GROWTH INDUSTRY

THE POLITICAL ECONOMY OF FERTILIZER IN AMERICA, 1865-1947

BY

TIMOTHY JOHNSON

(Under the Direction of Shane Hamilton)

ABSTRACT

Between the end of the Civil War and World War II, the American South became a leading producer and consumer of fertilizer in the nation as well as the world. Although the region has often been considered a backwater outside of the main currents of agricultural modernization, southern farmers growing inedible staples such as cotton and tobacco were among the earliest adopters of the mineral and chemical plant foods that have helped shatter previous limits on food and fiber production. While fertilizer manufacturers sold their products as a panacea that could, and did, transform farming, the revolution in agricultural practice that fertilizers represented only served to reinforce unequal race and class relations in the rural South. Fertilizer trade associations protected the interests of fertilizer manufacturers by promoting favorable agronomic research, discrediting critics, and by actively stifling farm organizations that sought ways to escape the trap of debt attached to fertilizer purchases. Pressure from the fertilizer lobby also played an important role in shaping the development of government-sponsored agricultural programs from World War I to World War II. Notably, state-sponsored research and development programs at the Tennessee Valley Authority's facility in Muscle Shoals, Alabama served as a subsidy for

highly capitalized chemical corporations that would eventually outcompete the small regional fertilizer manufacturers that had sustained southern agriculture since the Civil War. In turn, the federal commitment to fertilizer research helped expand the fertilizer market from beyond it stubbornly regional roots and deliver powerful agricultural chemicals to the rest of the nation and the world. This dissertation identifies the emergence of a new approach to farming that has helped transform global food and fiber production, along with landscapes around the world. Ultimately, it argues that the practice of fertilizer-fueled agriculture did not come to pass solely because of the intellectual work of scientists, but rather through negotiations between businesses, state actors, farmers, and the environment.

INDEX WORDS: Fertilizer, fertilizer industry, agriculture, American South, South, agricultural state, global nutrient economy, nutrient regimes, cotton, political economy, technology, environment, industry, business, chemical industry, National Fertilizer Association, Tennessee Valley Authority, Fixed Nitrogen Research Laboratory, World War I, World War II, New Deal, United States Department of Agriculture, sharecropping, tenancy, debt, nitrogen, phosphate, potash, potassium, guano.

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TIMOTHY JOHNSON

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TIMOTHY JOHNSON

Major Professor:	Shane Hamilton
Committee:	James C. Cobb Daniel Rood Paul Sutter

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
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INTRODUCTION

UNEARTHING THE ROOTS OF FERTILIZER-FUELED AGRICULTURE IN AMERICA

In 1951, the National Fertilizer Association printed a comic book entitled "The Conquest of Hunger Featuring Prosper Plenty and His Magic Chemicals." Across 16 colorful pages, a cherubic and surprisingly well-informed fertilizer sack takes two American youngsters on a journey through time and space to illustrate the indispensable role that fertilizer had played to make life better for people all over the world. On the front cover, Prosper Plenty leads an entourage of farmers, scientists, and businessmen to banish the Grim Reaper to oblivion, presumably for good. The message was unmistakably clear: fertilizer would save the world from deprivation and safeguard against population collapse of the variety described by the economist Thomas Malthus. When I first dug up Prosper Plenty in an archive, I was tempted to laugh the comic off as a ham-handed public relations stunt all too typical of the cold war era, albeit an entertaining one. Once I finished chuckling, however, it dawned on me that this comic book, silly as it seemed, actually raised substantive questions about the historical forces that had produced it. Why, for instance, would the fertilizer lobby have felt compelled to publish a comic book in the first place? Why would fertilizer need a lobby at all? Feeding plants seems like a necessary and seemingly uncontroversial act. Why

had the fertilizer industry created its own interest group all those years ago, and why did it go to such pains to project a positive image?[1]

As I pondered these questions, I sat in the offices of The Fertilizer Institute, a group that promotes and protects the interests of the fertilizer industry inside the Washington Beltway. It is the latest iteration of the National Fertilizer Association, which a group of Baltimore fertilizer manufacturers started in the 1880s to organize the fertilizer industry and defend itself against state regulations. Between its earliest days and now, the fertilizer industry has evolved from a small group of companies that imported guano and processed byproducts to sell as plant food into a sophisticated international chemical industry that has a presence in all but a few corners of the globe. This dissertation explores how that transformation occurred. To do so, it examines the social, political, and environmental forces that shaped the industry's growth and the reinvention of agriculture these forces helped to deliver.

When fertilizer first came into use in the mid-nineteenth century, large swaths of the eastern United States were untilled because of the poverty of the soil. By 1880, Americans spread some 753,000 tons of fertilizer on their farms, all of which were byproduct and mineral-based. By 1950 that number climbed to 20 million tons annually, and most came in the form of synthetic chemicals many times as powerful as the first generation of fertilizers in the nineteenth century. Today, fertilizer accounts for somewhere between 40 to 60 percent of the entire agricultural yield in the United States, and much more than that in other parts of

[1] Malcom W. Ater and National Fertilizer Association, *The Conquest of Hunger Featuring Prosper Plenty and his Magic Chemicals* (Washington, D.C.: National Fertilizer Association, 1951); Thomas Malthus, *An Essay on the Principle of Population*, ed. Geoffrey Gilbert (New York: Oxford University Press, 1993).

the world. In highly developed countries, the abundance of chemical nutrients in the soil is so great that it has created a tide of pollution in streams, rivers, and estuaries. At the same time, fertilizer has helped make farms so productive that fewer and fewer people are needed to tend them. The yields of chemical-input agriculture are so great that they have helped to transform the globe into a colony of city dwellers that pay little attention to the business of how crops are raised.[2]

Fertilizer has become so foundational to sustaining life around the world that it is easy to take for granted, like a utility so indispensable that it is difficult to imagine life without it. In spite of its ubiquitous, seemingly inevitable qualities, fertilizer has a history. This history is rooted in the political economy of the United States, and particularly in the South. There, America's earliest and most robust fertilizer market took shape to feed globally significant, inedible staple crops—particularly cotton and tobacco. During the period between the Civil War and the end of World War II, fertilizer manufacturers directed their products towards the production of the crops that fed the global economy, but did not enrich the farmers that grew them. Notably, the same period also saw fertilizer become essential to other industrial powers such as Germany, Britain, and Japan. Germany, in particular, was an important site in the production of agricultural science and technology, as well as a heavy consumer of imported fertilizer. Germany and the United States followed a similar trajectory, in which both nations relied upon fertilizer to feed the plants that were most important to each

[2] Alan L. Olmstead and Paul W. Rhode, "Fertilizer – farmers' expenditures, commercial fertilizer consumption, and liming materials used: 1850–1999," in *Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition*, edited by Susan B. Carter et al. (New York: Cambridge University Press, 2006); W.M. Stewart *et al.*, "The Contribution of Fertilizer Nutrients to Food Production," *Agronomy Journal* 97 (no. 1, 2005): 1-6.

nation's industrial economy. And while the production of agricultural knowledge and technology in Germany, as well as other regions of the United States during this period, is well documented, the creation of a new fertilizer regime in the South has been largely overlooked.

The global ubiquity of fertilizer is not merely the result of the development of science and technology, nor can it be explained away as a simple economic phenomenon that one might illustrate with line graphs and charts. The explosive growth in American agricultural productivity usually associated with the post-World War II period was the result of a global nutrient economy that had been developing for decades. The nationwide surge of fertilizer-fueled agriculture that came to fruition during the 1950s and beyond was the result of a long negotiation between businesses, state actors, farmers, laborers, and landscapes that had been going on for decades by the time fertilizers became a commonplace on farms across the entire United States and the world. As I argue, creating this new global fertilizer economy took *work*—and as the records of the National Fertilizer Association suggest, it was a complicated business performed by an array of individuals and competing interests. By sorting through the scattered records of fertilizer corporations, merchants, government agencies, and farmers, it becomes much less clear that the morally unassailable project of staving off hunger and "feeding the world" has been the driving impulse behind the rise of fertilizer-fueled agriculture. Examining the places where fertilizer production and use first took root reveals that those crops least likely to feed those who cultivated them became the primary beneficiaries of new chemical inputs.

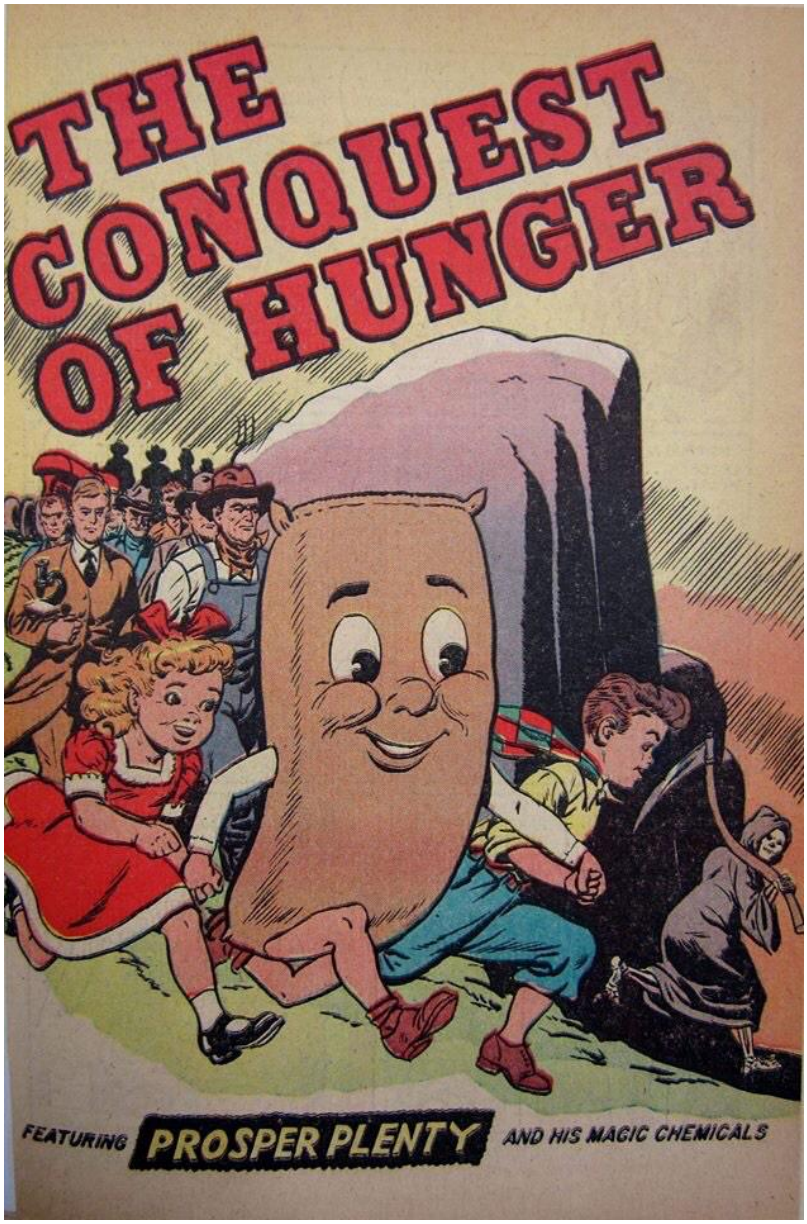

Fig 0.1. Cover image of National Fertilizer Association Comic, 1951. The National Fertilizer emphasized its role as a servant of the public good through many different types of media, including this comic book. (The Fertilizer Institute)

This dissertation examines now the global nutrient economy was not created by any one interest group, economic impulse, or stimulus, but rather through a relational process. Namely, it reveals how a complicated push-and-pull

between public and private interests was instrumental to creating a new agricultural regime. Exploring the internal dynamics of the fertilizer industry sheds light on the complex and surprising ways that a group of businesses have remade the global environment by summoning networks of capital, material, and labor. In their efforts to expand their market, the records of fertilizer manufacturers also show how these businesses were selling new agricultural practices along with their products. As such, the fertilizer industry serves as a compelling case study of the inextricable links between business history and environmental history. Insofar as the records of the fertilizer industry are chronicles of business practices, considering their broad implications in landscapes around the world, they are also an archive of epochal ecological change. Indeed, these records make it difficult to maintain the artificial boundaries between nature and culture or nature and capital.[3]

These connections were also bound up with new relationships between businesses and the state. In the United States, the development of the fertilizer industry happened alongside the build-up of public investment in agriculture since the Civil War that I call the "agricultural state." This term refers to the birth and steady growth of public agricultural agencies and programs that emerged after the Civil War, representing an important phase of American political development during the early twentieth century. This umbrella term captures a suite of related entities including the United States Department of Agriculture,

[3] Christine M. Rosen, "The Business-Environment Connection," *Environmental History* 10, no. 1 (2005): 77-79; Christine M. Rosen and Christopher C. Sellers, "The Nature of the Firm: Towards an Ecocultural History of Business," *The Business History Review* 73, no. 4 (1999): 577-600; Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* (New York: Verso, 2015).

agricultural experiment stations, the Cooperative Extension Service, the agricultural research programs of land-grant universities, state-level agricultural departments, as well as public-private interests such as the American Farm Bureau Federation. The scale and scope of the fertilizer industry's influence loomed especially large over the agricultural state as it grew, but its influence over the activities of these new agencies has remained obscure. Going far beyond merely brokering deals with legislators, the National Fertilizer Association orchestrated an industry-controlled research, public relations, and lobbying apparatus. In so doing, the NFA sought to generate favorable scientific findings, cherry-pick and promote beneficial public research, and influence state actors. The fertilizer industry's "Shadow USDA" functioned as an unseen hand, trimming and training the agricultural state to grow in ways that supported the industry's priorities.[4]

Actors within the agricultural state, however, had their own powerful incentives to become involved in the business of fertilizer production. New forms of public research helped accelerate the chemicalization of agriculture decades

[4] One the most forceful condemnations of the influence of private interests over the agricultural state remains Jim Hightower, *Hard Tomatoes, Hard Times: A Report of the Agribusiness Accountability Project on the Failure of America's Land Grant College Complex* (Cambridge, MA: Schenkman Publishing Company, 1971); see also James R. Kloppenberg, Jr., *First the Seed: The Political Economy of Plant Biotechnology, 1492-2000* (New York: Cambridge University Press, 1988). For a history of the networks of research funding and federal spending, see David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate* Capitalism (New York: Knopf, 1977); Sheila Jasanoff, ed., *States of Knowledge: The Co-Production of Science and the Social Order* (New York: Routledge, 2004). Other scholars that invoke the agricultural state or generally explore a more capacious definition of American agricultural policy include Adam D. Sheingate, *The Rise of the Agricultural Welfare State: Institutions and Interest Groups in the United States, France, and Japan* (Princeton: Princeton University Press, 2001); Shane Hamilton, *Trucking Country: The Road to America's Wal-Mart Economy* (Princeton: Princeton University Press, 2008); Ariel Ron, "Scientific Agriculture and the Agricultural State: Farmers, Capitalism, and Government in the Late Nineteenth Century," *Journal of the Gilded Age and Progressive Era* 15, no. 3 (July 2016): 294-309; Gabriel N. Rosenberg, *The 4-H Harvest: Sexuality and the State in Rural America* (Philadelphia: University of Pennsylvania Press, 2016).

before the spike in agricultural production that characterized the post World War II period. Cotton production, in particular, had become dependent on foreign fertilizer minerals by the turn of the century, but this new reliance was a liability in an era of U-Boats and naval blockades. The federal government was forced to assume new responsibilities by developing strategies to manufacture both explosives and fertilizers, both of which relied on similar natural resources and production technologies. Of particular significance, federal researchers tasked with finding new ways to develop these technologies delivered their findings directly to chemical manufacturers, without providing direct fertilizer subsidies to farmers, as many politicians had led the public to believe. Through this process, the feedback loop of arms and farms spending and research continued to escalate through the interwar period, delivering generous subsidies to chemical firms that brought fertilizer production to new levels during and after World War II.[5]

This re-periodization offers a longer history of public research and investment that pushes back against an emphasis on cold war era science and research spending that provided the material and technical basis of late-twentieth century agricultural development programs known as the "Green Revolution." Along with hybrid seed varieties and pesticides, fertilizer was a key element of the state-led global agro-development projects led by the famous plant geneticist Norman Borlaug and the Rockefeller Foundation. Yet, the powerful fertilizer that

[5] On the bundle of relationships between military research and agricultural science see Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (New York: Cambridge University Press, 2001); David Kinkela, *DDT and the American Century: Global Health, Environmental Politics, and the Pesticide That Changed the World* (Chapel Hill: University of North Carolina Press, 2011). On the role of public spending on innovation, see also, Mariana Mazzacuto, *The Entrepreneurial State: Debunking Public Vs. Private Sector Myths* (New York: Anthem Press, 2013).

was so crucial to these schemes has a deeper history in the push and pull between the fertilizer industry and the agricultural state long before Borlaug and his devotees came on the scene. These research and development projects, such as the Tennessee Valley Authority's fertilizer program, often ran afoul of segments of the fertilizer industry that lacked the resources to adopt new technologies—particularly the profusion of small regional companies that served particular segments of the South. First in the U.S. and then around the world, publicly funded fertilizer research has had an extraordinary impact on farming and ecosystems around the globe. In fact, as much as 75 percent of the fertilizer used around the world today depends upon technology developed by engineers in Muscle Shoals, Alabama.[6]

Some of what follows takes place in Washington, D.C. and the Mid-Atlantic region near the center of government and the corporate headquarters of fertilizer manufacturers. But the South, as the primary area of fertilizer application and the industry's center of gravity during the period, served as a staging ground for the incipient fertilizer-fueled agricultural system. In recent years, many historians have examined how southern cotton became the driving wheel of the globalized capitalist economy in the nineteenth century. Building upon these insights, I situate the South's central role in the creation of a related network, which I call the "global nutrient economy." More than anywhere else in

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[6] International Fertilizer Research Development Center, "TVA fertilizer technology used worldwide – but few new products since 1970s," accessed August 22, 2016, http://www.eurekalert.org/pub_releases/2008-08/i-tft082508.php. Current International Fertilizer Development Center staff and retired TVA fertilizer researchers have provided additional documentation for to support this claim.

the nation, the South was the key site in the production and consumption of materials drawn from a far-flung network of economically valuable minerals. Illuminating the development of these new global relationships brings into focus an overlooked but vital set of connections between the South, the nation, and the world. It also highlights the ways that the economic and environmental conditions peculiar to the South shaped the industry's development.[7]

