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Migrant Flows: Hydraulic Infrastructure, Agricultural Industrialization, and Environmental Change in Western Mexico, 1940–64

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Abstract

This article explores the relationship between the growth of irrigation works, environmental change, and rural migration in western Mexico from 1940 to 1964. It begins by analyzing how Mexico's expansion of hydraulic infrastructure facilitated the transfer of industrial agricultural technology through the US-based Rockefeller Foundation. US-sponsored technical assistance programs privileged irrigation- and input-intensive production, undermining traditional Mexican land tenure and agriculture regimes while industrializing and privatizing natural resources. These processes altered rural livelihoods and landscapes in western Mexico, intensifying migratory flows already amplified by the Bracero Program. By examining the origins of western Mexico's deeply rooted culture of migration through an

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environmental and technical lens, this article reframes conventional socioeconomic and political understandings of Mexican migrancy, revealing the essential roles of the natural and built environments in the growth of a mass phenomenon that dominates US-Mexican relations today.

INTRODUCTION

Scholars of migration, technology, and environment have overlooked the impact of hydraulic infrastructure on rural Mexican migration to the United States from 1940 to 1964. The growth of transnational Mexican migrancy not only occurred during a transformative period in the relationship between the Mexican state, people, and space, but it was also profoundly shaped by this reorientation. Beginning in World War II, Mexican planners and engineers (*técnicos*) prioritized the building of roads that linked national production and consumption centers, the expansion of irrigation works, and the migration of people out of Mexico's densely populated central-west region. The country's rapid modernization fueled dramatic changes in traditional agricultural regimes, land use patterns, rural perceptions of natural resources, and the environment itself. In official government rhetoric, infrastructure like hydraulic works charted the modern path to spatial and upward mobility, social justice, and political and economic integration.[1]

In reality, hydraulic technology fueled both progress and egress in Mexico. Official efforts to store, manage, distribute, and commodify water—a fundamental tenet of post-1940 modernization—increased rural spatial mobility and socioeconomic inequality. Proportionally, the rise in value of irrigation works on Jalisco's largest private and communal (*ejido*) farms mirrored the rise in legal Mexican laborers in the United States between 1940 and 1964 (figure 1). The majority of these braceros originated in Jalisco and Michoacán, states in western Mexico. And since *técnicos* believed "irrigation only makes sense where roads exist," new transportation networks were intrinsically linked to new water networks. New highways, bus transportation, and bracero recruitment centers lining Mexico's Pacific coast shifted traditional western Mexican migration routes away from Texas to California while intensifying migrant flows (figure 2). Fatefully, the development of Mexican water and road infrastructure facilitated the importation of an agricultural regime that radically altered rural landscapes and migrancy. Postwar development, predicated on infrastructure and industrialization, transformed Mexico into a nation of emigrants as agrarian Mexicans (*campesinos*) left the countryside in droves.[2]

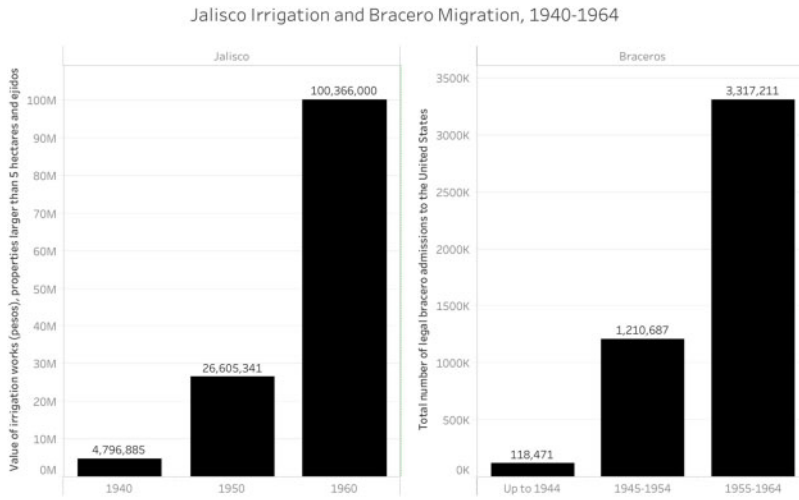

Figure 1. Total value of Jalisco irrigation works by decade and total number of bracero admissions to the United States in decade increments, 1940–64. Credit: Graph by author, derived from *Segundo censo agrícola-ganadero y ejidal, resumen general, 1940*; *Tercer censo agrícola-ganadero y ejidal, resumen general, 1950*; *Cuarto censo agrícola-ganadero y ejidal, resumen general, 1960*; and Manuel García y Griego and Mónica Verea Campos, *México y Estados Unidos frente a la migración de indocumentados* (Mexico City: Universidad Nacional Autónoma de México, 1988), 116–17.

The expansion of post-1940 Mexican irrigation and migration networks traced its origins, in part, to wheat and corn fields in the midwestern United States during the 1920s and 1930s. There, US scientists and farmers developed the methods and inputs for large-scale, mechanized, and industrialized agriculture. In Mexico, too, the 1930s inaugurated a transformative era for the nation's traditional land tenure regimes. Agrarian reform, inspired by the radical tenets of the Mexican Revolution (1910–20), was mandated by the 1917 Constitution. Yet it was unevenly implemented until the presidency of Lázaro Cárdenas (1934–40), who oversaw the massive reorganization of Mexican land and the "radical redistribution" of water via the expansion of minor works, like small reservoirs. Unlike US farms, Mexican agriculture in the 1930s remained largely rain fed in many states, especially Jalisco, and industrial inputs were minimal. One national irrigation map from 1937, however, hinted at the emerging interrelationship between hydraulic and human mobility. As pencil lines linked regional water projects, a brief note stated: "Put roads between irrigation districts." By 1938, nearly twenty bus lines serviced Guadalajara, Mexico's second largest city and the capital of Jalisco. Although Cárdenas's nationalization of US-owned properties and natural resources generated friction with the United States, US-Mexican tensions had eased by the outbreak of World War II. A new spirit of mutual assistance merged the two nations' agricultural

