la planta y servicio eléctrico de la empresa de luz eléctrica de Monterrey” (Monterrey, junio 6, 1892), Varios, exp. 22, Centro Eugenio Garza Sada. By the early twentieth century, Monterrey’s largest factories, including the first and most important steel plant in Latin America, and urban railroads depended on coal and coal-generated electricity. See “Descripción de la planta de luz eléctrica de la Compañía Fundidora y Afinadora de Metales de Nuevo León” (Monterrey, abril 1892), Varios, exp. 22, Centro Eugenio Garza Sada; “La Compañía Fundidora de Fierro y Acero de Monterrey,” *El Economista Mexicano*, agosto 17, 1912, Hemeroteca Nacional de México. An overview of Monterrey’s industry in the early twentieth century is Pablo Livas, *El Estado de Nuevo León. Su situación económica al aproximarse el centenario de la Independencia de México: Obra escrita con datos oficiales* (Monterrey, N.L., Méx., 1909), 33–58.
 44. See “La industria y el carbón. Su porvenir en la República,” *El Imparcial*, mayo 29, 1899.

45. "Empleo del petróleo para reemplazar el carbón de piedra en las máquinas de vapor," *El Minero Mexicano*, mayo 14, 1874.
46. Busto, *Estadística de la República Mexicana . . . Resumen y análisis de los informes rendidos á la Secretaría de Hacienda por los agricultores, mineros, industriales y comerciantes de la República y los agentes de México en el exterior, en respuesta á las circulares de 1° de Agosto de 1877*. Por E. Busto., vol. 2, 62.
47. Mexican petroleum production increased dramatically in the first two decades of the twentieth century, declined after 1921, stabilized until the 1940s, began to grow steadily for the next thirty years and then skyrocketed in the 1970s with the exploitation of underwater deposits. See Ángel de la Vega Navarro, *La evolución del componente petrolero en el desarrollo y la transición de México* (México, D.F.: UNAM, 1999).
48. "El petróleo empleado como combustible. Importantes experimentos," *El Economista Mexicano*, enero 4, 1902.
49. "Carbón y petróleo," *El Economista Mexicano*, marzo 10, 1902.
50. "El problema industrial y las exploraciones petrolíferas," *El Economista Mexicano*, marzo 8, 1902.
51. Carlos Díaz Dufoo, "La evolución industrial en México. El medio y la industria," *El Economista Mexicano*, October 18, 1902, 48–52; Carlos Díaz Dufoo, *La cuestión del petróleo* (México: Eusebio Gomez de la Puente, Editor, 1921), 20–36.
52. "Contract between S. Pearson & Son Limited and the Mexican Railway Company Limited for the Sale and Purchase of Fuel Oil" February 1, 1909, caja 1796, exp. 50885, Archivo Histórico de PEMEX. Pearson's company agreed to supply 30,000 barrels of fuel oil per month, or 360,000 per year.
53. By 1921, Pearson's company, now named El Águila, expected to sell between a low of 201,500 and a high 350,000 barrels of oil per month to the Mexican National Railways. See "Domestic Fuel Oil Sales, 'El Águila'" (Tampico: 1921), caja 1826, exp. 51792, Archivo Histórico de PEMEX.
54. By 1926, the Mexican National Railways alone consumed up to 5.5 million barrels of oil per year. "Compra de combustóleo por Ferrocarriles Nacionales de México" (México, D. F., 1926), Fondo Expropiación, caja 1891, exp. 52622, Archivo Histórico de PEMEX; "Consumo de combustóleo por Ferrocarriles Nacionales de México" (México, D. F., 1926), Fondo Expropiación, caja 1891, exp. 52622, Archivo Histórico de PEMEX.
55. These included the Ferrocarril Central, Interoceánico, Nacional de Tehuantepec, and Mexicano, among others. Manuel Flores, *Apuntes sobre el petróleo mexicano, por el Dr. Manuel Flores, dedicados a los Señores Miembros del XXVI Congreso Federal* (n.p.: n.p., 1913).
56. "Venta de combustóleo de El Águila a la Papelera San Rafael" May 1909, caja 2626, exp. 69980, Archivo Histórico de PEMEX.
57. "Domestic Fuel Oil Sales, 'El Águila'" (Tampico: 1921), caja 1826, exp. 51792, Archivo Histórico de PEMEX.
58. Gustavo L. Treviño, "Proyecto para la utilización del gas natural de Poza Rica resolviendo la crisis de la energía eléctrica del Valle de México, el abaratamiento del combustible industrial y doméstico y la deforestación" September 18, 1939, Fondo Expropiación, caja 2454, exp. 67117, Archivo Histórico de PEMEX.

59. "El adelanto de la hora comenzó a regir anoche," *El Demócrata*, February 20, 1921, Fondo Expropiación, caja 2356, exp. 64339, Archivo Histórico de Pemex.
60. "Primavera triste," *El Excelsior*, de abril 1921, Fondo Expropiación, caja 2354, exp. 64264, Archivo Histórico de PEMEX.
61. Secretaría de la Economía Nacional/Dirección General de Estadística, "Catálogo de empresas y plantas generadoras de energía eléctrica," 1937, Fondo Expropiación, caja 3808, exp. 91739, Archivo Histórico de Pemex. These percentages obscure wide variations among states.
62. Salvador Alvarado, "Para traer petróleo al estado [de Yucatán] en grandes cantidades. La medida reportará grandes beneficios," June 16, 1915, Fondo Expropiación, caja 2988, exp. 77480, Archivo Histórico de PEMEX.
63. Treviño, "Proyecto para la utilización del gas natural de Poza Rica resolviendo la crisis de la energía eléctrica del Valle de México, el abaratamiento del combustible industrial y doméstico y la deforestación."
64. See Matthew Vitz, "To Save the Forests": Power, Narrative, and Environment in Mexico City's Cooking Fuel Transition," *Mexican Studies/Estudios Mexicanos* 31, no. 1 (February 2015): 125–55.
65. Treviño, "Proyecto para la utilización del gas natural de Poza Rica resolviendo la crisis de la energía eléctrica del Valle de México, el abaratamiento del combustible industrial y doméstico y la deforestación."
66. Federico Bach and M. De la Peña, *México y su petróleo. Síntesis histórica* (México, D.F.: Editorial "México Nuevo.," 1938), 36. Michele Snoeck provides a figure of 39 percent. See his *El comercio exterior de hidrocarburos y derivados en México, 1970–1985*. (México: El Colegio de México, 1988), 14.
67. See Mar Rubio, "Contabilidad nacional medioambiental para productores de petróleo. Estimaciones para México y Venezuela (1901–1985)," *Investigaciones Históricas de Historia Económica* 8 (primavera de 2007): 141–65; Jofré González, "Patrones de consumo aparente de energías modernas en América Latina, 1890–2003," 64–65; Timothy Campbell, *Food, Water, and Energy in the Valley of Mexico* (Berkeley: Institute of Urban and Regional Development, University of California, Berkeley, 1982).
68. See Fridolin Krausmann, "A City and Its Hinterland: Vienna's Energy Metabolism 1800–2006," in *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, ed. S. J. Singh et al. (New York: Springer, 2013), 247–68.
69. Spencer R. Weart, *The Discovery of Global Warming: Revised and Expanded Edition*, (Cambridge: Harvard University Press, 2008), 5–7.