It may come as a surprise to some that the birth of chemical-intensive agriculture did not spring up from the fabled centers of agricultural innovation like Iowa or California, but rather in the postwar wreckage of the southern plantation economy. Often held up as a "backwards-looking" society, the South's rapid adaptation of fertilizer-fueled agriculture made it the progenitor of input-intensive agriculture in the rest of the country and the world. At the same time, the revolutionary new approach to feeding crops did not translate into a revolution in social relations. Noting this fact, I am echoing the voices of many historians of industrialization in the South who have shown how industrial development has had a tendency to reinforce, not revolutionize, social relations. As both an agricultural technology and a major industry of the New South, the sale, application, and production of fertilizer had a similarly calcifying effect on prevailing racial and social inequalities. As an industry woven into the fabric of

[7] The recent wave of histories of capitalism that make very strong arguments that cotton and slavery were the cornerstones of global capitalist development, rather than "pre-capitalist" as many earlier studies have claimed. These authors also emphasize the global relationships between places like the South, which American historians have all too often viewed within a national, rather than global lens. Sven Beckert, *Empire of Cotton: A Global History* (New York: Knopf, 2014); Edward Baptist, *The Half has Never Been Told: Slavery and the Making of American Capitalism* (New York: Basic Books, 2014); Daniel B. Rood, *The Reinvention of Atlantic Slavery: Technology and Capitalism in the Greater Caribbean*, 1830-1860 (New York: Oxford University Press, 2017). On the South's role as a "domestic laboratory" for American global development projects, see Tore Olsson, *Agrarian Crossings: Remaking the U.S. And Mexican Countryside in the Twentieth Century* (Princeton: Princeton University Press, 2017).

southern life, however, its resistance to challenging local custom helped make the southern sector of the industry particularly vulnerable as the industry evolved over time.[8]

Until now, the fertilizer industry has been in the scholarly province of three groups: economists, historians of science and technology, and industry insiders. Economists' preoccupation with price indexes and yields provide valuable data, but their interpretations often belie the complexity of the subject. I shy away from the tendency to tell stories with charts and line graphs, opting instead to pursue firsthand accounts that add context and texture to what can be reductive quantitative interpretations. In contrast, historians of science and technology have handled the material with care, but their emphasis has been the work of scientists in the laboratory and the minutiae of specific technological systems. As such, in many cases, attention to the influence of specific scientists' contributions has led scholars to credit just a few brilliant individuals with the construction of the global nutrient economy. To be certain, this project also pays close attention to the labor of scientists and engineers, but rather than

[8] Several different scholars emphasize the ways that an industrial, or "high modernist" aesthetic defined many of the most important agricultural regions of the United States in the twentieth century, but few of them look closely at the South, which often stands in as a region resistant to the forces of agricultural modernization. Steven Stoll, *The Fruits of Natural Advantage: Making the Industrial Countryside in California* (Berkley: University of California Press, 1998); Deborah Fitzgerald, *Every Farm a Factory: The Industrial Ideal in* Agriculture (New Haven: Yale University Press, 2003); James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998). On southern industrialization, see James C. Cobb, *Industrialization and Southern Society, 1877-1984* (Lexington: The University Press of Kentucky, 1984); David L. Carlton and Peter A. Coclanis, ed., *The South, the Nation, and the World: Perspectives on Southern Economic Development* (Charlottesville: University of Virginia Press, 2003); Bruce Schulman, *From Cotton Belt to Sun Belt: Federal Policy, Economic Development & the Transformation of the South, 1938-1980* (Durham: Duke University Press, 1994). An excellent recent work that blends the entwined histories of industrialization and environmental history in the South is William Boyd, *The Slain Wood: Papermaking and Its Environmental Consequences in the American South* (Baltimore: Johns Hopkins University Press, 2015).

emphasizing the heroic scientist's "Eureka Moment," it seeks out the channels by which these technologies flowed from the laboratory to the landscape. I show how businessmen and bureaucrats played a crucial role in that project. Finally, while many industry insiders have provided detailed descriptions of the industry's development, their work often lacks historical context. Texts such as these have served this project well as a source of reference material, but they offer little in the way of an analytical framework.[9]

Without a doubt, the most ambitious study of the American fertilizer industry is Richard Wines's 1985 monograph, *Fertilizer in America*. Wines documents the beginning of the industry in Mid-Atlantic states in the mid-nineteenth century, when manufacturers began to supplant manure and byproducts with mineral fertilizers in a process that he describes as a transition from "recycling to resource exploitation." While the text provides a detailed account and a fair assessment of the origins of the industry, the periodization Wines offers pays little attention to the industry's southern relocation after the Civil War and its absolutely vital role to producing staple crops there. Furthermore, the characterization of the evolution of the fertilizer regime from a recycling system to one characterized by resource exploitation misses the

[9] For an example of a good economic study of fertilizer, see Mirko Lamer, *The World Fertilizer Economy* (Stanford: Stanford University Press, 1957). For the history of science and technology of the fertilizer industry, a few fine studies are Alan I. Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890* (Ames: Iowa State University Press, 1985); Margaret W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans* (New Haven: Yale University Press, 1975). The best history of technology or STS accounts of fertilizer production are undoubtedly Vaclav Smil, *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (Cambridge: The MIT Press, 2001); Lewis B. Nelson, *History of the American Fertilizer Industry* (Muscle Shoals: Tennessee Valley Authority, 1990). A good examination of the nineteenth century agricultural transformation, see F.M.L. Thompson, "The Second Agricultural Revolution, 1815-1880," *The Economic History Review* 21, no. 1 (1968): 62-77.

complexity of the transition from the early phases of mineral exploitation to the wholesale chemicalization of agriculture that would occur in the mid-twentieth century. To suggest that the modern fertilizer system had taken shape by the turn of the twentieth century misses the most significant part of the story.[10]

In recent years, energy historians have provided useful models to capture the complex evolution of large systems by connecting the activities of consumers with the infrastructure that serves them. In many ways, this project has been influenced by that scholarship, which also grapples with the productivity of societies. I borrow a framework from David Nye and E.A. Wrigley to chart the evolution of fertilizer sourcing and production through a series of four successive "nutrient regimes." While these different phases often did—and still do—overlap with one another, they help to account for how America moved from a system of soil mining to chemical-fueled farming in less than a century. The four regimes are the extensive nutrient regime, in which farmers draw nutrients from virgin soil; the organic nutrient regime that circulates nutrients drawn from waste and byproducts; the mineral regime, in which industrial minerals provide the nutrient source; and finally, a chemical regime, in which sophisticated techno-chemical processes render minerals and petrochemical byproducts into powerful concentrations of plant food. These categories provide a way to untangle the complex network of nutrient flows in the industrializing capitalist economy. And while they are not the terms used by the historical subjects themselves, the following details how the phases did not proceed in smooth chronological

[10] Richard A. Wines, *Fertilizer in America: From Waste Recycling to Resource Exploitation* (Philadelphia: Temple University Press, 1985).

succession, but instead through a process of negotiation and contestation over time and across space. For example, although the Southeast was squarely within the mineral regime by the 1870s, it was not until after the World War II era that fertilizer became common in the Midwest, when new strains of hybrid seed corn that were receptive to large fertilizer inputs brought the region from the organic to the chemical fertilizer regime in a few short years.[11]

Across five chapters, this dissertation investigates the negotiations between business, state actors, and farmers that transformed the way that America, and later the world, supplies its food and fiber needs. Chapter One, "Dirt and Debt in the New South," investigates the creation of America's first major fertilizer market in the South. It examines the political ecology of the post-Civil War South to show how fertilizer became part of the fabric of southern life and an absolutely essential factor in the postwar surge in cotton production. To do so, it focuses on the state of Georgia, which led the nation in fertilizer purchases for almost the entire period this dissertation covers. It traces the experience of the region's earliest and most prominent fertilizer salesman, David Dickson, whose career trajectory links the antebellum cotton and slave economy with the postwar fertilizer boom. Using the agricultural press as his mouthpiece, Dickson transformed the loss of his enslaved labor force into an opportunity by

[11] Thomas G. Andrews, *Killing for Coal: America's Deadliest Labor War* (Cambridge: Harvard University Press, 2008); David E. Nye, *Consuming Power: A Social History of American Energies* (Cambridge: MIT Press, 1998); E.A. Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England* (New York: Cambridge University Press, 1988). See also Christopher F. Jones, *Routes of Power: Energy and Modern America* (Cambridge: Harvard University Press, 2014); Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (Chicago: University of Chicago Press, 1989); Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (New York: Verso, 2011).

selling fertilizers as a cure-all for the uncertainties of the post-emancipation labor regime. Selling a new way of thinking about farming as well as the fertilizer itself, Dickson and others like him capitalized on the new classes of poor and mostly landless farmers in the lower South. In the cash-poor southern economy, I explore the powerful—and largely ignored—role that fertilizer debt played in the lives of farmers, as fertilizer became a contested node of power relations between farmers and merchants. Finally, the chapter considers how southern farmers tried to form cooperative stores to circumvent these local power structures through the Farmers' Alliance. Where other scholars have emphasized the ways that farmers pursued cooperative action to consolidate power through sales as *producers*, I examine how the cooperatives carried special appeal in the South where farmers' status as *consumers* in the fertilizer powered cotton market made them even more vulnerable as a class. Ironically, Florida's wealthiest citizen—a bank owner who had made his fortune speculating in phosphate—underwrote the formative meeting of the Farmers' Alliance in Ocala, Florida.[12]

In Chapter Two, "Minerals of Empire," the focus shifts as we move from field to factory to take stock of the new commodity webs that the fertilizer industry assembled to feed the plants that fed the global economy. Southern cotton was a thoroughly globalized commodity that fueled textile production, but this chapter examines the parallel global network of plant nutrients that cotton production drew upon to remain viable. First, it examines the map of global fertilizer resources and situates America within the circulation of industrial minerals in the global nutrient economy. Then it looks at the sites of extraction

[12] For fertilizer tonnage data, see Appendix 1.

and production in the domestic fertilizer industry to shed light on the work that went into making these products. In mines and factories, the labor of fertilizer production was among the most dangerous and degrading in America's industrial economy in the early twentieth century. Finally, it also highlights the work of fertilizer executives that translated scientific theories into business practices. As their industry became more powerful, they created professional associations to protect their interests and influence the government. Not only did they seek federal assistance locating valuable mineral resources, but they also began to influence the activities of the agricultural state by wooing and challenging state actors as they saw fit.

In Chapter Three, "Diplomacy, Discovery, and Denial," the asymmetries of the global fertilizer resource map discussed in the previous chapter take on new significance as America entered a conflict that threatened to sever the international ties of the global nutrient economy. Forced to confront that fertilizer now underwrote America's most valuable crops, personnel from the agricultural state pursued three main pathways to try to secure steady supplies of minerals that fed American farms. One approach was *diplomacy*: businessmen and diplomats tried to broker an exchange of American phosphates for Germany's coveted potash salts. At the same time, Congress also devoted new funding for researchers to *discover* new, domestic sources of fertilizer. These scientists and prospectors looked for new mineral resources and scientific processes that would be useful to feeding plants and weapons alike. The National Defense Act of 1916 funded a new nitrogen-fixation plant in Alabama for wartime munitions and peacetime fertilizer production, serving as the first step in a major

program of public fertilizer research that would continue for decades. Still others *denied* the importance of fertilizer, arguing that the need for German potash salts was part of a "Teutonic Conspiracy" carried out by agricultural chemists brainwashed by their German heritage or university education. Finally, I detail how the Wilson administration's policy of public-private cooperation to build the American war machine created dazzling opportunities for fertilizer manufacturers to accrue lasting power and influence in Washington.

Chapter Four, "Every Farm is a Chemical Factory" delves into interwar battles over the nature of agricultural modernization by taking a trip to the laboratory. It examines how the scientists tasked with discovering nitrogen-fixation technologies carried out their postwar mandate to shift their focus from explosives research to fertilizer research. How this transition would proceed, I show, was an extremely significant, but mostly overlooked, footnote to the "Muscle Shoals Debate" over postwar fate of government facilities in Alabama. The Fixed Nitrogen Research Laboratory (FNRL) housed first in Washington, and later in Muscle Shoals, was the center of these activities. Instead of using their new technologies to build government-owned fertilizer plants to subsidize farmers directly, FNRL's leadership opted to act as consultants for American companies that wanted to put government-funded technologies to work. This decision had long-term impacts, but in the short term it helped American fertilizer manufacturers to generate more powerful nitrogen fertilizer more cheaply than ever before in the late '20s. The chapter also looks at the ways that the fertilizer industry reacted to these new, enterprising activities of the agricultural state. In Washington, the National Fertilizer Association's lobbying

activities ratcheted up as they attacked the fertilizer program in Muscle Shoals. They also became more involved in policing the work of county agents from the Cooperative Extension Service, especially those in the South that were helping farmers organize cooperatives. The NFA relied upon intelligence gleaned from local fertilizer dealers and pressured top-level USDA staff to punish or fire agents that were disrupting business-as-usual in local fertilizer markets.

Chapter Five, "Shadows of the Agricultural State," looks at the complicated relationship between New Dealers and fertilizer manufacturers through depression and war. Taking a close look at the Tennessee Valley Authority's agricultural polices, it parses the ways that the agency's fertilizer research and distribution network made plant food some of the most tangible evidence of New Deal policy for farmers not just in Tennessee, but also across the country. As it was with many other New Deal programs, however, these benefits intended to serve the worst victims of the economic crisis generally redounded to well-connected individuals. Even though subsidized fertilizer often ended up in the hands of those farmers who needed the assistance the least, the geographic scope of the program ensured that fertilizer became a mainstay in areas where it was seldom used before. The chapter then looks at the ways that fertilizer manufacturers tried to infiltrate and influence the expansive agricultural state of the New Deal era. I discuss how the fertilizer lobby's opposition to the TVA's fertilizer research and development revealed fault lines within the industry itself. Most significantly, the National Fertilizer Association's attacks on TVA's new super-concentrated fertilizer products were meant to protect the southern wing of the fertilizer industry for whom technological innovation represented a force of

economic and social disruption. The chemicalization of agriculture benefitted agile chemical corporations but left behind the small regional fertilizer manufacturers that had dominated the southern market since the Civil War. The chapter then looks at the government build-up of ordnance plants during the war, which laid the groundwork for the postwar transformation of the industry. In particular, it highlights how the federal government ramped up the program of public research and investment first established after the First World War on a colossal scale. The populist cry for federal fertilizer subsidies that had continued unabated since World War I fell silent as a deluge of federal spending flowed towards chemical corporations rather than farmers.

The Epilogue, "Texas City, 1947" revisits the important themes of the previous chapters through the lens of the Texas City Disaster. This devastating 1947 fertilizer explosion in a port outside of Houston leveled a Monsanto factory and oil refineries, laying bare the combination of public investment, private initiative, and petrochemicals that turned America into an internationally dominant agricultural powerhouse. The accident's locale—in ships destined to carry out foreign aid projects—highlights the ways that American plant food and fertilizer expertise would become a key part of Cold War-era aid and development schemes. The TVA's fertilizer research center in Muscle Shoals became a global center of technical development, and its staff threw open the doors to foreign governments and eventually set up offices abroad. Through agricultural aid programs collectively known as the Green Revolution, the TVA's Fertilizer Development Center helped disseminate new technologies and processes that are used around the world to grow seeds that produce high yields with heavy

fertilizer inputs. These developments, of course, have had a wide range of impacts that include increased agricultural yields around the world, but also new sources of fossil fuel dependence, pollution, public health problems, and agricultural debt. The innumerable ways that fertilizer has impacted human and non-human life defy simple narrative and are difficult to quantify.

If Thomas Malthus had never been born to write his essay on population and agricultural decline, agrochemical corporations would have had to invent him. To this day, the firms that supply the chemicals and seeds used to grow the bulk of the world's crops offer a variation of the cartoonish Malthusian storyline portrayed on the cover of *The Conquest of Hunger* to explain their own social value, justify their own activities, and even to account for their own history. As the following chapters reveal, the suggestion that these industries grew reflexively in response to the pressures of population is self-serving and historically inaccurate. There can be little doubt that the fertilizer industry has changed the world in innumerable ways, whether by providing the world with more food, or alternatively, by creating new sources of ecological instability and debt. Wherever one sits in debates about the costs and benefits of an agricultural system that delivers fabulous yields along with innumerable ecological costs, at the very least, what follows recovers the complex, contingent history of materials that have become essential to modern life.

NOTES ON TERMINOLOGY

The pages that follow contain an unruly menagerie of terms and concepts that include technical and scientific terminology that is sometimes arcane and often dated. I have done my best to wield the chair of the lion tamer to domesticate this jargon by explaining and contextualizing technical minutiae in the text wherever it rears its head. And yet, this dissertation is about fertilizer. I suppose that any reader that ventures beyond the introduction ought to be equipped with the tools to defend his or herself when uncomfortable linguistic situations arise. I offer a brief explanation of key terms and concepts below.

"Fertilizer" as I use the term, describes materials sold for their value as plant food. In the 1800s, agricultural journals referred to such products as "commercial fertilizers" as a way to distinguish them from organic materials containing plant nutrients like manure or compost, which also improve soil structure. Manure and compost bear valuable plant nutrients but in lower quantities than most fertilizer. The first commercial fertilizer to become a global commodity was Peruvian guano, a dry residue of bird dung collected from the Chincha Islands. Guano provided agricultural soils valuable nutrients many times as powerful as most animal manures. By the 1870s, however, guano deposits were virtually exhausted, but in many places, the term "guano" remained as a catchall term for fertilizer. Only adding to the confusion, certain fertilizer companies marketed their products as "guano" well into the twentieth century to appeal to

southern farmers who continued to use the dated term to describe all fertilizer until at least the 1950s. They understood that they were not buying actual guano, but the famed fecundity of the original commercial fertilizer left a lasting impression on the language of southern farmers.

Fertilizers are composed of a broad assortment of materials drawn from mines, minerals, and byproducts, yet all fertilizer materials are valued for their concentration of plant nutrients. The three most important nutrients for the growth of plants, also known as "macronutrients," are nitrogen, phosphorus, and potassium (N-P-K). Although all three of these elements were familiar to scientists at the time, in the 1840s, the chemist Justus von Liebig pioneered influential theories of plant nutrition that emphasized the role of each of the three macronutrients as serving distinct roles in the growth of plants. Liebig also popularized a principle called the "Law of the Minimum," which stated that a plant's growth is limited by that nutrient which it lacks the most. These widely influential theories offered a scientific explanation for longstanding agricultural practices, and helped launch new ways of thinking about plants, animals, and the relationship between humans and natural systems. Liebig was keen to put his scientific theories to work in the business world, and he launched a short-lived fertilizer company. For his scientific discoveries and commercial venture, von Liebig has earned the moniker of the "Father of the Fertilizer Industry," which is misplaced for more than a few reasons. First, commercial fertilizer was already a global commodity before his discoveries and business venture. Second, without diminishing his landmark discoveries, giving Von Liebig the credit for an

expansive global agro-mercantile commodity network ascribes God-like power upon a scientist while diminishing the activities of those who actually built it.