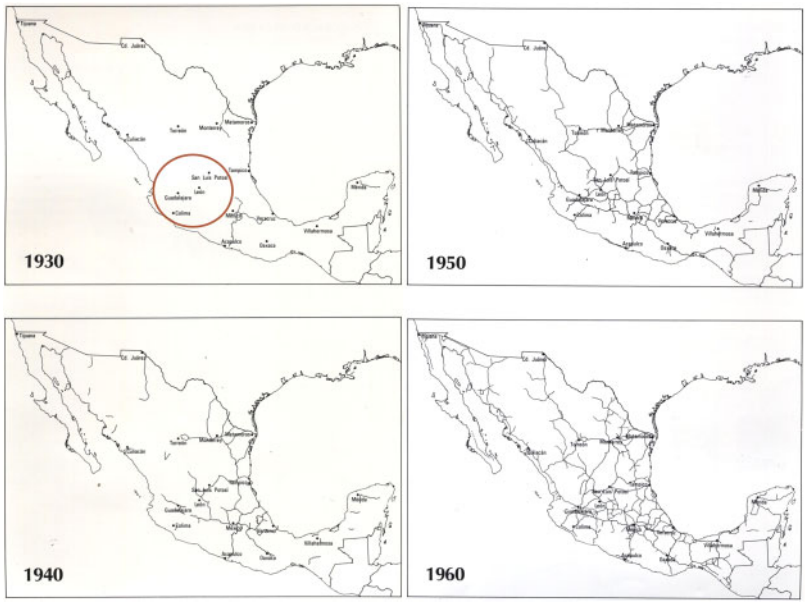

Figure 2. The Mexican highway network by decade, 1930–60 (circle indicates central-west Mexico). The Bracero Program (1942–64), in conjunction with the new highway infrastructure, shifted traditional Mexican migration routes away from Texas to California, where the majority of braceros were sent. In 1920, California received 22 percent of Mexican migrants. This figure increased to 53 percent by 1970. See Douglas Massey, Jorge Durand, and Nolan Malone, *Beyond Smoke and Mirrors: Mexican Immigration in an Era of Economic Integration* (New York: Russell Sage Foundation, 2003), 58–59. Credit: Map by author, based on maps found in Bernardo García Martínez, *Las carreteras de México, 1891–1991* (Mexico City: Secretaría de Comunicaciones y Transportes, 1992).

modernization and land reform projects through the Mexican Agricultural Program (MAP).[3]

MOBILIZING WATER AND MIGRANTS

World War II initiated a major shift in Mexico's political economy. Moving away from Cárdenas's domestically focused and redistributive policies, the state took a conservative turn, embracing US-Mexican cooperation and economic expansion. This shift, initiated by President Manuel Ávila Camacho (1940–46), was clearly manifested through the creation of two, pivotal binational programs: the Bracero Program (1942–64), a series of agreements governing the recruitment of Mexican workers for US agriculture and industry, and MAP (1943–61), known within Mexico as the Oficina de Estudios Especiales. Administered by the US-based Rockefeller Foundation and Mexico's agriculture secretary, MAP aimed to increase Mexican grain production through agricultural technology, particularly irrigation, and train Mexican scientists in modern agriculture. As the prominent

técnico Adolfo Orive Alba declared, irrigation represented the "most important and effective material tool to stimulate agriculture in Mexico." Shaped by the deficiencies of 1930s Mexican land reform, which had resulted in poor crop production and increased dependence on grain imports, MAP founded experimental camps throughout Mexico utilizing hybrid seed, fertilizers, pesticides, irrigation, and machinery. At the time, the majority of Mexican farms were small scale, rain fed, and unmechanized. With US farms hard-pressed to supply Mexico with grain while feeding Allied troops, leading technocrats on both sides of the border embraced the Rockefeller Foundation's assistance in Mexican agriculture.[4]

The Rockefeller Foundation's plan to increase production in Mexico was based on the US model. In the United States, average farm size had increased by 10 percent from 1930 to 1940, with the greatest growth in the "large farm" category. In 1943, the year that MAP began, the major trend in US agriculture, according to officials, was "greater commercialization" with "more emphasis on production for sale and less emphasis on production for home consumption." US officials also acknowledged that "unemployment and underemployment [could] be extreme and annual earnings very low" for agricultural workers in commercial, large-scale, and mechanized regimes. And, once inside Mexico, MAP experts trained in US wheat fields privileged wheat research over corn research on experimental farms in central-west Mexico. This stood in stark contrast to Mexican agricultural practices. Most *campesinos* grew traditional rain-fed staples such as native (*criollo*) corn and beans on small plots and primarily for home consumption, while wheat required substantive irrigation and chemical inputs inaccessible to most Mexican farmers.[5]

Even before MAP's inception, the Rockefeller Foundation viewed existing Mexican land tenure as a barrier to progress, reflecting the opinion of many Mexican officials and technocrats. After touring rural Mexico in 1941 in search of strategies to expand crop production, Rockefeller Foundation agronomists concluded that the primary factor impeding agricultural modernization was a lack of irrigation—a capital-intensive technology beyond the reach of most *campesinos*. Meanwhile, wartime Mexican exports and trade boomed, underscoring the profitability of increased yields while intensifying economic pressures on both private smallholdings and *ejidos*. This process cast the nation's traditional land tenure regimes as backward. Consequently, traditional agricultural practices and regions were targeted by the government for modernization. Western Mexico, home to the nation's largest corn-producing state of Jalisco, and Michoacán, a major wheat-producing state, were foremost in the binational technocrats' plans.[6]

In western Mexico, new hydraulic works tended to increase social conflict and resource inequality. In Michoacán's Tuxpan irrigation

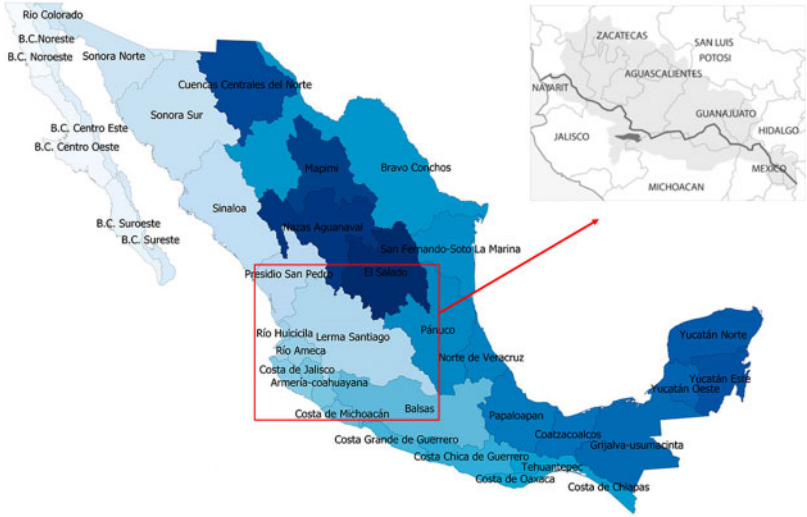

Figure 3. Left image: Mexican hydrological regions, with the Lerma-Santiago hydrological basin outlined in red. Right inset: The course of the Lerma and Santiago Rivers within the Lerma-Santiago hydrological basin (note Lake Chapala on the Jalisco-Michoacán border). Credit: Map by author, based on maps from the Comisión Estatal del Agua Jalisco (https://www.ceajalisco.gob.mx/contenido/cuencas_jalisco/) and "La cuenca en datos," *La Gaceta*, April 27, 2009 (http://www.gaceta.udg.mx/la-cuenca-en-datos/).