Ascribing von Liebig—or any other scientist—with so much credit for the repercussions of his scientific discoveries also undercuts the important work done by those that came before him. This includes knowledge produced by other scientists, as well as the tacit knowledge gleaned by farmers over the centuries. Ancient texts from India to Greece document the value of growing beans and other legumes to improve soils, and farmers in indigenous cultures have used legumes effectively without the need for validation from scientific thought. During the early 1800s, European farmers integrated legumes into a formal system of cultivation and crop rotation known as "convertible husbandry." Along with Jean-Baptiste Boussingault, Liebig validated the practice with scientific inquiry by demonstrating how leguminous crops converted nitrogen from the atmosphere into a form that is useful to plants. Regardless, I use the terms "legume" and "green manure" interchangeably to describe this category of plants, which includes alfalfa, peanuts, clover, and vetch. As an additional point of clarification, legumes are an important element of the organic nutrient regime, but they are also important to the organic farming movement, which was a distinct political and cultural movement of the mid-twentieth century.

Each of the three macronutrients has been derived from a succession of different materials over time, and each element plays a distinct role in the life cycle of plants. The first of these is nitrogen, which helps plants build amino acids and chlorophyll. In its stable form, nitrogen (N_2) is the most common gas in the earth's atmosphere. By contrast, plants can only absorb nitrogen as N_1, which is a

relatively rare molecule in the earth's biosphere. Legumes evolved in relation to bacteria that allow them to absorb and convert nitrogen from the air into its useful form. Minerals such as Chile's nitrate deposits also contain valuable concentrations of the molecule. In 1909, Fritz Haber developed a process to break the bond of atmospheric nitrogen and "fix nitrogen" from the air making it useful for fertilizer. As was the case with mineral nitrates, the ammonia produced through nitrogen fixation became an important source of chemicals to manufacture fertilizers as well as explosives. I use the terms "nitrogen fixation" and "nitrogen synthesis" interchangeably, and for the sake of clarity, I use the term "nitrogen" to refer to agriculturally valuable nitrogen sources drawn from a range of sources.

Phosphorus, the second macronutrient, is also essential to many parts of a plant's life cycle, but its absence in the environment is a common limiting factor in plant growth. As with nitrogen, manufacturing a water-soluble form of phosphorus for agriculture entails industrial processes. The most common source of phosphorus in fertilizer is derived from a group of minerals collectively known as "phosphates." The process of extracting and refining phosphates into fertilizers involves separating the valuable minerals from clay and gravel and later crushing and treating the mineral with sulfuric acid to create a material known as "superphosphate." For clarity, I use the term "phosphate" to describe the raw mineral as well as finished products.

The third macronutrient, potassium, helps plants retain water and stave off disease and pests, but like the other two points of the triad, it is often lacking in agricultural soils. The most common source of K for fertilizers is derived from

evaporate minerals known as “potash” (K_2O). Prior to the discovery of large mineral deposits of potash in Germany in the 1860s, wood ashes were treated in large pots and sold for their chemical value. The name potash remained after the discovery of new mineral compounds provided a much more concentrated source of the vital plant nutrient. An alkaline salt (*kali* in German), potash has been known by a number of names, which often denote different mineral compositions.

To this day, fertilizers contain the three macronutrients delineated in the 1800s, and these products are classified and labeled with an N-P-K content, usually expressed as the relative amount of each of the chemical elements. How these values are measured has changed over time. For instance, a bag of typical bird guano labeled 12-10-2 ostensibly contains twelve percent nitrogen, ten percent phosphorus, and two percent potassium. A common modern day fertilizer such as anhydrous ammonia labeled as 82-0-0 is composed of 82 percent elemental nitrogen. The contrast of these two types of fertilizer also illustrates the transition from extracted materials to chemically processed goods that have been designed to perform a more precise task. Whereas guano was relatively powerful compared to dairy manure (9-0-0), it is an extracted and unprocessed good. The transition from byproducts and minerals to the chemicalization of fertilizers such as anhydrous ammonia was a complex, historically contingent process, as we will see.

The businesses that emerged to collect, process, and distribute these materials are a diverse group of entities that I refer to as the “fertilizer industry” or “fertilizer manufacturers” interchangeably. The entire industry encompassed businesses of different sizes and specializations that changed over time, so I am

careful to differentiate and contextualize each of them in the text. It is also important to distinguish among the national manufacturers, regional fertilizer manufacturers, and chemical manufacturers. The large fertilizer companies that dominated the American fertilizer industry between the 1870s until about the 1940s were mostly centered in Mid-Atlantic cities like Baltimore and Richmond, with a few in Chicago, as well. These businesses processed, mixed, bagged, and shipped finished products to merchants and dealers around the country, particularly to their sales agents in the South. Regional fertilizer companies staked out smaller markets in the South and ran smaller factories closer to their clientele. Some of the regional companies were major operations that produced their own sulfuric acid to process raw materials into finished goods. Other regional fertilizer companies imported materials in bulk from different sources and blended them together in an industrial mixer. The final group is the chemical manufacturers that emerged in the beginning of the twentieth century. For these businesses, fertilizer production was usually just one part of a larger enterprise that was generally well capitalized and commanded more sophisticated industrial technologies in its production processes.

The term “agrochemicals” describes the assortment of materials and technologies that came into general during the agricultural transformation of the twentieth century. Beside fertilizer, other chemicals and soil inputs such as pesticides and fungicides have grown in tandem with synthetic fertilizer and new types of genetically selected and engineered seed, known as “hybrid seed.” Scientists have bred and selected seed varieties to grow more prolifically with support of agrochemicals, and these interlocking technologies have reduced the

labor inputs and increased agricultural yield in astonishing ways. Fertilizer is just a single part of this suite of interlocking technologies. Over time many agrochemicals have become connected to “petrochemicals,” which includes not only oil, but also byproducts attendant to petroleum production. Fertilizer manufacturers now rely upon large inputs of natural gas to synthesize nitrogen, making the production of petrochemicals and food interdependent in even more complex ways.

CHAPTER ONE

DISTURBED GROUND: DEBT AND DIRT IN THE NEW SOUTH

In May of 1868, David Dickson sat down to write an open letter to the editor of the *Southern Cultivator* from the desk of his sprawling Georgia cotton plantation to discuss his two favorite topics of discussion since the Civil War: Freedmen and fertilizer. Readers of the publication would have known Dickson as a regular contributor to the journal, who noted in his letter that although he was generally a private man, he was compelled to share an account of his system of agriculture with "the hope that good may result to the farming interest, so much paralyzed by the results of the war." Having dispensed with his pretension of modesty, Dickson offered his unique prescription for the "ills" of southern agriculture upended by war.[1]

Like other agricultural reformers of his day, David Dickson exalted excrement. He valued livestock as much for its soil-building manure as he did for its muscle power or meat. Among men like Dickson it was an article of faith that it was not only "hurtful to the purse, but sinful," for a farmer to waste manure that could be returned to a farm's depleted soils to increase the harvest and improve the tilth. Dickson often bragged that the judicious use of manure from his own plantation had made his acres some of the most productive and

[1] David Dickson, "Commercial vs. Homemade Manures," excerpted in *A Practical Treatise on Agriculture* (Macon, GA: W.J. Burke and Co, 1870), 138.

profitable in a region notorious for exhausted soils and careless cultivation. But since the war Dickson had transformed himself into the South's chief exponent of fertilizer materials from *off* the farm, known at the time as "commercial manures" or "guanos." Newly available materials like Peruvian bird guano and superphosphate gained popularity as potent alternatives to their barnyard counterpart in Northern Europe and Northeastern states as early as the 1830s, but not in Dixie. As a cure-all for the ailments of the postwar South, Dickson encouraged his peers to broadcast guano "on all the lands you cultivate…except a hole of water, or on a rock." If Dickson had his way, fertilizer would play a key role in the restoration of King Cotton after the destabilizing impact of war and—even more significantly—the collapse of slavery.[2]

More than the soil was at stake. For Dickson, fertilizer represented the keystone in a broader program of conservative reform that would reinstate King Cotton in a way that would not upset the pre-existing racial and economic order. Dickson reassured readers of the *Southern Cultivator* that commercial manures would not only solve problems of the land, but also problems of labor. In years since the war, many former slaves aspired to live on the land as independent family farmers, yet this aspiration threatened to upend the foundational social relationships of antebellum cotton culture. Once the owner of more than 140 slaves, David Dickson knew the grievances of the planter class. To allay their fears, Dickson insisted that fertilizer had made "laborers more cheerful and willing to work," and that it allowed him to "work freedmen, when they would bring you into debt without it." By this reckoning, ecological and racial problems

[2] Ibid, 136.

had the same solution, which he was prepared to sell by the ton in the form of his trademarked "Dickson's Compound" fertilizer.[3]

At first blush, the connection between the arrival of fertilizer and the end of American slavery might seem a bit tenuous. But perhaps even more surprising was that Dickson's suggestions about fertilizer caught on. In the years following the Civil War southern farmers became the first group of Americans to broadly embrace this new input-intensive approach agriculture. In particular, Georgia farmers latched onto this new way of feeding plants, purchasing some $4.3 million of fertilizer in 1879 and $5.7 million in 1889, leading the nation in both instances. But among early adopters, the seemingly magical qualities of fertilizers to grow plants on poor soil came at a cost. Farmers—many of them former slaves—assumed considerable personal debt to feed plants that did not yield food or even pay the bills. Thus, while the end of slavery offered the promise of a new era of free labor for all southerners, the reconstructed vision of southern agriculture bound farmers to a tenuous landscape, one in which ecology and economics were becoming intertwined in complex and unanticipated ways. Spurred on by the enormous postwar demand for an indispensible global commodity, fertilizer became a new fuel in the production of cotton. This chapter examines how farmers of the South became the unlikely shock troops of the mineral nutrient regime: a new input-intensive and debt-fueled approach to agriculture. By the same token, it examines how a revolutionary technology and practice helped forestall a revolution in social relations.[4]

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[3] Ibid, 138, 141.
[4] For state-level fertilizer data, see Appendix 1.

Why was it that time-tested approaches to maintaining soil fertility were scrapped for a radically different approach to feeding plants, and why did it occur so quickly in the American South after the Civil War? This question is especially salient considering the fact that postwar southern agriculture has an enduring legacy as "backward," resistant to change and lagging behind other regions of the country. History on the development of fertilizer use in the nineteenth century has largely—oddly—ignored the American South, where these new products found their most robust market in the United States until the second half of the twentieth century. For their part, historians of the South have largely missed the centrality of these new products in the postwar agricultural regime and credit market. One reason fertilizers may have been omitted from historical study is because they run counter to the portrait of southern agriculture as "backward" and "primitive"—characterizations that started with contemporary observers that have been echoed by historians ever since. Yet while these caricatures highlighted the plight of farmers, the tendency to portray the cotton cultivation in a certain way has obscured the dynamic elements within the region's otherwise undercapitalized and low technology agricultural system. Instead of perceiving the South as a lagging agricultural region, in fact, in many ways it was the American vanguard of modern input-intensive farming.[5]

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[5] The historiography of agricultural chemicals in the South is limited and generally lacking social context, see Rosser H. Taylor," The Sale and Application of Commercial Fertilizers in the South Atlantic States to 1900." *Agricultural History* 21, no. 1 (1947): 45-62; Weymouth T. Jordan, "The Peruvian Guano Gospel in the Old South," *Agricultural History* 24, no. 4 (1950): 211-221; Richard C. Sheridan, "Chemical Fertilizers in Southern Agriculture," *Agricultural History* 53, no. 1 (1979): 308-318; McKinley, Shepherd W. *Stinking Stones and Rocks of Gold: Phosphate, Fertilizer, and Industrialization in Postbellum South Carolina*. Gainesville: University Press of Florida, 2014. See also Roger L. Ransom and Richard J. Sutch. *One Kind of Freedom: The Economic Consequences of Emancipation*. Cambridge: Cambridge University Press, 1977; Ted Steinberg, *Down to Earth: Nature's Role in American History, Second Edition*. New York:

The adoption of new inputs and sources of credit from far afield highlight a broader set of connections between the South and the world that came with benefits and costs. Indeed, this new agricultural practice that fertilizer embodied is also inextricably tied to the postwar industrialization of the South. The South Atlantic states became the new center of gravity of the growing American fertilizer industry, as companies that had once focused on market gardening regions of Mid-Atlantic States found a rich and untapped market. Alongside local entrepreneurs like David Dickson, merchants from northern firms fanned out across the cotton kingdom and made arrangements with local furnishing merchants making them exclusive dealers of their products. Buoyed by credit from northern banks and firms, new factories and regional fertilizer mixers sprouted up in cities, towns, and alongside rural cotton gins. In turn, these local dealers extended credit to their customers who purchased fertilizer on credit at exceedingly harsh terms. The problem of nagging fertilizer debt became so severe that it contributed to the wave of agrarian discontent that threatened to topple the political order of the New South. By the late 1870s, as we will see, farmers began to seek ways to escape the fertilizer credit trap through collective action schemes introduced by the Grange and the Farmers' Alliance. These efforts to

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Oxford University Press, 2007. On the transnational connections between emancipation and debt peonage, see Edward D. Melillo, "The First Green Revolution: Debt Peonage and the Making of the Nitrogen Fertilizer Trade, 1840-1930." *American Historical Review* 117, no. 4 (2012): 1028-1060; Gregory T. Cushman, *Guano and the Opening of the Pacific World: A Global Ecological History*. New York: Cambridge University Press, 2013. On the transnational intellectual currents of southern planters, see Matthew Pratt Guterl, *American Mediterranean: Southern Slaveholders in the Age of Emancipation* (Cambridge: Harvard University Press, 2008). Two recent environmental histories detail the importance of fertilizer in the South and its relationship to the soils of the South, Drew A. Swanson, *A Golden Weed: Tobacco and Environment in the Piedmont South* (New Haven: Yale University Press, 2014), 201-208; Paul S. Sutter, *Let Us Now Praise Famous Gullies: Providence Canyon and the Soils of the South* (Athens: University of Georgia Press, 2015).

establish farm cooperatives failed in the short term, but they were not soon forgotten.

Notably, all of these changes occurred at a time in which America's agricultural state was in its infancy, and conspicuously absent from day to day life in the rural South. But rather than coming at the behest of agricultural experts, the new practice of applying fertilizer in and of itself led to the creation of new state departments of agriculture across the South. Crucially, these departments paid their bills by collecting taxes and inspection fees on fertilizers sold in their state, creating an incentive to promote fertilizer use and to remain independent of the federal agricultural bureaucracy. This phenomenon runs counter to a narrative about agricultural development that credits federal policy as the dominant force driving the transformation of the American countryside. Instead, as the South became dependent on new sources of plant food, state actors had to work reactively to regulate fertilizer production as it grew. These state chemists tested samples and affixed inspection tags to fertilizer sacks as an assurance of quality and a guarantee of its chemical content. Unfortunately, the promissory note that a fertilizer buyer signed to pay for his goods all but ensured that the benefits of the products would go to the crop and the merchant, rather than the farmer himself.[6]

[6] For studies of fertilizer and agricultural chemistry that focus on the nineteenth century, see Richard A. Wines, *Fertilizer in America* (Philadelphia: Temple University Press, 1985); Steven Stoll, *Larding the Lean Earth: Soil and Society in Nineteenth Century America* (New haven: Yale University Press, 2002); Benjamin R. Cohen, *Notes from the Ground: Science and Agricultural Improvement in the Early American Republic* (New Haven: Yale University Press, 2009); Carville Earle, *Geographical Inquiry and American Historical Problems* (Stanford: Stanford University Press, 1992); Margaret W. Rossiter, *The Emergence of Agricultural Science*; Alan I. Marcus, *Agricultural Science and the Quest for Legitimacy*.

Post-Emancipation Ecologies

In fifty years after the American Revolution a powerful textile industry centered in Britain created an insatiable market for cheap cotton. Supplying the demand for fiber, a wave of extensive cotton culture powered by the brutal abuse of enslaved labor unleashed a seemingly insatiable hunger for land that had leveled native hardwood forests, removed topsoil, and choked streams and rivers with upland sediments. With their human chattel in tow, settlers drifted from South Carolina to Central Texas in search of fresh soil, leaving a trail of eroded and exhausted "old fields" in their wake. Southern planters championed an agricultural system benefitted at the exploitation of seemingly limitless land and cheap labor at the expense of human suffering, as well stewardship and permanence. Yet while there is no doubt that the institution of slavery was and remains objectively immoral, to assert that chattel slavery inevitably fostered what would today be called an "unsustainable" agricultural regime ignores the southern planters who used their mastery of labor to conserve the soil. It was among members of this small class of planter agricultural reformers that early experimentation with "commercial manures" first caught on.[7]

Situated on the border of the rolling hills of the Piedmont Plateau and the Coastal Plain of Georgia, Hancock County was a center of conservative agricultural reform before the Civil War in the Deep South. In the early 1800s Hancock County was a booming part of the southern cotton frontier, yet by the 1850s it was becoming a backwater. The region was deeply impacted by legacies

[7] On conservation and slavery see Lynn A. Nelson, *Pharsalia: An Environmental Biography of a Southern Plantation, 1780-1880* (University of Georgia Press, 2007).

of extensive cotton cultivation fueled by slave labor and credit from Britain and the Northeast. The county's white population peaked at about 10,000 in 1800 after the State of Georgia offered up vast swaths of Indian Territory to settlers through a land lottery. By the eve of the Civil War, the white population had dwindled to about one third of its initial size, while the enslaved black population had nearly doubled. A contingent of white yeomen remained, but many white settlers had moved to points west and south in search of fresh soil and a fortune made with cotton.

Amidst these demographic shifts, and the environmental limitations presented by the area's exhausted soils, a group of eighteen wealthy planters started the Hancock County Planters' Club in 1837 to try to slow the tide of westward movement by demonstrating how agricultural improvement could revive the county's cotton lands. Specifically, they sought "the most eligible means of preparing and mode of applying manures to the exhausted fields" and the best ways to "prevent the waste of soil by heavy falls of rain." The club hosted lecturers, studied local soils, and hosted annual agricultural fairs. One of the founders of the club, William Terrell, endowed the first agricultural chair at the University of Georgia. Fawning editors from the *Southern Cultivator* gloated that the club's efforts to preserve the productive capability the soil would encourage "fixedness and stability" to an otherwise "roving population." One member of the club harangued his peers in 1843, that "we must revolutionize our system of agriculture, we must improve our lands, or we must abandon our homes." In this light, keeping the land healthy assumed political, even moral dimensions. Educated southerners were deeply influenced by classical thought, and they

found much to ponder in classical agrarian writings that justified slavery and linked the health of the soil to the stability of civilization itself.[8]

For their part, members of the Planters' Club were outliers in an agricultural regime that tended to be as indifferent to conservation as it was abusive to labor. These soil-obsessed planters were not motivated by impulses that would be familiar to modern environmentalists. Conserving the land meant preserving their position at the apex of a slave society, pure and simple. The principles of conservation farming, which was known as "convertible husbandry," were a means to a profitable and socially conservative end. But their reform efforts also tapped into a whiggish impulse that championed permanence and economic development over time. By dint of their wealth and philosophy, they had a considerably different sense of time and place than their contemporaries whose financial limitations led them to search for fresh soil and better prospects beyond the horizon. Long-term thinking was a luxury that the wealthiest planters could afford. Though not a member of the club himself, the young David Dickson was influenced by the efforts of the Planters' Club. He made it his life's work to restore his father's eroded plantation, which had been cleared from the forest a generation before. He subscribed to agricultural periodicals in search of the most up-to-date farming practices. He discovered Peruvian guano in the early 1840s,

[8] Gustavus B. Maynadier and W.J. Geib, "Soil Survey of Hancock County, Georgia" (Washington, D.C.: Government Printing Office, 1909), 553; The Hancock County Planters' Club Papers, Folder 10, Georgia Archives; "Address of R.P Sasnett, esq.," *Southern Cultivator*, Jan. 1846, 4, 1. On the Planters' Club, see also, James Bonner, "Profile of a Late Antebellum Community," *The American Historical Review*, Vol. 49, No. 4 (Jul., 1944), 663-680.

and claimed to be the first planter in the Deep South to use it on his plantation in 1846.[9]

Before the war manure had been Dickson's main tool for soil improvement, because he owned both a bountiful reserve of livestock and more than a hundred enslaved laborers to recycle the animals' byproducts to the fields. When General Sherman's troops came to Dickson's plantation en route to Savannah in the last days of 1864, this all changed. Not only did the soldiers liberate the hundreds of laborers on the plantation, they also commandeered whatever remained of his once massive herds. Before the war, they consisted of some 300 cattle, 200 sheep, 600 hogs, and 55 mules and horses. Surely the Confederacy's wartime scarcity also thinned their ranks, even though Dickson was loath to admit it. With a deficit of labor, animal power, and manure, suddenly, Peruvian guano seemed more valuable than ever. What had once been a costly supplement to the dung heap suddenly took on the luster of a holy grail. Selling fertilizer became his new obsession, but selling the very *idea* of using it to his neighbors would be his first task.[10]

Dickson had to convince his fellow laborlords-turned-landlords that fertilizer would be a valuable tool after slavery. Using the agricultural press as his soapbox, he summoned every rhetorical device he could muster. In the pages of the *Southern Cultivator*, Dickson limned the farm as a marketplace of nutrients, in which fertilizers were an essential investment. Channeling the agricultural

[9] Benjamin R. Cohen does an excellent job in parsing out the strains of this improvement ethic in the nineteenth century in *Notes from the Ground*; David Dickson, *A Practical Treatise on Agriculture*, passim.
[10] H, "Notes on Our Late Fairs," *Southern Cultivator*, December 1859*,* 17; Dickson, *Practical Treatise on Agriculture*, 141.

chemistry of Justus von Liebig in a familiar financial metaphor, Dickson called for people to put guano "into circulation" as a "currency" by adding as much as two hundred pounds of fertilizer per acre. The land was a commodity, but he was also suggesting the nutrients flowing through it were commodities, as well. Therefore, planters had to keep capital flowing to ensure they did not run down the "principle" bestowed upon the land by nature. Dickson lived by his own advice: Records show that he spent $3,000 on guano in 1867 alone. That same year, other farmers in Hancock County spent $40,000 on fertilizers, much of which, we can assume, was purchased from Dickson.[11]

Among planters and textile manufacturers, the postwar "labor question" was focused on concerns about how former slaves could be induced to work cheaply after emancipation. David Dickson provided a unique answer to the labor question by arguing that fertilizers could make cotton cultivation viable through the miracles of agricultural science. By pitching the idea that these new products could make free laborers more productive, Dickson pointed towards a new era on the Cotton Belt without upsetting the racial order of the South. This fact won the admiration of his peers. At an 1878 meeting of wealthy planters and farmers, an effusive member of the Georgia Agricultural Society celebrated the changes in cotton farming that Dickson had helped create: "Had it not been for the use of fertilizers when the war ended, I do not know what we would have done. With the labor we had, with exhausted soil, embarrassed as we were, like a ship going to

[11] I borrow the idea of landlords turned laborlords from Gavin Wright, *Old South, New South: Revolutions in the Southern Economy* (Baton Rouge: Louisiana State University Press, 1986), 17. Dickson, *A Practical Treatise on Agriculture*, 108-9; Dickson's purchases come from Stephen D. Heard Account Book, 1867, Stephen D. Heard Papers, Southern Historical Collection; Willard Range, *A Century of Georgia Agriculture: 1850-1950* (Athens: University of Georgia Press, 1954), 121-122

pieces and no small tempest lying upon us, the use of fertilizers was the plank with which we got to land."[12]

Dickson's system also won broad acclaim in other parts of the South, and even in other cotton cultures around the world. In 1869, the British Cotton Commissioner of Central India read Dickson's letters to the *Southern Cultivator* and tested some of the practices on the farms around his headquarters in Nagpore. He promised to send Dickson a copy of his colonial cotton report to show the impact fertilizer was having on local productivity. Indeed, in the years during the war the British had amended contract laws in India to find ways to force Indian farmers to eschew subsistence crops and grow cotton. Operating under this new semi-free labor system similar to sharecropping, Indian cotton production quadrupled during the Civil War. Flattering as the Cotton Commissioner's endorsement of Dickson's system might have been, the rise of cotton production in other areas portended global shifts in cotton production that were destined to cut into the South's monopoly on cotton cultivation in the coming decades.[13]

It might be said, then, that David Dickson provided a spark that helped ignite the fertilizer boom in the Deep South that would become a key part of the infrastructure that supported the postwar cotton economy. But other forces nudged Georgia farmers away from extensive agriculture to a fertilizer-fueled regime. One decisive factor was the movement of northern capital into new

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[12] *Transactions of the Georgia Agricultural Society* (Atlanta: James P. Harrison and Co., 1878), 473.
[13] Dickson, *Practical Treatise on Agriculture*, 19. On the rise of Indian and global cotton production see Sven Beckert, *Empire of Cotton: A Global History* (New York: Knopf, 2015), esp. 252-269.

southern markets after the war. Railroad construction in Georgia and throughout the South began to gain steam during the late 1860s, quickening the transportation of goods and reducing shipping costs to and from once remote parts of the South. Sensing new opportunities, fertilizer manufacturers who had supplied truck farmers around northern seaboard cities eyed the emerging market in the staple-producing South—and particularly in the worn cotton lands of the Southeast. In an 1869 letter to a Massachusetts fertilizer dealer, Boston fertilizer wholesaler George Davenport wrote that, "owing to the great demand for [fertilizer in the] South compared with the small amount wanted in New England" the Pacific Guano Company was pulling up the stakes and moving its entire fertilizer business and supplies down the coast in search of better profits. The records of another Pacific Guano fertilizer jobber from Charleston, South Carolina in the early 1870s reveal that Davenport's predictions about the southern market were correct. The demand for fertilizer was so great that farmers were demanding it "by the carload," and regional distributors for the Pacific Guano Company were unable to keep pace with demand throughout the 1870s.[14]

Southern industrialists also cashed in on the region's fertilizer market by exploiting the rich phosphate deposits around Charleston, South Carolina, and later in Florida and Tennessee. Before the war, South Carolina's coastal phosphate beds had mostly drawn the attention of fossil hunters and geologists,

[14] For more on the rise of early fertilizer manufacturers, see Richard Wines, *Fertilizer in America*. Regarding railroad construction, Woodward notes that the real construction boom came after 1880, C. Vann Woodward, *Origins of the New South, 1877-1913* (Baton Rouge: Louisiana State University Press, 1985), 120. George Davenport & Co. to P.W. Dudley & Company, March 27, 1869, Warshaw Collection of Business Americana, Fertilizer Series, Box 1, "Pacific Guano Co.," Smithsonian National Museum of American History; Correspondence, John N. Robson Papers, Duke.

but after the war the mineral's fertilizing value captured the attention of investors. Chief among them was the chemist Nathaniel A. Pratt, who had overseen geological surveys of the Confederate states in search of minerals for explosives and other strategic resources during the war. After Appomattox, Pratt capitalized on his knowledge of the region's geology to help develop the Ashley River phosphate beds, helping create a new fertilizer industry near Charleston. With the assistance of new rail lines and the state's proximity to the phosphate beds of South Carolina, fertilizers in Georgia in the 1880s were $12 to $15 per ton cheaper than in states to the west. As more phosphate deposits were opened in Tennessee and Florida, southeastern states became not only major fertilizer consumers, but also exporters in an increasingly globalized economy of plant nutrients. This early example of postwar industrialization in the South helped resuscitate postwar cotton production well beyond what it had been before the war began—especially in eastern states like Georgia, where the soil had been so depleted by extensive agriculture and erosion. Fertilizer played a leading role in Georgia's cotton renaissance by providing a mineral "fuel" for cotton cultivation that helped the eastern Cotton Belt remain a key part of the global cotton economy after the combined economic and ecological disruptions of war and extensive cultivation.[15]

[15] N.A. Pratt, *Ashley River Phosphates: History of the Marls of South Carolina and the Discovery and Development of the Native Bone Phosphates of the Charleston Basin* (Philadelphia: Inquirer Book Job Print, 1868), 6; Shepherd W. McKinley, *Stinking Stones and Rocks of Gold,* passim; Harold E. Malde, *Geology of the Charleston Phosphate Area, South Carolina*, Geological Survey Bulletin 1079, (Washington, D.C.: Government Printing Office, 1959), 1-7. On the transition from the organic economy to the mineral-based energy economy, see E.A. Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England* (Cambridge: Cambridge University Press, 1988).

The Inception of the Agricultural State in the South

During the Civil War, the Federal government had taken unprecedented legislative steps to support farmers and to expand agricultural education through a series of laws designed to promote agriculture. Prior to the war, the U.S. Patent Office housed a barebones agricultural bureaucracy, including a seed-distribution program. But the new laws were much more far-reaching. One created the United States Department of Agriculture. The Morrill Land-Grant Act sold public land to fund state universities that would provide agricultural instruction. In 1887, the Hatch Act allocated federal funding for state agricultural experiment stations, and in 1889 Congress elevated the Secretary of Agriculture to a cabinet-level position. These sweeping laws sowed the seeds that would grow into the powerful agencies and institutions that constituted the robust agricultural state of the mid-twentieth century. The first Commissioner of the United States Department of Agriculture, Isaac Newton, famously defined the agency's mission as a quest for higher yields: "To make two blades of grass grow where one had grown before" by bringing new and improved farming practices to the American people.

Historians have rightly emphasized how these federal initiatives have played an absolutely formative role in the evolution of American agriculture. As later chapters discuss, federal agricultural policy did indeed remake the South and the nation as a whole. Flagship federal farm programs like the Cooperative Extension Service would be born in the rural South. Yet these institutions have overshadowed the fact that in the decades immediately after the Civil War, it was not federal, but state-level initiatives that were the most immediately important

to the states of the former Confederacy. Even more significantly, it was new agricultural practices that helped build the agricultural state. This is a reversal of the notion that policy initiatives would disseminate new practices. In particular, the sudden and widespread use of fertilizer in southern states created a regulatory vacuum that the states filled individually, without federal oversight. Following the lead of Connecticut and other states with public chemists and boards of agriculture, southern state governments created their own state departments of agriculture that became *de facto* fertilizer inspection agencies.

Although most farmers did not wade too deeply into the rarefied world of agricultural chemistry, buyers still wanted an appraisal of their fertilizer's value beyond the smell and taste tests that served as informal measures of quality. Scandalous tales of fertilizer adulteration reinforced the sense that farmers needed a measure of consumer protection against unscrupulous sales. At a meeting of agricultural chemists, the U.S. Secretary of Agriculture Norman J. Colman likely described this sense of consumer distrust best when he quipped that, "The road to riches seems to be not in the path of honesty, but in the great highway of rascality." Yet it was not the federal government that led the charge to regulate the growing fertilizer industry.[16]

While still under the auspices of federal Reconstruction, in 1868 Georgia's General Assembly created the position of state chemist to guarantee that fertilizers sold in the state contained the plant nutrients that they advertised. In 1874, Georgia established a state-level department of agriculture to expand its

[16] US Department of Agriculture Division of Chemistry, *Methods of Analysis of Commercial Fertilizers*, Bulletin no. 7 (Washington, D.C.: Government Printing Office, 1885), 23.

regulatory powers and keep pace with the volume of fertilizers entering the state each year. The state inspectors attached tags to each bag of fertilizer translating the opaque language of chemistry into slightly more legible terms. To fund the new department, fertilizer manufacturers paid a fee for each shipment of their products that the state chemists inspected. The profits from inspection fees financed the agency as the department's duties expanded to include the regulation of other commodities, agricultural research, and geological surveys of the state's resources. In 1875 alone, the state's inspectors tested 48,000 tons of fertilizer, encompassing 112 different brands. Seeing a similar rise in fertilizer application in their own states, other southern states created their own regulatory schemes, almost always funded in some measure by inspection fees.[17]

Fertilizer paid the bills, but the many agricultural experts did not always see the expanding use of commercial manures as a sign of progress. Georgia's first Commissioner of Agriculture, Thomas P. Janes, observed the rise of farm debt across the state and pointed to the new obsession with expensive fertilizers a primary cause. "The injudicious use of high-priced fertilizers has been a fruitful source of loss and embarrassment" according to Janes, who regarded mushrooming fertilizer debt as evidence that Georgia's farmers were on the wrong path. Why pay to feed one's plants when one could build the soil by rotating crops and applying manure? In 1875 the department reported that

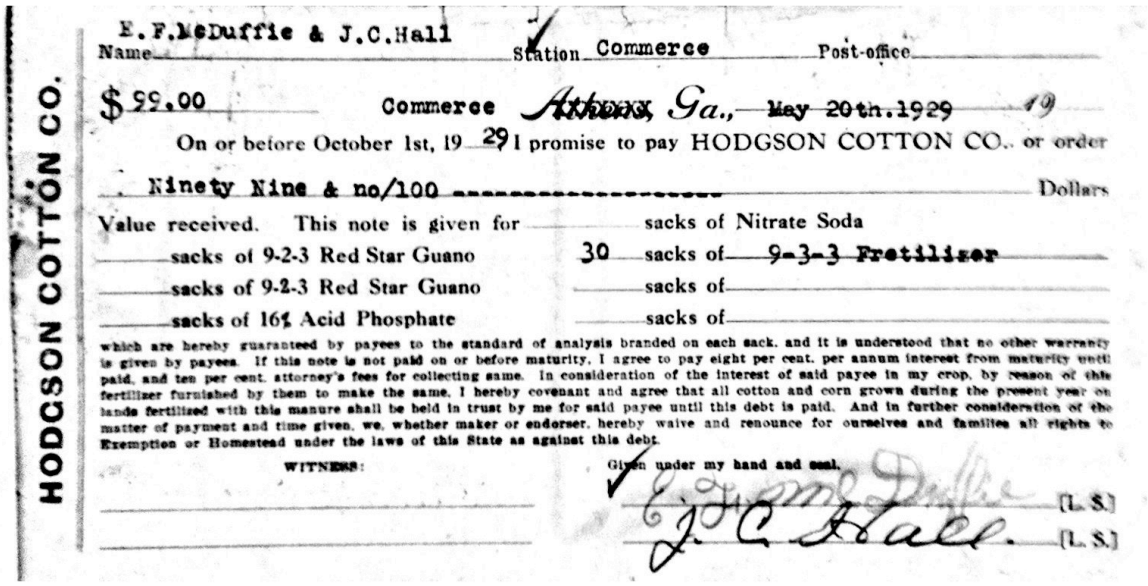
[17] *Annual Report of the State Department of Agriculture*, (Savannah: J.H. Estill, 1878), 9-10; *Acts of the General Assembly of the State of Georgia*, 1868, 1874.

Georgia farmers spent $2.5 million on commercial fertilizers, while only fifteen percent of the state's farmers saved stable manure to feed their plants.[18]

Figure 1.1. South Carolina women spreading fertilizer, 1905. The southern fertilizer regime drew upon new networks of labor, capital, and systems of transportation and distribution. But at the point of application its use had a very low bar of entry, and required very little technology, which made it a fit in amid the cash-poor South. The relative dearth of draft animal power and manure made hand spreading "commercial manures" a common practice in the South. These women were spreading fertilizer for cotton with funnels in the spring of 1905. (Bureau of Agricultural Economics, NARA II)

[18] H.C. White, *Annual Report of the State Department of Agriculture*, 1875, 37.

Figure 1.2. Fertilizer analysis tags. These adorned each sack of fertilizer sold in most states. The manufacturers usually paid the State Department of Agriculture or chemist a fee for each tag, which provided a "guaranteed analysis" for consumers and funding for the state agricultural department. These departments successfully prevented legislative attempts to establish national fertilizer standards to protect their revenue streams. (Warshaw Collection, NMAH)



HODGSON COTTON CO.

E.F.McDuffie & J.C.Hall
Name Station Commerce Post-office

$ 99.00 Commerce Athens, Ga., May 20th.1929 19

On or before October 1st, 19 29 I promise to pay HODGSON COTTON CO., or order

Ninety Nine & no/100 Dollars

Value received. This note is given for sacks of Nitrate Soda

sacks of 9-2-3 Red Star Guano 30 sacks of 9-3-3 Fretilizer

sacks of 9-2-3 Red Star Guano sacks of

sacks of 16% Acid Phosphate sacks of

which are hereby guaranteed by payees to the standard of analysis branded on each sack, and it is understood that no other warranty is given by payees. If this note is not paid on or before maturity, I agree to pay eight per cent. per annum interest from maturity until paid, and ten per cent. attorney's fees for collecting same. In consideration of the interest of said payee in my crop, by reason of this fertilizer furnished by them to make the same, I hereby covenant and agree that all cotton and corn grown during the present year on lands fertilized with this manure shall be held in trust by me for said payee until this debt is paid. And in further consideration of the matter of payment and time given, we, whether maker or endorser, hereby waive and renounce for ourselves and families all rights to Exemption or Homestead under the laws of this State as against this debt.

WITNESS: Given under my hand and seal.

E F McDuffie [L. S.]

J C Hall. [L. S.]