district, for example, small private landholdings increasingly competed with *ejidos* for water after the agrarian reforms of the 1930s. This inflamed private property advocates, especially the Cristeros and Sinarquistas, two conservative groups based in rural western Mexico who denounced the *ejido* as socialism. *Ejidos*, whose communal lands were granted and administered by the federal government, were often bastions of agrarian reform and state support. In one instance, the construction of Tuxpan's irrigation district resulted in smallholders from Tuzantla losing access to water they had utilized "since time immemorial." Violence flared in the late 1930s as a result of tensions like these. Hydraulic works, therefore, mobilized conflict as well as water. Nevertheless, *técnicos* viewed irrigation districts as ideal built and natural environments that enabled the state to control rural production and people.[7]

The Lerma-Chapala-Santiago hydrological basin, in which Jalisco and Michoacán partly reside, reflected the tensions and contradictions witnessed in Tuxpan but on a greater scale (figure 3). The Lerma River, which is one of Mexico's most important rivers in one of the nation's most densely populated regions, already featured, according to one Mexican official, an ecosystem "completely modified by man." Despite this, the state assured *campesinos* that new hydraulic works would conquer rural Mexico's age-old foes: resource inequality and nature's volatility. Seasonal rainfalls left western rivers flooded,

then dry, reducing *campesinos*, in one *técnico*'s words, to a "constant desperate state." Thus, new water works signified rural Mexico's "great salvational project." Reality refuted rhetoric in western Mexico, however, as publicly funded irrigation networks were devoted mostly to large northern farms and *ejidos* after 1940.[8]

The wartime Mexican state, focused on rural modernization and export growth, viewed the mobilization of water and *campesinos* as a boon to both. President Ávila Camacho devoted his administration's resources to mechanizing agriculture. He envisioned building vast hydraulic projects in northern Mexico to facilitate this goal and to encourage the resettlement of central-west *campesinos* there. Due to immediate postwar demands, however, population redistribution via water infrastructure remained, according to Adolfo Orive Alba, a "radical solution." With parts of Europe and Asia in ruins, the pressure to expand postwar production surged, exposing Jalisco and Michoacán to renewed scrutiny. Jalisco's administrative region led the nation in total cultivated hectares and total production value in pesos. Yet its production value per hectare lagged behind nearly every other Mexican region. This was largely attributed to the small-scale, rain-fed subsistence agricultural regimes that predominated in western Mexico.[9]

In this context, US scientists saw the destruction of traditional agricultural regimes as essential to the expansion of Mexican crop production. Culturally biased policies and attitudes, often fully supported by *técnicos* and Mexican political and scientific elites, defined binational technical assistance from MAP's outset. The Rockefeller Foundation's assumptions were articulated in two early and crucial conclusions rendered by MAP officials in 1944: most land in Mexico was "useless" without irrigation, and most irrigation was "wasted" by Mexican farmers. At the same time, Mexican Agriculture Secretary Marte Gómez, a vocal advocate (and salesman) of irrigation technology, observed negatively that 60 percent of arable land was controlled by *ejidos* and small farms. As the postwar era began, binational technocrats were convinced that traditional land tenure was an obstacle to Mexico's economic development and global integration.[10]

Mexican agriculture's wartime modernization paved the way for a boom in emigration to the United States driven by technology and infrastructure. The increase in Mexican migrancy was not unwelcome, particularly for US officials. While seemingly counterintuitive, increasing Mexican crop production via US technology served to boost US corporate agriculture. Mexico had continued to require imports of US grain after the war's end, dismaying US officials fixated on feeding war-torn Europe. Yet US grain shipments to Mexico were explicitly sustained to ensure a reluctant Mexican government's continued participation in the Bracero Program. In 1946, the US

ambassador to Mexico warned that if the United States ended grain exports to Mexico it was choosing "between the [Bracero] program and generally good relations with Mexico and a stable Mexico and a Mexico cooperating with us" and "a Mexico driven to hunger and revolution." In the eyes of US officials, then, expanding Mexican production achieved three strategic postwar goals: it decreased Mexican grain demands, alleviated Mexican instability, and continued the Bracero Program beyond its wartime parameters. Therefore, US efforts to foment irrigation-intensive agriculture in Mexico were driven, in no small measure, by a desire to sustain a foreign worker program that provided cheap labor for an increasingly corporate US agriculture regime.[11]

TRANSFORMING LAND TENURE AND LANDSCAPES

President Miguel Alemán's (1946–52) industrialization and development policies transformed rural inequality, mobility, and environments more than any president since Porfirio Díaz (1876–1911). In a dramatic departure from the radical redistribution of natural resources in the 1930s, Alemán intensified the state's post-1940 conservative turn by reforming water and land regimes primarily to benefit private industry. His administration altered constitutionally mandated land parcel size and ownership restrictions, vastly expanded irrigation infrastructure, reformed farm credit, and encouraged the redistribution of central-west *campesinos* to northern Mexico. To realize these ambitious goals, Alemán restructured Mexico's hydraulic works bureaucracy. In December 1946, the National Irrigation Commission, founded in 1926, was reconstituted as the Secretariat of Hydraulic Resources (SRH).[12]