Figure 1.3. Guano note, 1929. Guano notes provide explicit evidence of the ways that taking an advance for fertilizer, as most did, could easily undermine a farmer's already tenuous economic security. Note that all guano notes came to maturity on the same date, meaning that all farmers buying from the same company had to settle up at the same time, weakening their ability to await favorable cotton prices. (Harry Hodgson Papers, UGA)

So why were farmers so loath to recycle manure or plant green manures in their fields? Historians of science have highlighted the influence of agricultural chemistry in Northern Europe and the Eastern United States as coaxing farmers away from the time-tested wisdom of convertible husbandry and down the path of chemical dependence. To a certain degree, evidence from Georgia corroborates this argument. For instance, beginning in the 1880s, the Georgia Department of Agriculture published and distributed the lectures of the French agronomist George Ville, who argued that, "the present condition of agriculture demands a free use of chemical fertilizers" rather than manures, which his experiments had shown to lack essential plant nutrients in their proper quantity. The only viable path for farmers going forward, according to Ville, would be to forgo the

"pretended necessity" of gathering manure and take up the "*permanent importation* of chemical fertilizers." Georgia's Commissioner of Agriculture had become so enthusiastic about fertilizers by 1887 that one state senator suggested that, "instead of calling the bureau the department of agriculture it should be called the department of guano." But the publications of Georgia's Department of Agriculture provide more evidence about the attitudes of the agency's staff than the factors that went into individual farmers' decisions about how to feed their plants.[19]

Part of the reason that southern farmers were not able to practice convertible husbandry lay with the specific political ecology of the postwar South. Most southern farmers had foregone manure conservation and crop rotations before the Civil War because an abundance of cheap land made extensive agriculture a logical—albeit destructive—approach to raising crops. In spite of admonishments about the value of convertible husbandry, Georgia farmers faced a new reality that made chemical fertilizers doubly appealing. One problem was that the size of farms had dwindled in southern states, and would continue to do so for decades. The spatial limitations of shrinking farms—owned increasingly by absentee landlords insistent on maximum cotton acreage—meant that more and more farmers were growing cotton right up to the front door. If growing cotton was a condition of credit for landlords and furnishing merchants, rotating leguminous crops to cover the soil and fix nitrogen in the fields was a luxury that

[19] On the negative impacts of agricultural chemistry, see Carolyn Merchant, *Ecological Revolutions: Nature, Gender, and Science in New England* (Chapel Hill: University of North Carolina Press, 1989); Michael Pollan, *The Omnivore's Dilemma: A Natural History of Four Meals* (New York: Penguin Books, 2006), esp. 146; George Ville quoted in *Georgia Annual Report of the State Department of Agriculture*, 1889, 95; "The Brady Bill," *Atlanta Constitution*, Jul. 19, 1887, 2.

few farmers had. In fact, in the years following the war, the crop diversity of the South actually declined compared to pre-war years, when there was a higher rate of food crop production. In the new postwar economy in which cotton was the only recourse to credit for small farmers, growing food crops was increasingly difficult. Furnishing merchants sold food for plants and humans alike, and farmers had to swallow the high cost of these imported goods.[20]

To protect the investments of northern and European creditors that underwrote the cotton economy, as well as the more localized interests of merchants and landlords, southern legislatures created new financial instruments. Lawmakers passed Georgia's first crop lien law in 1866 to jumpstart the credit market of the stalled agricultural economy that had recently lost its most valuable assets—namely, enslaved laborers. The lien laws evolved over time, but in essence they allowed creditors and landlords to furnish supplies or rent land to farmers in the spring in return for a portion of the harvest in the fall. On paper this arrangement was not inherently malicious to borrowers. After all, interest is intended to reward a lender for assuming risk, and investing in the cash poor economy of the Cotton Belt was not necessarily a safe investment. In practice, however, crop liens allowed landlords and merchants to dictate harsh credit terms, and to exercise a great deal of power influence over a farmer's operations. The ecologically and economically insidious consequences of the crop lien system—by establishing cotton cultivation as a non-negotiable term of credit, for instance—are well documented. Less well known are the impacts of

[20] On food production and crop diversity in the South, see Sam Bowers Hilliard, *Hog Meat and Hoecake: Food Supply in the Old South, 1840-1860* (Carbondale, IL: Southern Illinois University Press, 1972); Carville Earle, "The Price of Precocity: Technical Choice and Ecological Constraint in the Cotton South, 1840-1890." *Agricultural History* 66, no. 3 (1992): 25-60.

Reconstruction-era laws regulating fertilizer sales. If fertilizer had become a key part of the material infrastructure of cotton cultivation, it could not been so without the credit instruments acted as the financial infrastructure that supported it.[21]

Because it was regularly sold on very harsh terms, fertilizer contributed to a landscape of monoculture debt. Between 1870 and 1890, Georgia farmers purchased 75 to 85 percent of all fertilizer on credit at inflated prices. To make things worse, starting in the 1870s, farmers borrowing fertilizer for spring planting could expect to sign a "guano note." So-named after imported Pacific bird dung fertilizers that eventually fell out of use, guano notes were similar financial instruments to crop liens. In essence, they were promissory notes by which farmers offered a portion of their crop after harvest in exchange for fertilizers. Fertilizer merchants wanted to ensure a safe return on their investment, so they stipulated that farmers planted cotton as a condition of sale. Thus, purchasing fertilizer on credit was yet another legal inducement that made cotton the only viable option for poor farmers. Quite often, the same person might act as a landlord and a merchant, as well.[22]

Ostensibly, farmers purchased fertilizers because they would increase their profits by reaping a more bountiful harvest. The state chemist's guaranteed chemical analysis was supposed to act as a consumer protection and an assurance of quality, but chemistry could only go so far to protect anyone landless cotton

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[21] On the crop lien see Woodward, *Origins of the New South*; Ransom and Sutch, *One Kind of Freedom: The Economic Consequences of Emancipation* (Cambridge: Cambridge University Press, 1977). On legal underpinnings of tenancy, see Harold D. Woodman, *New South—New Law: The Legal Foundations of Credit and Labor in the Postbellum Agricultural South* (Baton Rouge: Louisiana State University Press, 1995), 1-10.
[22] Range, *A Century of Georgia Agriculture,* 101.

farmers. Guano notes give us evidence that the benefits of the fertilizer were mostly divvied out to the lending merchants (and to the plants), rather than the farmers who applied them. Clearly farmers recognized benefits from the application of fertilizer from the deep green leaves and larger bolls they saw as they chopped their cotton. As evidence of this, fertilizer purchases continued in a strong upward curve for decades after the war, suggesting that people believed it was a valuable tool in cultivation. But guano notes provide evidence that the financial risks involved with purchasing fertilizer fell most heavily upon farmers, and that these risks only became more acute over time.[23]

Beginning the final year of federal Reconstruction, in 1877 the Georgia General Assembly passed a constitutional amendment allowing debtors to waive the homestead exemption, a legal protection on the homes and household goods of debtors from their creditors. As a result, after 1877—almost without exception—fertilizer dealers attached stipulations to their guano notes that required the signer to waive their homestead protection as a condition of credit. Thus, whether a farmer was advanced $2 or $200 worth of fertilizer in the spring, failing to produce the cotton or cash outlined on the note in the fall might mean losing one's home, mule, or even household goods. A critic of guano notes lamented that, "farmers cannot obtain credit unless they sign a waiver note, and waive everything except their wife and baby; and dealers would require those waived if they could." This was, of course, overstatement, but there is no doubt

[23] Guano notes were exceedingly common in use but relatively rare in archival collections. County deed books in some states aggregated guano notes, but the Hodgson Cotton Company Records at UGA and the John N Robson Papers at Duke both offer collections. On the homestead exemption, see Steven Hahn, *The Roots of Southern Populism: Yeoman Farmers and the Transformation of the Georgia Upcountry* (New York: Oxford University Press, 1983), 195.

that guano notes could bring financial ruin. Repeated federal inquiries into the financial practices of the fertilizer industry made it clear that, in many cases, the best return a farmer could expect after purchasing fertilizers "on time" at inflated credit prices would be to break even.[24]

The plight of sharecroppers was severe, but in spite of personal privation, measured by yields, cotton made a comeback. In the early 1880s, the Bureau of the Census sent a team of soil scientists and geologists across the states of the former Confederacy as well as Oklahoma and California to take stock of American cotton production. Their findings provide a snapshot of a region much changed since the war. Cotton remained the staple crop in the Deep South, but it was being cultivated in new ways and in new places. Since the war, Mississippi was the leader in cotton production due to the "exceptional fertility" of its soil and the singular pursuit of cotton cultivation there. Quite beyond that, the newly opened Mississippi Delta was just beginning cotton cultivation and its rich alluvial soils yielded record-breaking cotton crops. With its combined natural advantages and shorter history of cultivation, it would remain a jewel of the cotton kingdom long thereafter.[25]

The report noted that, somewhat surprisingly, Georgia was a close second to Mississippi in cotton production in 1880, albeit for different reasons. Georgia lacked the natural advantages of the alluvial lands of Mississippi; it had a longer history of cultivation that had taxed its soils. Georgia's surprising cotton

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[24] "The Brady Bill," *Atlanta Constitution*, July 19, 1887, 2; Ransom and Sutch, *One Kind of Freedom*, 188. The Federal Trade Commission investigations of the fertilizer industry are discussed more extensively in the following chapters, but especially in Chapter Two.
[25] E.W. Hilgard, *Report on Cotton Cultivation in the United States: Part I* (Washington, D.C.: Government Printing Office, 1884), 7.

resurgence came in spite of the state's ecological history, and largely because of its newfound dependence on fertilizer. Across the state, small dealers selling phosphates, oil byproduct cottonseed meal, and German potash peddled their wares on credit to farmers seeking bigger harvests. Georgians led the nation both in expenditures and in tonnage of fertilizer. And although the mineral and byproduct-based fertilizers Georgians applied lacked the concentration of modern chemical fertilizers, they were effective enough to radically change the map of cotton production within the state and to create a new consumer market for agricultural inputs in the South. Part of the reason that fertilizer was so effective was the lack of phosphate in the soil of the eastern Cotton Belt combined with the relatively high content of phosphoric acid in the fertilizer that was then available. In the 1870s and '80s, the southern phosphate industry provided fertilizer that was at least half the price of Peruvian guano, making it a mainstay for cotton growers.[26]

Fertilizers also opened new areas and drew new populations into cotton cultivation, especially among white yeomen farmers of the Georgia Upcountry and the Coastal Plain. Whereas the extensive agricultural pattern created a westward moving cotton frontier before the war, fertilizers provided farmers with the ability to overcome certain challenges of soil and climate and cultivate agricultural inner peripheries—that is, areas that had been bypassed during the initial wave of land clearing and cultivation. Because fertilizers accelerated the rate of plant growth, they allowed upcountry farmers to exploit the soils of the

[26] Ibid.; Carville Earle, "The Price of Precocity: Technical Choice and Ecological Constraint in the Cotton South, 1840-1890" *Agricultural History* 66, no. 3 (1992): 25-60.

cooler temperature regime and shorter growing season of Southern Appalachia. Fertilizers allowed cultivation at higher elevations, thus bleeding the traditional boundary of cotton cultivation northward. The new marketplace of plant foods also expanded the area of cultivation to lower elevations in the nutrient-poor soils of the Coastal Plain. Even within the old cotton lands of the Piedmont region, fertilizers allowed farmers to look at eroded fields with fresh eyes. Yet as they became more closely connected to the market by new railroads and equipped with inputs to grow cotton, white smallholders that had long prioritized "safety first" subsistence farming became cotton cultivators. On top of this, new stock and fence laws intended to protect crops from livestock grazing on the open range made raising hogs and cattle increasingly difficult. Beside fertilizer, farmers found themselves dependent on the merchant for food, and deprived of an important source of income. These combined forces exposed once-independent white smallholders to many of the same economic insecurities that bedeviled their African American counterparts. This newfound instability would become a force of political unrest in the coming years.[27]

From the perspective of those whose businesses relied on a cheap supply of cotton, however, the return of large crops was cause for celebration, and many attributed cotton's resurgence to fertilizer. For the banks that extended the credit that underwrote the southern fertilizer industry and the cotton crop itself, the fertilizer boom was a hallmark event documented in the pages of the *New York*

[27] On "inner peripheries" and frontiers, see Robert B. Marks, *China: Its Environment and History* (New York: Rowman & Littlefield, 2012), 173-176. R.H Loughridge, Report on the Cotton Production of the State of Georgia, (Washington, D.C.: Government Printing Office, 1884), 56. Other historians have noted the ways that fertilizer changed the map of cotton cultivation, including Hahn, *The Roots of Southern Populism*, 145.

Times. As one reporter put it, "More than gold was to California, diamonds to Brazil and the Cape, or silks to France, commercial fertilizers are to the South." On the ground, however, farmers were conflicted about the value of fertilizers. According to farmers who submitted opinions to the 1880 cotton survey, fertilizers were at once a blessing and curse. A farmer in upcountry Hall County, Georgia claimed that fertilizers "made a climate," by quickening plant growth and allowing cotton cultivation in cooler climes. In Clarke County, another submitted that, "the best farmers use them and would not be without them." Another reported that fertilizer increased crop production by fifty percent. In contrast, others asserted that, "they increase the crops but not the net profits of farming," that they "are used for the benefit of the crops, not for any lasting addition of the soil." At worst, they "make farmers of this region poorer each year." Another observer put it more forcefully when he said that fertilizer debt was "an incubus which alone defeats any value" in the fertilizer itself."[28]

As a rule, it did not make fertilizer salesmen poorer. When the planter-turned-fertilizer salesman David Dickson died in 1885, his account book was filled with the names of his tenants and neighbors who owed him money for fertilizer and other debts. More than 120 of the debtors in the book were in "bad" or "doubtful" standing, but in spite of unpaid tabs Dickson left behind a fortune valued in the hundreds of thousands of dollars. The Sparta *Ishmaelite* eulogized Dickson as having "revolutionized the farming system of this section" by introducing guano to Georgia's farmers. The writer also noted that "he made no

[28] C.R.M., "The Soil of the South," *New York Times*, Oct. 16, 1881; R.H Loughridge, Report on the Cotton Production, 165; *Atlanta Constitution*, Nov. 17, 1899, 4.

effort to force his methods of agriculture on others, but it followed as the natural logic of events."[29]

As any sharecropper could attest, the evolution of a system that recognized cotton as the one and only source of credit for farmers created unnatural circumstances that defied logic. The case of the Heath family in Warren County, Georgia provides a striking illustration. In a letter dated October 29, 1894, farmers Jerry and Jenny Heath sent a letter to their absentee landlord with news that they had "made plenty of corn this year—will make 500 bushels on the place this year—but cotton crop is sorry." Although they had agreed to pay thirty bales of cotton for rent, they had only managed to grow fifteen, despite applying generous quantities of fertilizer on their land. The Heaths complained that cotton was not worth raising with prices around five cents a pound. With no other way to raise money, they begged their landlord to accept corn as payment. It is unclear whether their landlord was willing, but it is all but certain that the merchant who had sold them their fertilizer would not have assented to the request. In August of 1896, the Heaths wrote once again, pleading that the eight hundred pounds of cotton the landlord expected for rent was "two much," unless they had "more land and better land." This unique correspondence makes one thing clear: Sharecroppers like the Heaths found it all but impossible to raise enough cotton to satisfy their landlord and merchants on poor land, sometimes even when they applied fertilizer. Most likely, the Heaths' desire to plant less cotton and more corn went unheeded since paying off guano notes almost always

[29] David Dickson Will, in David Dickson Papers, Georgia Archives. On the contestation of Dickson's will, see Kent A. Leslie, *Woman of Color, Daughter of Privilege: Amanda America Dickson, 1849-1893* (Athens: University of Georgia Press, 1995), 79; *Sparta Ishmaelite*, "Mr. David Dickson," Feb. 25, 1885.

necessitated cash or cotton. They were squeezed between poor soil, costly inputs, and low cotton prices.[30]

Other farmers embraced fertilizer as an essential tool, but found that the debt associated with guano notes could be a serious liability. The Alabama sharecropper and son of a former slave, Ned Cobb, discovered that landowners would often relegate renters to the poorest soil on a farm and lend money for fertilizer with the specific intention of grifting their tenants at settle up time after the harvest. Cobb's attempts to purchase fertilizer from other dealers were stifled by his landlord, who made sure that no merchant in any of the surrounding communities would sell fertilizer to anyone who lived on his land. Even though Cobb was among the rare farmer who was occasionally able to pay his debts in cash, he still found doors closed to him. Cobb's landlord wanted him to sigh a guano note with the specific aim of maintaining Cobb, known to be an adept farmer, as a debtor. In this sense, the ecological limitations of poor soil created a unique leverage that landlords could use against renters. Guano notes were not just financial documents, but evidence of the dynamic role of the landscape in the power relations among the people who lived on the land.[31]

Among those who left a written record of their attitudes about fertilizer, then, "ambivalence" might best describe the general feeling about the commodity's relative merits. This uncertainty has been washed away by the deluge of minerals and byproducts farmers applied to their soils, and shadowed by the mountains of guano notes that accumulated in merchant's desks and

[30] Camak Family Papers, Jerry and Jenny Heath to Mary Camak, 29 October 1894, Hargrett Library; Heath to Camak, August 5, 1896.
[31] Theodore Rosengarten, *All God's Dangers: The Life of Nate* Shaw (Chicago: University of Chicago Press, 1974), 143-158

ledger books across the South. If farmers purchased guano at the landlord's behest or by their own volition, the result was the same: By the early twentieth century, almost no one could remember a time when fertilizer was not a part of the annual agricultural cycle on the Cotton Belt. By the same token, few could remember a time when fertilizer was not synonymous with debt. A 1916 Federal Trade Commission report on the fertilizer industry showed how extensive the use of fertilizer had become in the Southeast and the prohibitively high prices that farmers paid for them. Manufacturers justified the steep credit prices as a form of insurance against default. The report found that the landless families who constituted the majority of southern farmers faced interest rates that were "exceptionally burdensome," even "extortionate."[32]

Given the personal, often adverse, relationship between debtors and lenders it should not come as a surprise that fertilizer merchants felt justified selling their goods to farmers at high prices. Even if merchants had personal knowledge and good faith in their customers to pay off their debts, the fertilizer companies that extended the merchant the credit demanded a guarantee. Yet whether merchants used fertilizer debt as a tool to keep borrowers under their power, or if they were inclined to find ways to bargain with their customers, the records of fertilizer dealers show that some fertilizer debts stayed on the books for decades. The list of debtors from the Empire State Chemical Company store in Commerce, Georgia, showed that among the dozens of unpaid guano notes in 1942, a number of farmers owed on fertilizer debt dating back to the late '20s,

[32] Federal Trade Commission, "Report on the Fertilizer Industry, August 19, 1916" (Washington, D.C.: Government Printing Office, 1916), xvii.

and many of the names were crossed out and marked as "dead" in the margin. Debts ranged from $5 to $450, but no matter how small a debt was, each guano note carried with it a homestead exemption waiver, ensuring that default could result in the seizure of the family's possessions. From a distance, it is hard to imagine a more degrading contract: A document in which someone waived their entire family's legal rights to property in exchange for a few sacks of guano. The state chemist may have guaranteed the quality of the product, but state laws created contracts that made poor farmers sign away some of the scant legal protections they had. Amidst a staggering depression, in 1890 cotton prices dropped to a 30-year nadir. Given these conditions, it is little wonder that farmers began to push back against an economic and political climate that was making them feel less secure by the year.[33]

Alliances and Entanglements

In December of 1890, delegates from a national coalition of politically engaged farmers traveled from around the country to convene in the unlikely location of Ocala, Florida. There, they planned debate the best way to improve their standing in a national political and economic climate that seemed rigged against them. In 1868, the Central Florida town of Ocala had a population of less than 300 hundred, but by 1890 it had become a regional hub financed by the area's newfound mineral wealth. By the time of Farmers' Alliance meeting, it had grown into "a thriving and prosperous city with modern improvements and

[33] Commerce Store Account List, 1942, Harry Hodgson Papers, Box 8, Folder 4, Hargrett Library, UGA.

conveniences," home to banks, hotels, as well as new railroad lines that connected the once-remote area to the rest of the country, and the world. In fact, it was John F. Dunn, a wildly successful phosphate speculator, and local banker who offered to subsidize the meeting of the Farmers' Alliance himself. Offering a lavish set of cash gifts and free rail fares to the convention's attendees, Dunn's bid was enticing enough to convince the meeting's planners to switch their convention location from the seaside tourist destination of Jacksonville to landlocked Marion County. During their meeting, they decided on a list of political demands that defined their vision. They did not know it at the time, but their gathering would turn a little-known corner of Florida into an important footnote in American political history.[34]

That the Farmers' Alliance met and set about defining their political priorities in Ocala, of all places, carries certain degree of significant, yet little noted irony. John "Phosphate King" Dunn, as he was known, was not only a bank owner—he was known as the wealthiest man in Florida. At the time of the Alliance meeting he was consolidating his power in the state Democratic Party to try to secure a nomination in a run for the Senate, which was a virtual guarantee for a seat in Congress under the system of one-party rule that was coming to define southern politics at the time. While the Farmers' Alliance began as an explicitly apolitical organization, observers from both major parties viewed the group with suspicion, fearing that its leaders might abandon their self-imposed political exile and disrupt party politics. Others, as was the case with Dunn,

[34] G.M. Wells, "The Florida Phosphate Rock Deposits," *The American Fertilizer* III no. 1 (Jul. 1895): 27.

surveyed the Farmers' Alliance and saw an untapped vein of the electorate that a keen observer of the political landscape might be able to exploit. Nevertheless, at the meeting Dunn funded, the Farmers' Alliance made it clear that upending the national banking system was central to their political priorities. Their demands also called to end speculation on agricultural commodities, as well as the direct election of Senators. The latter would ensure that political parties would be held accountable to a popular vote, and force them to abandon the precise brand of insider politics that Dunn himself was using to pursue a Senate nomination. Examining the list that became known as the "Ocala Demands," one can only wonder if Dunn had buyer's remorse for his investments in the Farmers' Alliance. Dunn lost his bid for the senate seat to the incumbent in January 1891 and saw his fortune vanish amidst a national depression, and died suddenly in 1893.[35]

The strange entanglements between the Farmers' Alliance and the networks of power that the incipient Populist insurgency hoped to disrupt go even further. The very same railways that carried Alliancemen into Ocala also moved thousands of tons of ground phosphate out of Central Florida to Atlantic ports like Fernandina Beach each year. From there, schooners ferried the rock to fertilizer production centers that processed and sold it in eastern states as well as lucrative markets in Northern Europe. With the decline of South Carolina phosphate production, investors like Dunn had amassed fabulous wealth by buying up land rich with minerals that were helping ratchet up crop production around nations of the North Atlantic. Even as the South Carolina phosphate

[35] Samuel Proctor, *The Florida Historical Quarterly* 28, no. 3 (Jan. 1950): 161-181; *New York Times*, January 19, 1891, 5; *New York Times*, June 18, 1892, 4.

industry began to wane, the exploitation of the Florida beds, and soon thereafter deposits in Tennessee, transformed the United States from a net importer of fertilizer minerals in 1889 to an exporter by 1899, with Germany and England as its leading customers. Largely because of phosphate shipments, by 1899 U.S. fertilizer exports outpaced imports at a rate of six to one. It was the agricultural value of phosphate that had made Dunn rich and put Ocala on the map. Yet, by increasing crop output, these same products also played a role in lowering crop prices and also incurring debt on farmers who purchased them, thereby contributing to the farmers' economic plight. Farmers that relied on fertilizer to grow cotton were at the beginning of one global commodity chain and the terminus of another.[36]

In the Ocala Demands, the Farmers' Alliance laid out a plan to disrupt the financial challenges that the changing economy presented to rural Americans, and many of these proposals resonated among southern farmers. As cotton prices plummeted, farmers both white and black saw the Alliance as a force that could help them reclaim sovereignty and push back against the troubling sense that they had become ensnared in a system that remunerated merchants and speculators but not themselves. And while the Farmers' Alliance, as well as the People's Party that grew out of it, identified itself as a coalition of producers who created wealth from the soil, many of the challenges they faced also emerged

[36] Edward Ayers, *The Promise of the New South: Life After Reconstruction* (New York: Oxford University Press, 2007), 249-251. Ayers notes that Dunn was that had made a fortune speculating in phosphates, but does not connect this to the key role that phosphates played in global commodities markets at the time. On Florida phosphates, see Arch Frederic Blakey, *The Florida Phosphate Industry: A History of the Development and Use of a Vital Mineral* (Cambridge: Harvard University Press, 1973), 25-26; Twelfth Census of the United States, Agriculture, Part One, 1900, cxvii; Nelson, *History of the U.S. Fertilizer Industry*, 91-93;

from their status as consumers. Cotton, as well as tobacco farmers, especially found themselves beholden to merchants for agricultural supplies and food. A similar process of monoculture and fertilizer dependence emerged in the bright leaf tobacco region of the Virginia and North Carolina Piedmont during this same period. In all of the South Atlantic states, by the late 1880s, in most areas fertilizer had become integral to farming, and it represented one of the greatest expenses that farmers incurred during the year, usually second only to rent. The Farmers' Alliance addressed these challenges by attempting to subvert the local furnishing merchant by creating cooperatives that would sell goods to members at wholesale prices.[37]

The southern wing of the Farmers' Alliance was especially concerned with creating "Alliance Exchanges," where members could store and sell their cotton on their own time to wait for the best price. Drawing on the scheme of the British Rochdale Plan, these exchanges also provided cooperative purchasing arrangements that allowed farmers to circumvent their local merchant. In 1889, for example, the Alliance Warehouse in Columbus, Georgia boasted that it had lowest prices in town for fertilizer along with any other goods that a farmer would need. Alliances ran ads in the paper reminding members to avoid buying fertilizer until the local Alliance had negotiated for the best prices and grades. When the Central Georgia Alliance appointed an agent to purchase the group's fertilizer, they were insistent that their dealings were "strictly of a business nature," and that there was "nothing political" in their activities. Of course, as the Alliances

[37] *Atlanta Constitution*, Nov. 17, 1899, 4. On the harvest and valuation of wheat, see Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: W.W. Norton, 1991); Drew A. Swanson, *A Golden Weed: Tobacco and Environment in the Piedmont South* (New Haven: Yale University Press, 2014), 201-208.

attempted to avoid doing business with prominent commercial interests by forming cooperatives, their actions were unmistakably political in nature, even if their words were not. The merchants that sold farmers their fertilizer and often ginned and purchased their cotton, as well, were not pleased. Luckily for them—and thanks in part to their opposition—the exchanges did not last long.[38]

As was the case with the political fortunes of the Populist Party, the Farmers' Alliance and its exchanges were failures—at least in the short term. The Populists failed as a lasting national political party, yet they sowed seeds that affected important long-term change. Continued political pressure from old Populist strongholds eventually led to legislation and federal support for many of the most important planks of the party platform. This advocacy also helped farmers elicit support for organizing cooperatives in many parts of the country. With its powerful local merchants, ginners, and fertilizer salesmen, however, the South would remain hostile territory for cooperatives for decades to come, even though personnel in the agricultural state gradually began to advocate for cooporeratives. In 1912, a young researcher in the USDA's Bureau of Markets published a study arguing emphatically that farm cooperatives were likely the single best way to improve the fortunes of the poor cotton farmers across the South. Echoing a refrain of the Populists, he believed that farmers "shared with

[38] Sven Beckert refers to this impulse as "cotton populism," *Empire of Cotton*, 344. On the Southern Farmers' Alliance, see Robert C. McMath, *Populist Vanguard: A History of the Southern Farmers' Alliance* (Chapel Hill: University of North Carolina Press, 1975). On "forward-looking" Populism, see Charles Postel, *The Populist* Vision (New York: Oxford University Press, 2007). On farmer cooperatives, see Victoria Saker Woeste, *The Farmers' Benevolent Trust: Law and Agricultural Cooperatives in Industrial America, 1865-1945* (Chapel Hill: University of North Carolina Press, 1988). "The Alliance Warehouse," *Daily Enquirer-Sun*, Columbus, Georgia, Mar. 31, 1889, 7; "A Purchasing Agent Appointed for the Central Georgia Alliance," *Weekly Telegraph*, Macon, Georgia, Nov. 19, 1890, 7.

too many middlemen the profits that are rightly theirs." The study's author, Charles J. Brand, urged both state and national lawmakers to pass laws that would protect farmers' right to establish cooperatives. As we will learn in future chapters, Charles J. Brand would become the nation's leading protector of those selfsame middlemen in the coming decades as he fought tooth and nail to undermine the creation of co-ops in the South from his post as the lead lobbyist of the fertilizer industry.[39]

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Between the end of the Civil War and the turn of the century, fertilizer had played a pivotal role in revitalizing cotton cultivation across broad regions of the southern landscape. In the uncertain period immediately following the war, fertilizer merchants and landlords recognized that these new products could serve as a valuable cultivation tool amidst the transition from enslaved labor to a free labor system. Specifically, as families sought to farm independently, usually on rented land, fertilizer helped crops grow in areas that were worn and eroded by the extensive cultivation regime that was typical before the war. A variety of new fertilizer materials, known at the time as "guanos," found a special niche for farmers on small plots that lacked the capacity to practice crop rotations or gather and spread manure to improve their soil. Yet while new mineral inputs

[39] Elizabeth Sanders, *Roots of Reform: Farmers, Workers, and the American State, 1877-1917* (Chicago: University of Chicago Press, 1999); Charles J. Brand, "Improved Methods of Handling and Marketing Cotton" in *Yearbook of the United States Department of Agriculture 1912* (GPO: Washington, D.C.), 443-462.

were a boon to merchants and the industries that were hungry for cheap cotton, for farmers, they were less beneficial because of the debts they incurred.

State-level agricultural institutions and laws helped bolster the postwar cotton regime in such a way that protected the interests of merchants and landlords, while exposing poor farmers to debt and privation. And although lawmakers created institutions such as state departments of agriculture and new contract laws as ways to ostensibly protect consumers and invigorate local economies, they offered few meaningful protections for farmers. The consumer protections offered by state chemists, for example, were meant to guard against fertilizer fraud and adulteration. In practice, however, the inspection services offered by these agencies were more beneficial to the departments themselves, since they drew their revenue stream by collecting fertilizer inspection fees from manufacturers. Worse yet, the guarantee of purity fertilizer inspection offered did little to protect farmers from the harsh terms of the contract that anyone lacking the cash to purchase fertilizer had to sign. These contracts—known as "guano notes"—protected the interests of merchants by requiring the signee to deliver a certain amount of cotton at harvest as surety against the loaned fertilizer. But the notes included provisions that made signees waive their rights to protections on their personal property. As rates of tenancy and poverty soared among black, and growing ranks of white farmers, fertilizer purchases became an additional inducement to grow cotton at the expense of food crops.

Responding to their own diminished status, in the final years of the nineteenth century, farmers in the South and the Midwest began to advocate for legislative protections that they believed could help restore their economic and

political influence. At a pivotal 1890 meeting in Ocala, Florida, national delegates of the Farmers' Alliance convened to draft a set of reforms intended to address threats to their livelihood and to restore their stake in the nation's political economy through a series of legislative demands. Ironically, the Ocala meeting was underwritten by a powerful banker who had made his fortune in phosphates, a fertilizer mineral that was helping flood the cotton market as well as generating a new source of debt among farmers, especially those in the South. Local Alliances tried to subvert the power of fertilizer merchants by forming cooperatives that failed to succeed, but not before convincing many farmers that cooperatives would be a key tool to protect themselves against the whims of the market in the future.

Fertilizer was mixed blessing for farmers in the South, but it was absolutely vital to cotton production for the global market. It had enabled a newly stable and predictable cotton monoculture in regions of the South in which mixed cropping had existed before. And while fertilizer was of little concern outside of the South and eastern market garden areas before 1900, it would become a national priority in just a few short years. The next chapter will examine the how the interregional and international dependence on raw fertilizer materials created unanticipated vulnerabilities for the nation itself. Over time, more and more American farmers found themselves tangled in a complex web of chemicals and raw materials needed to make their crops grow. Looking beyond the horizon of the cotton field, the subtle agricultural revolution instigated by mineral fertilizers created geopolitical blind spots as America entered a new era of foreign relations in the Age of Imperialism.

CHAPTER TWO

MINERALS OF EMPIRE

In early February 1908 Edward Hodgson sat on a veranda of the Hotel Tivoli, a retreat for dignitaries and wealthy travellers visiting the unfinished Panama Canal. Hodgson, who went by "Ned," was on a mission to expand his family fertilizer business, the Empire State Chemical Company, which supplied cotton farmers around the Piedmont of Northeast Georgia. Hodgson had caught a train to New York and boarded a steamer to Panama, where he toured the Canal Zone with more than idle interest. In a letter to his wife Mary, Hodgson related his visit to the Culebra Cut, the deepest section of the canal, where machines and men were "slowly and surely moving millions of years of earth" so that "great ships will come, and Uncle Sam can send his fleet to the other side of his great country without having to steam around the world." Once complete, the canal could serve Hodgson's own interests by reducing shipping costs between the booming southern fertilizer market and the nitrate fields on South America's distant West Coast. America's growing international reach, it seemed, could help prop up the fertilizer-fueled crop regime that men like Hodgson were assembling. And while it may be unusual to think of businessmen as ecological actors, as Hodgson and his ilk coordinated systems of labor, finance, and transportation to

coax minerals from the earth to feed plants, their actions wrought untold change upon landscapes around the world.[1]

Panama was just a brief stopover on Hodgson's circuitous quest around the globe to meet the gatekeepers of the world's most valuable industrial minerals. In Georgia, Hodgson had a robust market and a supply of phosphates close to hand, but for a "complete" fertilizer containing all three of the primary plant nutrients he also needed sources of nitrogen and potassium. Politics and geology dictated that Hodgson would have to do business with mineral cartels on two different continents. From Panama Ned Hodgson shipped off to barter with wholesalers in Valparaiso for a good price on saltpeter (sodium nitrate), at the time the most potent agricultural nitrogen available on the global market. Hodgson intended to use this mineral to replace cottonseed meal, a byproduct of cottonseed oil manufacture, and a cheap source of organic nitrogen in the South. Selling a byproduct of cotton back to farmers had long been a convenient—if ironic—arrangement for Hodgson and his ilk, but cottonseed meal was becoming a valuable livestock feed. Brokering a deal with the nitrate cartel would have given Hodgson an edge with a potent mineral fertilizer while allowing him to sell his byproduct to meatpackers. Even if Hodgson had had success in Chile, war would soon disrupt shipping and divert the explosive nitrates towards the killing fields of Europe. Most of the Empire State Chemical Company's nitrogen would still be derived from organic byproducts in the coming years.[2]

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[1] Edward Hodgson to Mary Hodgson, 5 February 1908, private collection of the Hodgson family, Athens, Georgia.
[2] Empire State Chemical Company, Inc. 1914 Census of Manufactures Schedule, Harry Hodgson Papers, Box 8, Folder 5, Hargrett.

It is not clear how Ned Hodgson made his way from Chile to the Alpine town of Lofer, Austria, but his long journey was rewarded with a warm reception. Hermann and Walderman Schmidtmann, a father and son who owned some of Germany's richest potash mines, welcomed Hodgson as their guest. Insofar as such a thing is possible, the Schmidtmanns were the "bad boys" of the global potash market. Unlike the United States, where fertilizer manufacturers were still in the early stages of pursuing federal support and assistance, Germany's powerful central government harnessed fertilizer production and application as part of a state-directed program of agro-industrial production. The nation's potash monopoly was critical to the scheme. Individual firms sold and distributed potash, but the Imperial Government set strict export prices to ensure high profits. It also ensured low domestic prices to encourage heavy fertilizer use among German farmers to support the nation's own economically significant staple crops, particularly sugar beets. Bristling against these strictures, the Schmidtmanns broke ranks and sold their goods to eager American buyers like Hodgson below the prices set by the cartel. In 1910, a new German law banned selling below cartel prices, but by then the Schmidtmanns had already established an international fertilizer empire in their own right. Controlling potash mines, and later, phosphate mines and a large sulfuric acid plant in Tennessee, the Schmidtmann's International Agricultural Corporation would become one of the largest fertilizer concerns in the world. Hodgson worked hard to win their friendship, even going as far as arranging a marriage to strengthen their bond. When Waldemar Schmidtmann visited Athens, Hodgson introduced

him to Mary Fortson, a finishing school student who Waldemar married and brought home to Austria in 1912.[3]

Following Hodgson's lead, this chapter moves away from the local context of southern farms to outline some of the increasingly complex commodity networks that underlay the mineral fertilizer regime that had become so central to American staple crops, especially cotton. This regime drew upon its own networks of labor, capital, and resources to feed the growing capitalist economies of the world, working in syncopation with the quickening interregional and international pulse of agricultural commodities across space. As Hodgson and others like him knew firsthand, the fertilizer business was built upon a far-flung and ultimately tenuous set of relationships, continually threatened by the whims of political instability, labor unrest, and resource scarcity. All of these variables threatened to undermine the stability that these products promised to crop production. Put differently, agricultural regions—themselves the hinterlands of rapid urban expansion and industrialization—now had their own hinterlands that served as key sites in the supply chain. But new interdependencies, however productive they were, bred new vulnerabilities.