The SRH's elevation to a federal secretariat revealed the centrality of hydraulic technology to Alemán's rural development strategy and fueled unprecedented public works planning. *Técnicos* explicitly linked progress to irrigation networks, proclaiming the two "indistinguishable," while Mexican planners envisioned projects that would irrigate millions of hectares. MAP officials depended on this hydraulic revolution since experiments with hybrid crops in central-west Mexico strictly involved irrigation. Moreover, the tenants of Mexican irrigation districts were required, by contract, to only use hybrid seed engineered by MAP. Hybrid seed required irrigated water, and these two expensive inputs compelled many *campesinos* to seek farm credit.[13]

Hydraulic technology was integral to historic 1947 land reforms that privatized Mexico's national lands and destabilized traditional land regimes. Alemán's budget prioritized both large and small

irrigation works, with hydraulic spending increasing in orders of magnitude over previous decades. In Michoacán and Jalisco, for example, a commission was created for the Rio Grande de Tepalcatepec basin, encompassing eighteen thousand kilometers. The project aimed to construct multiple public works for irrigation, hydroelectricity, and, crucially, roads. And in small towns like Villa Guerrero, Jalisco, small water works like the Boquilla Dam were built. With rapid infrastructure construction already underway, Alemán issued a decree on September 7, 1949 that further undermined traditional smallholder agriculture and land tenure. The law focused on irrigation dues, fees that *campesinos* often could not afford. It mandated that debt from any unpaid dues was backed by the *campesino*'s own land, thus facilitating dispossession. If *campesinos* failed to pay the fees they were denied water, which in turn often resulted in hybrid crop failure, leading to loan defaults on industrial chemicals, seed, and/or machinery. With those debts backed by their land, the outcome for increasing numbers of *campesinos* was land loss. Furthermore, due to the adoption of laborsaving machinery on large, irrigated, and commercial farms, Alemán's reforms aggravated rural unemployment.[14]

The Rockefeller Foundation provided Mexican technocrats both crucial financing and scientific legitimacy during this turbulent period of land privatization and consolidation. In 1947, the foundation's Natural Sciences division devoted nearly 20 percent of its global budget to MAP alone. That year, Nelson Rockefeller, at the time a former US assistant secretary of state, bestowed the coveted stamp of modernity on Alemán's agrarian reforms. He proclaimed that the Alemán administration had ushered in "a new era of progress and development" in Mexico. Its embrace of irrigation and agricultural industrialization symbolized, to Rockefeller, "the road which leads to rising standards of living and greater opportunity for the people of Mexico."[15]

However, hydraulic and agricultural technologies, promoted as agents of increased production and prosperity, were undermined by Mexico's increasingly volatile weather. Corn, the staple of rural Mexico's traditional rain-fed farms, was a case in point. Hybrid seed developed by MAP, like the popular Rocamex V-7 variety, was engineered in central Mexico solely for irrigated lands. However, this seed was sold throughout the country—to rain-fed farms as well as to irrigated ones—leaving *campesinos* more vulnerable to climate fluctuations than they had been growing *criollo* stock that had evolved in each region. This became readily apparent when a widespread, years-long drought contributed to extremely poor crop production throughout Mexico in 1949. The drought hit central and northern Mexico the hardest, fueling emigration to the United States. This drought also strained groundwater reserves, compelling Jalisco

campesinos near Lake Chapala, Mexico's largest freshwater lake, to implore President Alemán to install pumps to "avert disaster."[16]

Crucially, the rapid growth of infrastructure during the 1940s generated environmental and social change in western Mexico. Hydraulic works reduced water levels, altering lake and riverbeds. New works near Etzatlán, Jalisco, left farms in former lake beds prone to flooding and drought, often ruining *campesinos*' crops. Alemán's reforms permitted the sale of newly drained national lacustrine and riparian lands, resulting in their privatization and consolidation, often by foreign interests. Additionally, new rural road infrastructure destroyed trees that prevented topsoil loss and reduced runoff. Indeed, farmland in both Michoacán and Jalisco exhibited some of the nation's worst erosion by the century's end. New roads also helped spread agrochemical use. Between 1950 and 1960, nitrogen, phosphorus, and potassium usage grew by a factor of fourteen, while pesticide usage increased by nearly a factor of nine in a similar period. As expensive industrial inputs were adopted and often misapplied, western *campesinos* were compelled to endure the effects of polluted water and soils.[17]

Hydraulic infrastructure fueled emigration in postwar Mexico by dictating MAP research and Mexican development. By 1950, most hybrid wheat—a MAP priority—was grown on large farms and *ejidos* in northwestern Mexico, where vast hydraulic projects irrigated the land. Small rain-fed farms, which continued to dominate agriculture nationally, primarily grew corn, especially in western Mexico. By devoting government and natural resources to export-oriented, irrigated crops like wheat, to the exclusion of subsistence, rain-fed crops like corn, MAP and Mexican policies helped mobilize western *campesinos* northward. This fulfilled a key tenet of the *técnicos*' post-1940 rural modernization strategy. However, *campesinos*, often indebted due to costly inputs or displaced by land consolidation and mechanization, did not settle in the northern Mexican irrigation districts as envisioned. New highways linking western and northern Mexico, lined with bracero recruitment centers, also led to the US border, drawing migrants upward to higher-paying US jobs like capillary action (figure 4).[18]

The Cold War increasingly politicized rural Mexican industrialization. In 1950, MAP became part of the Point IV Program, a new US technical assistance program created to reduce communism's appeal globally. According to US President Harry Truman, Point IV provided "qualified experts" to foreign governments "to advise and assist on development problems." The Rockefeller Foundation embraced its new Cold War directive. Foundation President Warren Weaver, contradicting MAP's wartime humanitarian pretenses, reminded his scientists that the Rockefeller Foundation had begun work in Mexico primarily for political and scientific purposes. MAP, in fact, laid the