Fertilizer manufacturers like Hodgson were at the vanguard of a changing approach to agriculture in the United States, even if he and other members of his industry struggled to find their footing amidst the complex commodity chains

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[3] "How Grandaddy Got His Lamp," private Collection of Hodgson family. On the Schmidtmanns and the Kali Syndikat, see Mira Wilkins, *The History of Foreign Investment in the United States to 1914* (Cambridge: Harvard University Press, 1989), 276-279. On the rise of Germany's agricultural science, see Mark R. Finlay, "Science Practice and Politics: German Agricultural Experiment Stations in the Nineteenth Century" (Ph.D. dissertation, Iowa State University, 1992).

upon which their businesses were built. In part to hedge against this sort of uncertainty, manufacturers formed professional associations to emphasize their role as a positive and modern force in the American economy, rather than fly-by-night peddlers of bones and waste products. Crucially, groups like the National Fertilizer Association and the Southern Fertilizer Association realized that they could build their businesses atop the structure of the expanding American state. This included developing relationships with land-grant colleges and experiment stations, but as fertilizers were derived from distant foreign mineral deposits, manufacturers also depended on America's growing international clout. The expansion of the mineral nutrient regime would be built not only by capital, but also by the industry's ability to influence and mobilize expanding state structures. Even as reformers inveighed against the combination of fertilizer companies into large multistate corporations, calls to curb the nefarious "fertilizer trust" mostly fell upon deaf ears from state actors who supported the industry's priorities. And while this relationship between business consolidation and the rise of state power fits a common theme in this phase of American history, the case of the fertilizer industry connects the seemingly insular, self-interested actions of businessmen with the creation of an emerging global system.

Today, fertilizer is understood as a key part of a modern food system that is closely linked with projections about global food security and political stability, but this has not always been case. This chapter explores the historical origins of that association, and argues that we need to consider the actions of fertilizer manufacturers as major drivers of agricultural transformation. The fact that the expansion of the far-flung geography of the mineral fertilizer regime coincided

with an era of heightened imperial saber rattling helped create what historian Thomas Robertson has dubbed a "Malthusian moment." Yet while American fertilizer manufacturers often cast themselves as the bulwark against agricultural decline, their primary market during this period was not in food crops, but in cotton and tobacco production. Regardless of this fact, fears of productive decline cast shadows of doubt in a nation that had very seldom questioned its long-term agricultural prospects. As the frontier and the organic nutrient regime collapsed with it, it became increasingly clear that mineral nutrients would become crucial to coalescing state power in the new century.[4]

Nutrient Imperialism and the Malthusian Moment of 1898

It is impossible to consider the eastern United States' growing reliance on fertilizer in the late nineteenth century without considering the region's economic significance in relation to global markets. As we saw last chapter, in the political ecology that followed the collapse of slavery in the American South, obtaining fertilizer became a precursor to growing cotton. Local phosphate deposits notwithstanding, producing one globally significant commodity such as cotton required procuring other costly commodities on the world market, namely nitrates and potash. Until domestic sources became available, obtaining mineral fertilizer supplies would mean that American fertilizer concerns would have to do business with foreign firms. To forgo these minerals carried catastrophic consequences for cotton production, which was almost without exception

[4] Thomas Robertson, *The Malthusian Moment: Global Population Growth and the Birth of American Environmentalism* (New Brunswick, NJ: Rutgers University Press, 2012). Robertson discusses the mid-twentieth century, but notes 1898 as a significant antecedent to his period of study.

America's most economically significant export for the entire nineteenth century. The inducement created by this valuable agricultural commodity would eventually help enlist the power of the federal government to help procure the raw materials needed to grow cotton crops.[5]

During the nineteenth century, federal assistance for agriculture in the United States generally came in two forms. As discussed in the previous chapter, the first type gained momentum during and after the Civil War, when the Republican-dominated government began funding agricultural education and promoting agricultural research on a national level through landmark pieces of legislation. The other came prior to that, through the actions of obtaining and distributing land to American settlers, which was in itself, an imperial enterprise. Whether the government expropriated land from indigenous peoples or obtained it by purchase or treaty, securing land was a major function of American expansion and an engine of agricultural productivity in the continental United States across the entire nineteenth century. While this expansion was largely confined to the continental U.S., prior to the Civil War, one law created a foundation for America's aspiration to become a global power beyond the confines of the continental U.S. Significantly, this law points to the emergence of the mineral fertilizer regime, and highlights its deep connections with overseas imperialism.[6]

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[5] Douglas A. Irwin, "International Trade in Goods and Services," in *Historical Statistics of the United States Millennial Edition Online*.

[6] A recent text on the agrarian strain in Republican politics is Adam Wesley Dean, *An Agrarian Republic: Farming, Antislavery Politics and Nature Parks in the Civil War Era* (Chapel Hill: University of North Carolina Press, 2015).

In 1856 President Franklin Pierce signed the Guano Islands Act, which allowed American citizens to claim and seize uninhabited islands and reefs for fertilizer minerals. In the 1850s, the law was intended to provide fertilizer for American farmers, not to expand American territory overseas. This obscure mid-century law provided a legal framework for later imperial forays, namely during and after the Spanish American War in 1898. But beyond its legal trappings, the Guano Islands Act enshrined a connection between territorial expansion and the economic geology of the mineral nutrient regime. Emboldened by the power granted by the new law, in the coming years American fertilizer interests and wayward sailors claimed more than 70 islands and atolls ranging from the Caribbean to the South Pacific, all with the hope of cashing in on the lucrative fertilizer trade.[7]

One might envision the search for guano as a swashbuckling, manurial coda to the California gold rush, but this bout of nutrient imperialism created a legacy of human suffering, ecological devastation, and administrative headaches for American politicians. Fertilizer interests quickly discovered that the only feasible way to find laborers to work on these inhospitable and remote workplaces was to trick them and hold them in a state of *de facto* captivity, especially through debt peonage—darkly mirroring the experience of southern farmers toiling to pay down guano notes. One such workplace was Navassa Island, an arid phosphate island located off the eastern tip of Haiti. Following a claim under the Guano Islands Act a number of fertilizer interests mined the

[7] The best analysis on the Guano Islands Act remains, Christina Duffy Burnett, "The Edges of Empire and the Limits of Sovereignty: American Guano Islands." *American Quarterly*, 57, no. 3 (2005), 779-803; see also Jimmy M. Skaggs, *The Great Guano Rush: American Entrepreneurs and American Overseas Expansion* (New York: St. Martin's Press, 1994).

exceedingly hard mineral phosphate there through the 1880s. Reports of labor unrest began to filter back to the United States, and violence erupted in 1889 when workers attacked the company managers and overseers, creating a sensation that became known as the "Navassa Riot."

The Navassa Riot would have been a forgotten instance of Gilded Age labor unrest had not the worker's circumstances gained publicity from the attention of President Benjamin Harrison. With similar odds of finding a message in a bottle, Harrison received a letter from one of the workers detailing their suffering. Like most of the rest of the workers on Navassa, he was a black man hired in Baltimore, and he complained that he and his coworkers lived like slaves. Managers had enticed them with promises of good wages and quick passage home should they chose to return. In fact, they were held in debt to the company store, and forced to work under hellish conditions until they could pay down the debt and earn their passage home. In the *salitre* fields of Chile's Atacama Desert, nitrate miners worked under a similarly dismal system of debt peonage known as the *enganche*.[8]

Guano mining proved to be dangerous for workers, but is was also devastating to the arid environments of the South Pacific. As discussed in the previous chapter, the extraordinarily valuable guano deposits of the Chincha Islands on the Peruvian Coast were virtually exhausted by the 1870s. Guano Islands and other nutrient-rich landscapes would be even more dramatically transformed as human laborers were eventually replaced by engine powered

[8] Edward D. Melillo, "The First Green Revolution: Debt Peonage and the Making of the Nitrogen Fertilizer Trade, 1840-1930." *American Historical Review* 117, no. 4 (2012): 1028-1060; Gregory T. Cushman, *Guano and the Opening of the Pacific World: A Global Ecological History* (New York: Cambridge University Press, 2013).

extraction techniques, including hydraulic mining operations, draglines, steam shovels, and explosives. But these isolated sites were far afield, and while they had devastating effects on local landscapes and peoples, few in the world's economic centers mourned their destruction in an era of careening resource extraction. Like coal, and later oil, mineral fertilizers were fuels: they were powering the agricultural landscapes of many of the era's imperial powers. Peculiarities of geology, climate, and political boundaries created difficulties for those nations whose industrializing economies and urbanizing populations had the highest demand for mineral fertilizers, but the sites of extraction and application were far removed and out of sight. The problems of obtaining mineral fertilizer added yet another geopolitical imperative for North Atlantic powers during the Age of Imperialism, although only those unfortunate enough to perform the work of mining the minerals had anything approaching a clear accounting of their true costs.[9]

Cracks in what appeared to be a solid, albeit far-flung basis of feeding the global economy's most valuable crops began to show more clearly in 1898, the very same year America went to war with Spain in pursuit of its own imperial ambitions against Spain. At an annual gathering of the British Association for the Advancement of Science, Sir William Crookes delivered a speech about food security, what he called "The Wheat Problem." In his discussion—which took place one hundred years after the publication of Reverend Thomas Malthus's influential "Essay on the Principal of Population"— Crookes identified the

[9] On the condition of guano workers, see Skaggs, *The Great Guano Rush* and Gregory Rosenthal, "Life and Labor on a Seabird Colony: Hawaiian Guano Laborers, 1857-1870, *Environmental History* 17, no. 4 (2012): 744-782; Katerina Martina Teiwa, *Consuming Ocean Island: Stories of People and Phosphate from Banaba* (Bloomington: Indiana University Press, 2015).

vulnerability of Britain's increasingly globalized food system. In particular, he focused on the growing demand for the grain, which he tellingly characterized as "the most sustaining food grain of the great Caucasian race." Echoing Malthus, he suggested that demand for wheat was increasing as the virgin prairie that had supplied wheat was diminishing, even with the British Empire's global reach. Crookes bemoaned the fact that his island nation relied on imported food, and argued that Britain would not be able to sustain itself in the eventuality of a war. "We eagerly spend millions to protect our coasts and commerce; and millions more on ships, explosives, guns, and men." His concern was that the United Kingdom failed to "take necessary precautions to supply ourselves with the supremely important munition of war—food."[10]

Crookes reasoned that Britain would need to generate large supplies of fertilizer at home to support its farms in the face of a blockade. But unlike Malthus, Crookes was a technological optimist who held the belief that science and technology would inevitably provide solutions to the calculus of deprivation. It would only be a matter of time, he reasoned, before scientists would "fix" atmospheric nitrogen and solve the problem with a technological solution. His optimism notwithstanding, his Malthusian alarm bell would reverberate among scientists and agricultural experts around world. In the United States it resonated for another set of reasons.

Crookes's lecture struck a chord among Late Victorian Britons because theirs was an import economy, dependent on steam-powered shipping and naval

[10] Sir William Crookes, *The Wheat Problem* (New York: G.P. Putnam's Sons, 1900), 11-12; Alfred W. Crosby, Jr. *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (New York: Cambridge University Press, 1986).

supremacy to keep the nation fed and clothed. To the British, hiccups in the flow of grain from abroad were not just bad business; they were symptoms of a deeper illness in the imperial scheme. But what would be America's solution to the Wheat Problem? Among Crookes's American critics, most took issue with his calculations about the diminishing productivity of America's wheat frontier. How, they demanded, could a British scientist question the tremendous potential of the wheat lands beyond the Mississippi, with soils so rich that it supplied wheat to the U.S. and Britain, besides? Then, as now, the mere suggestion of natural limits on American expansion and growth are certain to elicit condemnation from those whose business rest upon the—at least professed—belief that natural resources are inexhaustible. Even if it was framed as a challenge to scientists, the calculations that inspired Crookes's speech could be easily dismissed as an affront to America and its seemingly boundless natural wealth.[11]

Among America's scientific community, on the other hand, Crookes had underlined a serious problem. It generated what historian Thomas Robertson has called a "Malthusian moment," a political scare premised on resource scarcity—be it real or imagined. USDA statistician and *National Geographic* editor John Hyde took the problem seriously enough to crunch the numbers to offer a statistical corollary to Frederick Jackson Turner's "frontier thesis." Turner famously interpreted the Census Bureau's 1890 pronouncement of the closing of the frontier as a challenge to American democracy. The frontier experience, he believed, had been part of what had made the American character distinct from

[11] Avner Offer, *The First World War: An Agrarian Interpretation* (Oxford: Clarendon Press, 1989), 81, 220.

its European counterparts. For his part, John Hyde saw the declining yield of America's agricultural land as an economic and political liability, one that the federal government would have to deal with in the very near future. Hyde predicted that the days of America's extensive frontier farms were rapidly closing. In his words, "The great fact that underlies the enormous productive capacity of the United States to-day is, of course, the transfer from government ownership to individual proprietors, within a single generation, a body of land hundreds of millions of acres in extent and for the most part of extraordinary fertility." But if fresh soil had underwritten America's growth, what would support its future agricultural prospects was uncertain. Concurring with Crookes, Hyde believed that science and technology alone could solve the nation's fertility problem.[12]

It is telling, and perhaps misleading, that these transatlantic discussions about agricultural productivity during the Age of Imperialism were framed in terms of foodstuffs, rather than fiber. Crookes was correct to emphasize the central importance of wheat to the British diet, yet there can be little doubt that cotton—an inedible crop—was the most important agricultural commodity to the British economy. It was also absolutely vital to the economic health of entire regions of the United States, across the farms of the South as well as in the textile industries of along all the states of the Eastern Seaboard. Cotton, and specifically American cotton, had been the keystone of Britain's unparalleled industrial economy during the nineteenth century. Between 1800 and 1860, cotton textiles

[12] Thomas Robertson, *The Malthusian Moment*, passim*;* Frederick Jackson Turner, *The Frontier in American History* (New York: Henry Holt and Company, 1920); John Hyde, "America and the Wheat Problem," *The North American* Review, 1899, Vol. 507, 191. On the expanding role of science in the federal government, see Hunter DuPree, *Science in the Federal Government* (New York: Harper & Row, 1957).

accounted for between 40 to 50 percent of the value of all of Britain's exports, and nearly all of it came from the United States until the Civil War. In the period since the war, cotton had surpassed wheat and flour and was America's most valuable export commodity, with a total export value of $240 million in 1900—nearly double the value of all wheat products exported that year. With the production of cotton so deeply dependent on fertilizer, ensuring a steady circulation of N-P-K minerals was fundamental to the economic fortunes of the empires of the North Atlantic. In other words, in terms of its relationship to Britain's economy, fertilizer was at least as important to its textile industries as it was to wheat production at the time. For Britain and America alike, the prospect of a fertilizer shortage was really more of a cotton problem than a wheat problem.[13]

At the turn of the century, the fate of the fertilizer industry was most closely linked to the price of cotton and the demands of the textile industry. After the fashion of Sir William Crookes, however, as a rule, American fertilizer manufacturers preferred to frame their role in society as a safeguard against hunger, rather than as loyal retainers of King Cotton. And while it was imperative to cotton production, fertilizer was also integral to lucrative food crop cultures in some regions of the United States, as well as food production in Northern Europe. In Prussia, domestic potash, Chilean nitrates, and American phosphates helped Germany achieve the highest agricultural yields ever seen in human history. In particular, imported fertilizers helped Germany establish a thriving sugar beet

[13] Beckert, *Empire of Cotton*, 205-206; Douglas A. Irwin, "Exports of Selected Commodities: 1790-1989," Table Ee569-589 in *Historical Statistics of the United States*.

industry in the late nineteenth century. Similar to American post-emancipation cotton production, German landowners constructed a racialized labor system that cast Polish peasants as ideally suited to agricultural labor, as well as a system that held them in a form of economic bondage comparable to sharecropping. Like American cotton, the German Empire's domestic sugar industry relied on a combination of monoculture, labor exploitation, and fertilizer minerals to power economic growth.[14]

Fully invested as they were in the mineral nutrient regime, European nations had a more acute sense of the ways that global shipping might expose them to deprivation. And even though the Cotton Belt had become deeply ensnared in the same global networks, in many ways America's agricultural state had not come to terms with just how essential N-P-K minerals had become to the health of the nation's most valuable crops. Agricultural experts and urban reformers believed that conserving waste products from the nation's mushrooming cities would be enough to reverse the pattern of agricultural expansion and soil exhaustion. As Malthusian reverberations could be heard in scientific circles, something akin to what would now be called an ecological sensibility began to echo in journals and government reports, where scholars called for city dwellers to "close the loop" and return garbage and waste back to the soils of their agricultural hinterlands. The 1900 *Census of Agriculture*, for instance, argued that "refuse and garbage of cities is, in most cases, carried away by rivers or dumped directly in the sea," representing a "waste of vast quantities

[14] For an excellent account between Germany's efforts to recreate American cotton production in Togo, see Andrew Zimmerman, *Alabama in Africa: Booker T. Washington, the German Empire, and the Globalization of the New South* (Princeton: Princeton University Press, 2010).

of good fertilizing material." Why not put that refuse to work and transform the farmer from a miner into a manufacturer, who could harness "fertility, natural and artificial, [as] his source of power"? Of course, the call for a rural-urban recycling system was not new. This impulse had been a regular refrain since at least the mid-nineteenth century. By 1900, however, even manufacturers who were the most committed to the "recycling mentality" were beginning to understand that the supposedly symbiotic city-country nutrient exchange would be insufficient to meet the nation's growing nutrient demands.[15]

Fictions of the Recycling Mentality

Leafing through the documentary remnants of the late-nineteenth-century fertilizer industry, one might get the impression that the whole business was built on a foundation of bones. Bones had been used to make fertilizer for centuries before they were incorporated into the emerging fertilizer industry beginning in the mid-nineteenth century. And yet, while bone fertilizers promised to turn waste products into an agriculturally valuable and profitable commodity, these "recycled" materials highlight some of the limits and liabilities of the late organic nutrient regime. Specifically, it suggests that the supposed efficiencies that industrial scale nutrient cycling offered were in fact quite vulnerable and costly, incurring severe damage to landscapes as well as harm to the bodies of the workers whose labor coaxed the value out of byproducts.

[15] U.S. Bureau of the Census, *Twelfth Census of the United States, Agriculture, Part I* (Washington, D.C.: Government Printing Office, 1900), cxxxvi.