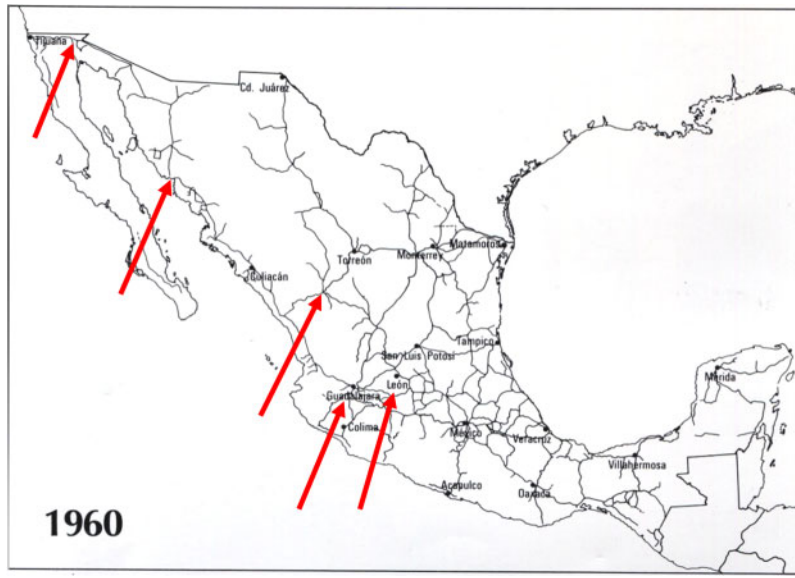

Figure 4. Major bracero recruitment centers in Mexico in 1960. The arrows indicate from left to right: Mexicali, Baja California; Empalme, Sonora; Durango, Durango; Guadalajara, Jalisco; and León, Guanajuato. Credit: Map by author, based on a map found in Bernardo García Martínez, *Las carreteras de México, 1891–1991* (Mexico City: Secretaría de Comunicaciones y Transportes, 1992).

scientific and ideological groundwork for Point IV. It had been tasked with Americanizing not only Mexican agriculture but also Mexican scientists, values, and peoples since 1943. Now, with the Point IV Program, US officials contended that only US technology could help the world's developing nations overcome food shortages and resource inequality.[19]

Under Point IV, the Rockefeller Foundation aggressively promoted agro-technology to the detriment of Mexico's balance of trade and environment. In 1942, Mexico had imported nearly twelve million tons of equipment worth almost thirty-two million pesos. By 1948, imports reached nearly ninety million tons worth almost four hundred million pesos. By 1950, US machinery and chemical salesmen overran the Mexican countryside. MAP Director George Harrar complained that he could not get any research done on the experimental farms since he was always dealing with "the usual succession of representatives of fertilizer, insecticide, fungicide, seed and book companies." Meanwhile, a Rockefeller Foundation film asserted that Mexico suffered from the "cancer of erosion," whose only solution was US "knowledge and experience." The film showed nitrogen, potassium, and phosphorus being mixed into fertilizer cubes, while *campesinos*, lacking protective gear, sprayed insecticide. By 1951, financially and environmentally costly inputs like these contributed

to Mexico having one of Latin America's largest trade deficits with the United States.[20]

As more US technology flowed into, and modified, rural Mexican landscapes, more *campesinos* flowed out. Their migrations were facilitated by US farm lobbyists who swarmed the US embassy in Mexico City, exerting pressure on diplomats to continue the Bracero Program. Technology and extreme weather increasingly worked in US corporate agriculture's favor. One *campesino* recalled heavy rains causing a dam to fail in Jalisco, flooding multiple *ejidos*' crops. Mexican officials had no other recourse than to give these *ejidatarios* bracero permits. Similarly, in 1951, irrigation works in northwestern Michoacán left some farms dry and others flooded. Mexican critics increasingly linked mass bracero emigration to the inequities generated by the hydraulic and agricultural regimes promoted by MAP. One journalist noted that many western *ejidatarios* lacked "water for irrigated cultivation" and "resources to work their parcels," forcing them to "abandon" their lands to work in the United States.[21]

CEMENTING RURAL INEQUALITY AND MIGRANCY

Campesinos historically viewed their environments in terms of natural resources to be both exploited and preserved. Yet the rapid transformation of Mexican landscapes via the expansion of hydraulic infrastructure radically altered *campesino* perceptions of the land as well as the land itself. By the early 1950s, for instance, Jalisco *campesinos* who had once viewed lakes in terms of their traditional uses now perceived fertile cropland being wasted. In 1953, one such group demanded that the state build hydraulic works to drain Lake Magdalena so that they could cultivate the lakebed. Lake Chapala, bordered by both Jalisco and Michoacán, was particularly vulnerable to modern technology and ideology. Its levels dropped precipitously in the 1950s due to water works that diverted the Lerma River's flows. In fact, some western Mexicans advocated draining the nation's largest lake completely, asserting it was more valuable "without water."[22]

President Adolfo Ruiz Cortines (1952–58) continued his predecessors' commitment to irrigation expansion and land privatization and consolidation. Consequently, from 1950 to 1960, the number of cultivated hectares in Mexico grew by 27 percent to nearly fourteen million. Traditional land regimes continued to receive intense scrutiny, with the Rockefeller Foundation blaming the "excessively small size" of Mexican landholdings for production woes in 1952. *Ejidal* land, which was constitutionally prohibited from sale or rental, was increasingly rented out under Ruiz Cortines, which effectively consolidated and disentailed it. *Ejidatarios* were also often left unemployed

due to the mechanization of their former parcels. Those who did retain use of their lands were often denied farm credit and inputs since their parcels were deemed to be too small for public or private investment. Adding insult to injury, *ejidos* were frequently the preferred sites for new roads and highways, which facilitated the downward and spatial mobility of *ejidatarios*.[23]

As MAP's influence swelled in the mid-1950s, cracks also widened in its relationship with the Mexican state. Rockefeller Foundation scientists resented *técnicos*' grandstanding and self-promotion. They claimed that Mexican officials, emboldened and enriched by the rapid expansion of the country's economy in preceding years (known as the "Mexican Miracle"), increasingly claimed primary credit for MAP's successes. According to the Rockefeller Foundation, Mexico's Green Revolution remained highly dependent on US technology and expertise since Mexican farmers in 1954 were still not producing enough food for an "adequate diet." Complicating relations further, Mexico was outraged by the mistreatment of its braceros and undocumented migrants in the United States, viewing mass deportations as an affront to Mexican pride and sovereignty.[24]

As binational relations deteriorated, the Rockefeller Foundation devoted more time and resources into getting engineered seed and industrial inputs adopted by Mexicans. A key MAP priority in 1954 was training *campesinos* in Jalisco in proper fertilizer usage. Fertilizer use spread rapidly throughout Mexico's central plateau from 1950 to 1965 due to greater extension efforts, promotion, and credit, with the greatest growth seen in Jalisco's and Michoacán's wet regions. Though fertilizer was originally intended for irrigated, large-scale, and mechanized commercial farms, small-scale rain-fed farmers eagerly adopted it. As a result, dollar remittances sent home by bracero and undocumented migrants in the United States frequently paid for industrial inputs for their own farms. *Campesinos* accustomed to saving their best *criollo* corn for the ensuing year's seed found that expensive MAP hybrids lost potency in their second generation, requiring annual repurchase. And hybrid corn and wheat varieties were delicate and cross-pollinated easily with existing strains, decreasing their efficacy and yields.[25]

By the late 1950s, both the unpredictability of rainfall and the rise in wheat production increased pressures on western *campesinos* to emigrate. Poor corn harvests led the government to privilege wheat production in Jalisco and Michoacán in 1957, with some local officials even promising the free use of machinery for wheat farmers. But hybrid wheat, engineered to produce greater bushels per acre, grew densely packed and required large amounts of water, which bred more fungi and insects, requiring more pesticide. When the costs of industrial agriculture were tallied, the Rockefeller Foundation's own experts conceded, farming in Mexico resembled an "engineering

venture" requiring "substantial capital investment." Therefore, medium and large landholdings enjoyed the lion's share of state-controlled credit and water resources. This left *campesinos* largely dependent on US migration and dollars (or migration to Mexico's urban centers) as their primary strategy to support their small farms.[26]

The environmental and social tolls of hydraulic industrialization intensified during the 1950s. Profligate use of pumping by large, mechanized farms depleted groundwater reserves (especially in northern Mexico), poor drainage and excessive salinity rendered land useless, and the overapplication of fertilizers damaged soil fertility. Ironically, then, technologies promoted by MAP decreased the land's natural productivity in the long run. It was no coincidence that the term of President Ruiz Cortines witnessed the apex of legal bracero migration—over 445,000 US admissions in 1956. The reciprocal growth of hydraulic and road networks in western Mexico presented *campesinos* with an existential quandary. Infrastructure increased spatial mobility, yet reduced economic mobility, within rural Mexico. By migrating to the rural United States, *campesinos*' economic mobility expanded, while their spatial mobility was severely restricted (legal braceros) or outlawed entirely (undocumented migrants). Both scenarios, however, resulted in Mexican migrants' exclusion from full political, economic, and social inclusion in either nation.[27]

Investments in new highways and roads helped fuel the Mexican Miracle, and hydraulic works continued to drive Mexican road building into the late 1950s. As a consequence, western Mexican landscapes came to be defined by extreme fluidity in terms of irrigated water, social and environmental instability, and spatial mobility. Michoacán represented a case in point. One survey boasted that Michoacán's capital, Morelia, and its hinterland featured "a magnificent road network" linking it to Jalisco and central Mexico. Multiple roads traversed Michoacán's Zamora region, connecting Guadalajara and the US-Mexico border to vast tracts of land "appropriate for mechanized farming." The state was praised for its supply of abundant cheap labor. In theory, then, Michoacán represented the ideal environment for industrialized agriculture. In practice, however, water, road, and agricultural technologies made the state ripe for mass out-migration.[28]

FROM INCREASING PRODUCTION TO MITIGATING CONFLICT

Mexican agricultural production and hydraulic infrastructure increased dramatically in the decade and a half following MAP's creation. From 1948 to 1958, Mexico experienced the world's greatest annual average increase in food production. By the latter year,

two-thirds of Mexican irrigation works were massive projects constructed by the federal government. For the Rockefeller Foundation, these results were proof of its policies' efficacy and validated its view that publicly financed irrigation should be reserved for the "better farms" (large-scale, industrial) that controlled a quarter of Mexico's arable land. At the same time, the foundation reiterated its wartime vow that it was not seeking to produce grain surpluses for export or profit. Yet MAP's former director, George Harrar, viewed surpluses as beneficial since they boosted other Mexican industries, transportation most of all.[29]

When US scientists like Harrar claimed that agricultural industrialization drove economic and spatial mobility, they based this view on US statistics. By 1960, the western and southwestern regions of the United States were epicenters of corporate agriculture. In the West particularly, vast road and hydraulic networks permitted higher population densities and more intensive agriculture. According to US data, these irrigated regions contained more hard-surface roads and more highly developed highway systems than rural regions lacking irrigation. In the United States, irrigation directly correlated with better roads, higher farm production, and greater spatial and upward mobility. Because MAP had not brought similar benefits to Mexico, the Rockefeller Foundation's inability to fully graft modern US technology onto traditional Mexican agriculture left technocrats like Harrar increasingly cynical about MAP's future.[30]

The perceptions of the Rockefeller Foundation and US experts like Harrar were crucial to both Mexican and world history since they ultimately shaped global development and landscapes. Harrar's career and ideological trajectories reflected this fact. Harrar, MAP's first director in 1943, was promoted in 1955 to the position of Rockefeller Foundation Director of Agriculture overseeing research worldwide. In 1961, Harrar was named interim, then permanent, Rockefeller Foundation president. His intimate knowledge of MAP informed the foundation's dramatic shift that began in the early 1960s. Under his leadership, the foundation's mission evolved from using US technology to feed people in developing nations to utilizing US technology to curb their reproduction. By reducing population, the Rockefeller Foundation hoped to alleviate global hunger and resource inequality, thus minimizing the appeal of communism during the Cold War.[31]

As the Cold War progressed, Harrar grew more assured of US technology and the *campesino*'s inability to benefit from it. Reflecting on the late 1950s, Harrar admitted that the *campesino* still overwhelmingly maintained traditional agriculture practices and "did not have the knowledge, the materials, nor the capital to increase the productivity of his land by modern means." In 1961, Harrar added: "You don't give a man a very complex diesel tractor if he's only been a mule man all of his life." And, years later, the Rockefeller Foundation

president blamed rural inequality on the *campesinos* themselves: "There is really no way to expect that the untutored . . . small farmers who haven't had the benefits of education can take maximum advantage of . . . better seeds, disease and pest control" and "better systems of irrigation." Harrar had taken this technologically deterministic view of traditional Mexican agriculture and applied it globally. The best hope for developing nations was not only to increase production but also to reduce population. In practice, this philosophy was not much different than the one that had guided MAP in previous decades. US technologies had performed a population control function in rural western Mexico by cultivating a culture of migration to the United States.[32]

As rural Mexican infrastructure, production, exports, and environmental change grew in the early 1960s, familiar conflicts flared anew. Despite nearly two decades of MAP's intervention, a comprehensive regimen of hybrid seed, agrochemicals, and irrigation remained unknown on most small private farms and *ejidos* in Jalisco. *Campesinos* continued to depend on traditional rain-fed agriculture. With land increasingly altered by hydraulic works, and as rainfall grew more erratic while more water was captured for irrigation storage, rural violence erupted. To make matters worse, Mexican experts noted "alarming" salinity levels in many irrigation districts. In this context, one group from Michoacán warned the SRH that "extremely grave conflicts" would erupt with the *ejidatarios* controlling their area's water supply unless it stepped in. In response, the SRH began planning a new, massive hydraulic project for the Lerma River.[33]

MAP concluded as the Lerma Project began, leaving a lasting legacy in Latin America and beyond. Rockefeller Foundation President Harrar and Mexico's agriculture secretary signed an agreement finalizing the foundation's withdrawal in 1961. By then, nearly half of the foundation's funds devoted to Latin American agricultural science over the previous two decades had gone to Mexico. Millions of dollars had been spent training *técnicos* in US universities. MAP staff (and assumptions) were transferred to developing countries where the Rockefeller Foundation's agricultural and population control technologies reaped controversial results. Although the foundation's focus shifted away from Mexico, its core mission never wavered, sowing fertile ground for US science, values, and exports globally. The US-based Inter-American Development Bank (IDB) quickly filled the foundation's void as the dominant financial and technical force in rural Mexican and Latin American industrialization.[34]

The IDB, a multilateral finance system created in 1959 and controlled by the United States, intensified technological and environmental change in Mexico like the Rockefeller Foundation before it. In 1962 the IDB demanded, as a prerequisite for the Mexican government to receive credit to finance new hydraulic works, that industrial

inputs like fertilizer and hybrid seed be utilized on all ensuing irrigated lands. Consequently, the funding proposal for the Jalisco Plan (part of the wider Lerma Project) projected a five-year investment of $150 million for hydraulic works. Yet only $60 million were allocated for hydraulic infrastructure, while $55 million were earmarked for "agricultural inputs, including credit for seeds [and] fertilizers." In the early 1960s, Mexican officials, awash in US funding and facing rural unrest, doubled down on the technologies driving rural inequality and environmental change.[35]

The SRH proclaimed that the Lerma Project and the Jalisco Plan were designed to keep braceros and undocumented migrants within rural western Mexico. Yet President Adolfo López Mateos (1958–64) continued his predecessors' boosterism of demographic mobility via water infrastructure and land reform. These policy contradictions were shaped by the changing political climate in the United States, including the end of the Bracero Program in 1964. Facing a potential influx of returning migrants to central-west Mexico, and flush with IDB financing, *técnicos* planned a larger wave of public water works to mitigate anticipated conflict, despite the fact that hydraulic technologies had fueled land loss, job loss, and violence in the past. Officials were bolstered by data showing that Mexico's irrigated acreage had risen from two million in 1946 to 6.2 million by 1963, allowing farmers to export seventy-two thousand tons of wheat in 1963. But corn production, which was far more vital to western *campesinos*' lives, proved more erratic. Rockefeller Foundation observers blamed the disparity between wheat and corn yields on the reluctance of these "small-scale farmers" to adopt modern agricultural techniques and inputs.[36]

By 1964, the main constant in rural Mexican development was contradiction. Water works were viewed as the primary solutions to the very inequality and conflict that they were known to aggravate. Irrigation infrastructure, promoted as the answer to climate volatility, had precipitated environmental change and intensified its effects. Industrial agriculture, hailed as the modern road to higher living standards, frequently led to downward mobility for *campesinos*. The Lerma Project embodied these inconsistencies in western Mexico. After decades of rapid infrastructure and economic growth, Mexican officials faced the mass return of the people who had borne much of the burden of modernization: rural migrants. Mexican analysts noted that jobs had to be created in the Lerma basin, "one of the greatest sources of braceros," given that the program's end heralded "intense social conflicts." Therefore, after two decades of binational cooperation, billions of dollars of debt, and nearly 4.5 million bracero migrations, rural inequality in western Mexico had changed little. Rural livelihoods, migrancy, and landscapes, however, had changed forever.[37]

CONCLUSION

For *campesinos*, the effects of land tenure reform and agricultural industrialization were mixed and numerous. By 1969, half of Mexico's farms still grew native corn despite two decades of MAP research and extension. In total, 57 percent of cultivated land in Jalisco remained in *ejidos* and 45 percent of arable land grew corn and beans, with vast segments of the state featuring rain-fed regimes. Only 16 percent of corn-sown land grew hybrids, while most corn was grown on "small, rain-fed plots," with research revealing little difference in yields between hybrid and *criollo* seed. Results were similar in countries where the Green Revolution took root, like India, where a decade of wheat research and extension resulted in only a third of cultivated land using irrigation by 1980. Yet Harrar maintained that the Rockefeller Foundation's "most fundamental contribution" to global agriculture was providing foreign peoples with the technology to break out of the "fatalistic farm patterns of the past." This assessment contradicted reality in post-1965 Mexico. As Mexicans began an unprecedented and largely undocumented phase of labor migrancy to the United States, the Green Revolution's "most fundamental contribution" to rural Mexican society had proven to be transnational migration.[38]

The relationship between bracero-era hydraulic and agricultural industrialization, environmental change, and transnational migration is clear today. From 1940 to 1964, however, Mexican and US technocrats ignored Green Revolution technology's effect on downward and spatial mobility as yields increased. Between 1945 and 1970, production on Mexico's industrial farms increased by 22 percent. By 1970, Mexico produced four times more wheat than it had in 1945. In fact, MAP's former wheat research director, Norman Borlaug, was awarded the Nobel Prize in 1970 for his work in India. In a Rockefeller Foundation film chronicling the Green Revolution, which was released that same year, Borlaug vowed that this industrial agricultural regime was "as Mexican as tortillas, refried beans, and *chile*." He spoke of social justice and how the people of the world deserved to "live decently." Yet the nearly three hundred thousand Mexicans deported from the United States that year, most from central-west Mexico, contradicted Borlaug's benevolent assessment of US technology. Rapid hydraulic infrastructure expansion had irreversibly altered landscapes and livelihoods in Mexico. It was only fitting then that, as Borlaug delivered his final thoughts on science, development, and humanity, the camera slowly zoomed out to reveal the agronomist seated in front of a vast Mexican reservoir—both a symbolic and concrete testament to hydraulic technology's role in building an emigrant Mexico.[39]

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Notes

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1 For examples, see Mary Mendoza, "Treacherous Terrain: Racial Exclusion and Environmental Control at the U.S.-Mexico Border," *Environmental History* 23 (January 2018): 117–26; Mikael Wolfe, *Watering the Revolution: An Environmental and Technological History of Agrarian Reform in Mexico* (Durham: Duke University Press, 2017); Deborah Cohen, *Braceros: Migrant Citizens and Transnational Subjects in the Postwar United States and Mexico* (Chapel Hill: University of North Carolina Press, 2011); Luis Aboites, *La decadencia del agua de la nación* (Mexico City: Colegio de México, 2009); Angus Wright, *The Death of Ramón González: The Modern Agricultural Dilemma* (Austin: University of Texas Press, 2005). H. Flores, "Algunos problemas de la Reforma Agraria," *Revista de Economía*, October 15, 1945, box 56, ex. 144, Carlos Lazo Collection (CL), Archivo General de la Nación (AGN), Mexico City; Manuel Ávila Camacho, *Informe que rinde al H. Congreso de la Unión* (Mexico City: Secretaría de Gobernación, 1941), 71.

2 *Segundo censo agrícola-ganadero y ejidal, resumen general*, 1940; *Tercer censo agrícola-ganadero y ejidal, resumen general, 1950*; *Cuarto censo agrícola-ganadero y ejidal, resumen general*, 1960; Manuel García y Griego and Mónica Verea Campos, *México y Estados Unidos frente a la migración de indocumentados* (Mexico City: Universidad Nacional Autónoma de México, 1988), 116–17; James Sandos and Harry Cross, "National Development and International Labour Migration: Mexico 1940–1965," *Journal of Contemporary History* 18 (January 1983): 45; *Caminos y desarrollo: México, 1925–1975* (Mexico City: Secretaría de Obras Públicas, 1975), caption 94; Douglas Massey, Jorge Durand, and Nolan J. Malone, *Beyond Smoke and Mirrors: Mexican Immigration in an Era of Economic Integration* (New York: Russell Sage, 2003), 58–59.

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4 Marcos Cueto, ed., *Missionaries of Science: The Rockefeller Foundation and Latin America* (Bloomington: Indiana University Press, 1994), iv; Adolfo Orive Alba, "Una tierra sedienta," *Investigación Económica* 6 (1946): 239; "Estado general de las siembras y cosechas en la República Mexicana durante el mes de junio de

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construyan con urgencia las obras que reclama el aumento constante de la población en la cuenca de Lerma, proporcionado trabajo aquellos que necesitan vicir [sic] de la agricultura para que no emigren en calidad de braceros," August 9, 1961, box 3098, ex. 4276, AS.

34 American Chamber of Commerce of Mexico, May 11, 1962, Series 1: General Office Files, box 1, fol. 14, 2, RG 6, SG 13 (FA398), RAC; "Operating Program in Agriculture," December 5–6, 1961, Series 300: Latin America, Subseries 300.D: Latin America-Natural Science, box 14, fol. 110, RG 1.2 (FA387), RAC; "The Agricultural Sciences Program in Latin America: Present Activities and Projections," September 1963, Series 300: Latin America, Subseries 300.D: Latin America-Natural Science, box 14, fol. 108, 4, RG 1.2 (FA387), RAC; "Financial Summary: Program in the Agricultural Sciences, 1941–1964," Subgroup 2: Administration, Program and Policy, Subseries 923: Agriculture, box 4, fol. 16, 1, RG 3 (FA112), RAC (the sum represents between $20 and $30 million for 2019, adjusted for inflation); Dylan Matthews, "'The Time of Vasectomy': How American Foundations Fueled a Terribly Atrocity in India," *Vox*, June 5, 2019, https://www.vox.com/future-perfect/2019/6/5/18629801/emergency-in-india-1975-indira-gandhi-sterilization-ford-foundation.

35 "Síntesis del Plan Lerma, fines de metas programadas," n.d., box 3650, ex. 50589, AS (the greater sum represents $1.2 billion in 2019, adjusted for inflation); "Memo from Lerma Chapala Santiago Working Group," n.d., box 3650, ex. 50589, AS.

36 "Recomendación de la Comisión de Estudios"; Adolfo López Mateos, "Decreto que constituye con carácter permanente la Comisión del Desierto," n.d., box 512, ex. 371068, 1–3, AGN; Secretaría de Obras Públicas, "The Rockefeller Foundation: Meeting of the Board of Consultants for the Agricultural Sciences, Tarrytown House," August 10–12, 1964, Subgroup 2: Administration, Program and Policy, Subseries 923: Agriculture, box 4, fol. 15, 4–5, RG 3 (FA112), RAC.

37 A confidential report detailing dam and irrigation district plans revealed the project's principal objective was not to increase production but, rather, to alleviate strife. "Préstamo a Nacional Financiera, S.A. de México: (Nueve sistemas de riego: Cuenca Lerma-Chapala-Santiago)," July 1, 1964, box 2706, ex. 37941, 1, 25, AS; Massey, Durand, and Malone, *Beyond Smoke and Mirrors*, 60 (this figure does not include undocumented migrants).

38 Fowle, "Recollections of J. G. Harrar," 9, 63; Ireson, "Landholding, Agricultural Modernization," 353, 356 (these statistics were calculated under rain-fed conditions); Biplab Dasgupta, "India's Green Revolution," *Economic and Political Weekly* 12 (February 1977): 245; Ana Minian, *Undocumented Lives: The Untold Story of Mexican Migration* (Cambridge: Harvard University Press, 2018), 4–5. From 1965 to 1986, around twenty-eight million undocumented Mexicans entered the United States.

39 Simonian, *Defending the Land of the Jaguar*, 171; *Horizontes: La Revolución Verde* (film), Gemini Films/David Boyer Productions, 1970, Series 1: Rockefeller Foundation Films, box 1, DVD no. 134, Audiovisual Materials (FA752), RAC; Jorge Bustamante, "Undocumented Immigration from Mexico," *International Migration Review* 11 (July 1977): 154; Laura Maderey, "El recurso agua en la República Mexicana," *Revista Geográfica*, January–June 1994, 145; A. S. Oberai and H. K. Singh, "Migration Flows in Punjab's Green Revolution Belt," *Economic and Political Weekly* 15 (1980): A2–12.