Early in his studies of agriculture the organic chemist Justus von Liebig had suggested using acid to break down bones for fertilizer, but the first to put this theory into practice was the British gentleman farmer John Bennet Lawes. Lawes developed a process to treat bones with sulfuric acid to render their phosphoric acid soluble, and later built a factory and marketed his product as "superphosphate." Rich in phosphate, a mineral in desperately short supply in most agricultural soils, superphosphates won approval in American agricultural periodicals and among farmers. Manufacturers also processed bones by grinding or steaming them to make bone meal or by burning them to make a product called "boneblack." A 1901 technical guide for bone businessmen explained that "the framework supporting the fleshy tissues of the animal order, which we call bone, is a combination of phosphates of lime and magnesia, carbonate of lime, and alkaline salts." Other parts were valuable for glue and fat, but this "framework" of bones was the raw material of the superphosphate trade. Those who would manufacture superphosphate and bone meal had to become bone collectors first. The quest for bones started close to home but eventually ranged far and wide.[16]

[16] Thomas Lambert, *Bone Products and Manures: An Account of the Most Recent Improvements in the Manufacture of Fat, Glue, Animal Charcoal, Size, Gelatine, and Manures* (London: Scott, Greenwood & Co., 1901).

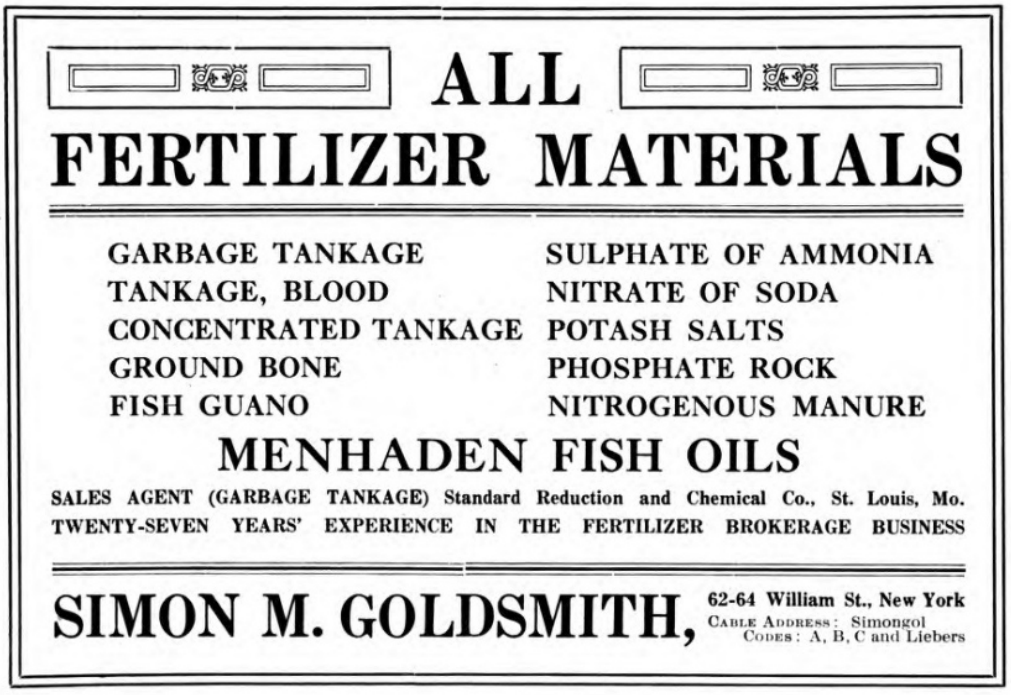

Figure 2.1. List of byproduct fertilizer materials, 1911. This ad offers the cornucopia of materials that defined the organic nutrient regime. Fertilizer manufacturers in the late nineteenth and early twentieth centuries drew from a variety of waste streams in addition to minerals and chemicals. Over time, the lower chemical value goods were often redirected towards industrial animal production. (From The American Fertilizer Handbook [Philadelphia: Ware Bros, 1911], 8)

THE PHOSPHATE MOVEMENT FOR 1897.

The phosphate business for the year has been quiet. A most searching utilization of various natural bone products has made a mark in the mineral phosphate trade, but garbage, abbatoir, etc., supply is now its limit, so that 1898 should show some renewal of the old time activity in the phosphate trade. Prices will never be much higher.

The total movements for the year was:

	Foreign.	*Domestic.*	*Total.*
South Carolina	65,829	257,211	323,040
Florida	436,472	124,959	561,431
Tennessee	16,175	86,196	102,371
North Carolina	—	2,000	2,000
Pennsylvania	—	1,600	1,600
	518,476	471,966	1,000,442

As compared with 1896, the figures are:

South Carolina.	*1897.*	*1896.*
Domestic	257,211	232,100
Foreign	65,829	82,260
Total	323,040	314,360
Florida, Rock.	*1897.*	*1896.*
Domestic	2,415	9,750
Foreign	346,862	313,121
Total	349,277	322,871
Florida, Pebble.	*1897.*	*1896.*
Domestic	122,544	91,144
Foreign	89,610	84,385
Total	212,154	175,529
Tennessee.	*1897.*	*1896.*
Domestic	86,196	42,911
Foreign	16,175	—
Total	102,371	42,911

The more complete details of the phosphate industry are given below:

Detail of Florida Phosphate Shipments for 1897.

BRUNSWICK, GA.

		Tons.
January—		
Liverpool, U. K.	Rock	1,665
February—		
Liverpool, U. K.	Rock	1,570
Rotterdam, Holland	Rock	2,000
		3,570
March—		
Hamburg, Germany	Rock	2,750
Bremen, Germany	Rock	2,080
		4,830
April—		
Bremen, Germany	Rock	1,508
St. Petersburgh, Russia	Rock	1,654
Liverpool, U. K.	Rock	1,070
		4,232
May—		
Liverpool, U. K.	Rock	2,500
Bremen, Germany	Rock	1,500
		4,000
June—		
Rotterdam, Holland	Rock	2,000
Liverpool, U. K.	Rock	48
Hamburg, Germany	Rock	500
Cette, France	Rock	500
		3,048
July—		
Hamburg, Germany	Rock	1,000
August—		
Stettin, Germany	Rock	2,850
September—		
Liverpool, U. K.	Rock	500
Stettin, Germany	Rock	2,602
Bremen, Germany	Rock	5,250
		8,352
October—		
Liverpool, U. K.	Rock	2,265
November—		
Bremen, Germany	Rock	4,927
Liverpool, U. K.	Rock	1,476
		6,403
December—		
Liverpool, U. K.	Rock	2,700
Bremen, Germany	Rock	1,214
		3,914
Total for Brunswick	Rock	48,129

Fig 2.2. Florida phosphate exports, 1898. The global nutrient economy underwrote food security and state power during the Age of Empire. This 1898 fertilizer trade magazine details the destinations of Florida phosphates in ports around the world, especially in Germany, the British Isles, and mid-Atlantic manufacturing hubs. (From "The Phosphate Movement for 1897," *The American Fertilizer* VIII, No 1 [Jan. 1898]: 3)

Prior to the rise of automobiles, large American cities produced 10,000 to 15,000 horse carcasses a year, creating a public health nuisance, or to the laborer willing to don a kerchief over his face, a source of income. Bone fertilizer manufacturers based in urban centers like Philadelphia and Baltimore looked nearby, calling at the backdoors of butcher shops and stables and canvassing the streets for dead animals and other sources of bone and flesh. The Baugh & Sons Company of Philadelphia bragged that its employees "traverse[d] regular routes through the city" to "buy up many thousands of tons of fresh animal bones each year." But like other companies they also imported bones by train and boat from further afield. After American settlers and soldiers hunted the bison nearly to extinction in the 1870s, homesteaders across the Great Plains gathered their sun-bleached bones and sold them to fertilizer manufacturers at rail depots for $4 to $12 a ton. Streams of bones flowed east by rail from the countryside and amassed under the open-sided warehouses that flanked superphosphate factories. But this stream of bones became a torrent of blood by the turn of the century with the rise of massive industrial slaughterhouses. In the American Midwest and later the Rio de la Plata, meatpacking firms supplied bones, blood, and other animal byproducts known as "tankage" to fertilizer manufacturers. For the meatpackers, bones and blood were leftovers from animals that had made their trip to the city "on the hoof"—that is, still alive and intact. Eventually Chicago's two leading meatpacking firms, Swift and Armour, opened their own fertilizer factories and became leading fertilizer dealers.[17]

[17] "Baugh's Raw Bone Manures," 1913, Warshaw Collection of Business Americana, National Museum of American History; J. R. McNeil, *Something New Under the Sun: An Environmental*

As efficient as this arrangement seemed, it came with staggering human costs. Conditions in bone fertilizer mills had the reputation of being among the most dangerous and degrading jobs available in an era of extremely dangerous industrial workplaces. In his lurid exposé of Chicago's slaughterhouses, Upton Sinclair evoked the awful conditions of those who toiled in Chicago fertilizer mills, which absorbed "waste products of all sorts." Workers slogged through "suffocating cellars where the daylight never came," where a visitor would encounter "men and women and children bending over whirling machines and sawing bits of bone into all sorts of shapes." The same acid that workers used to dissolve the bones had the ghastly effect of eating away at their clothes, shoes, and even their own flesh during shifts that could exceed twelve hours at a time. Sinclair may have been prone to overstatement, but other reports corroborate his fictionalized account.[18]

In 1915, Ida Tarbell reported on the conditions that helped to spark a strike in fertilizer plants in Roosevelt, New Jersey, where deputies loyal to the management shot and killed a number of the strikers. The workers were protesting to improve conditions in massive acid-soaked factories that were subsidiaries of the American Agricultural Chemical Company and Armour Fertilizer Works. In addition to complaints about wage cuts and long hours, workers in the factories had also gone on strike to call attention to the utter destruction that working in the plants wrought upon their bodies. The town doctor alleged that workers suffered serious respiratory problems from breathing

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History of the Twentieth-Century World, (New York: Norton, 2015), 310; Andrew C. Isenberg, *The Destruction of the Bison*, (New York: Cambridge Press), 160.

[18] Upton Sinclair, *The Jungle* (New York: Doubleday, Jabber & Company, 1906), 106.

in dust, along with severe burns from acid spills and leaks. Beyond that, he observed a high rate of malnutrition, since wages were eaten up by the cost of clothes and shoes that dissolved continuously from exposure to acid. Tarbell argued that safer working conditions would likely also have improved efficiency at such plants, where worker turnover was high due to such appalling conditions.[19]

In the South, where Jim Crow segregation usually reserved factory labor for whites only, superphosphate manufacturing jobs were often filled by black laborers. Strikes in these factories were common, and often resulted in violence and mass arrests, as was the case in Wilmington, North Carolina in April 1912. Because manufacturing superphosphate necessarily involved the use of large quantities of sulfuric acid, it was among the most dangerous and degrading positions in the America's industrial economy. Even though fertilizer manufacturers were well aware that accidents in their plants came with very high stakes for their labor force, the industry still had one of the highest accident rates among the chemical industries. One study of the industry detailed how acid frequently spewed forth from corroded pipes and vessels, and that regular inspection of the inside of tanks was essential to prevent spills. For the unlucky worker tasked with inspecting the inside of a tank, safety protocol suggested that he be tied to a rope so he could be pulled out quickly if there was any build up of

[19] Ida M. Tarbell, "Sticking to the Old Ways: The Golden Rule in Business," *American Magazine*, 1915, 37-38.

caustic gases or explosions. In the early twentieth century, worker safety was far from a top priority of the fertilizer industry.[20]

Rather than resorting to euphemism, however, many byproduct fertilizer manufacturers embraced their macabre position in the bloodstained recesses of society's metabolism. In their advertisements, the Baugh & Sons Company proudly displayed the colossal piles of bones that stood outside of their factories. In the shadow of these gargantuan ossuaries workers appear tiny and vulnerable, as though an avalanche of skulls might crush them at any moment and merely add to the pile. Company insignias depict blades dripping blood over flourishing plants, evoking the continuities between death and life that connected city and country, factories and farms. It was a cycle of nutrients that seemed to only grow in size as crops flowed to cities on trains and fertilizer returned on the same rails carrying agricultural byproducts that helped stimulate the soil. They projected this imagery in their advertisements even though it did little to help their reputations among agronomists who considered manufacturers unscrupulous dealers who would sell anything they could get their hands on, regardless of its agricultural value. On the contrary, manufacturers boasted that fertilizers were enabling a system of intensive farming that had "invariably resulted in enhanced profits in the market returns and increased land values."[21]

[20] *The Crisis* (New York, May 1912), 10; Theodore J. Kreps, *The Economics of the Sulfuric Acid Industry* (Stanford: Stanford University Press, 1938), 239, 242.
[21] "Baugh's Raw Bone Manures."

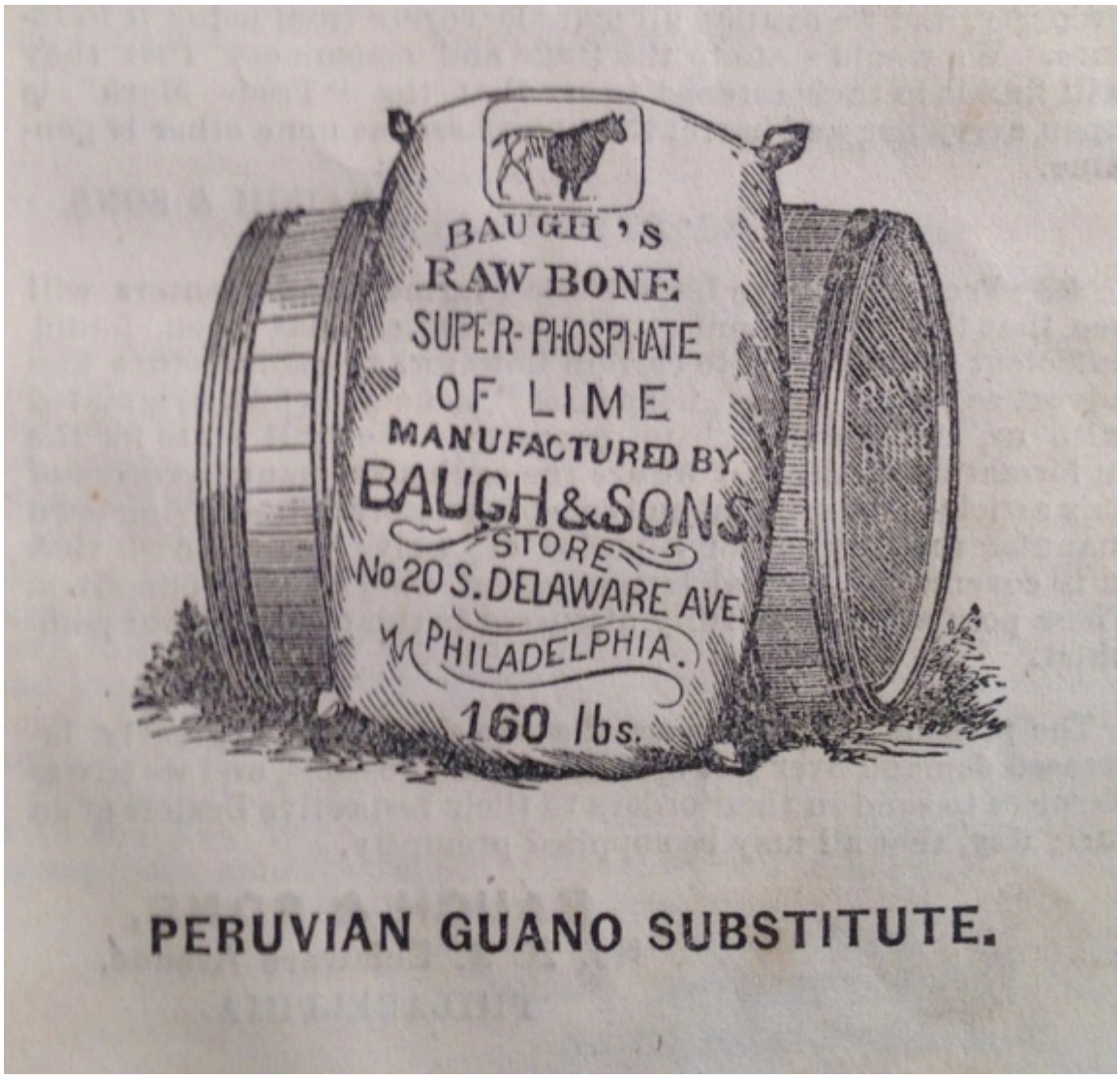

Figure 2.3. Baugh & Sons Fertilizer Advertisement, 1966. Marketing dissolved bone fertilizer as a stand in for the coveted Peruvian Guano fertilizer illustrates how manufacturers drew from a rotating array of inputs that served as the material basis of the early fertilizer trade. (Williams Haynes Collection, Chemical Heritage Foundation, Philadelphia)

Figure 2.4. Detail of Walker, Stratham & Company advertisement, c. 1900. In which a tramp asking for a handout is kicked into a pile of bones to be turned into fertilizer. This emphasizes some of the very dark humor employed to promote animal-based fertilizers, which attempt to make light of mortality. Such imagery became more rare as fertilizer manufacturers worked to emphasize the quality of their products by stressing its chemical qualities and economic value on the farm, rather than its dubious origins in a factory. (Warshaw Collection, NMAH)

Figure 2.5. Interior of Baugh & Sons bone fertilizer factory, c. 1900. This scene evokes Upton Sinclair's fictional Durham's fertilizer plant in The Jungle. (Baugh & Sons Collection, Rubenstein Library, Duke University)

Figure 2.6. Interior of the Pacific Guano Company in Berkley, California, 1941. Even as fertilizer production became more sophisticated, the task of blending fertilizers often remained arduous and dangerous. (RG 16, NARA II)

The industrialization of meatpacking, in particular, appeared to offer an efficient way of returning the leftover products of the animal "disassembly line" back to farms as fertilizer. Companies learned quickly that these efficiencies proved fictitious. Gilded Age industrial operations generated byproducts at a staggering rate, but meatpackers discovered that turning byproducts like bone into plant food required massive outlays of capital, credit, energy, and chemicals. The example of Chicago's Armour Fertilizer Works illustrates the point. At an

exhibit at the 1893 Columbian Exposition, Philip Armour's lieutenant, Charles MacDowell, learned that German chemists had transformed meat byproducts into an array of valuable materials. This piqued MacDowell's interest. One of the top executives in the company, MacDowell claimed to have coined the phrase that Armour "lost nothing from the animal, but the squeal." In 1893, however, he knew that this was actually not the case. Like other meatpackers, the Armour Company constantly faced nuisance complaints for dumping offal and other offensive waste products near their factories. If the German example proved effective, Armour could solve the dumping problem while generating revenue through fertilizer sales. In his memoir, MacDowell explained that Phillip Armour remained skeptical of the value of chemistry to his operations. "Dipping into the chemical kettle," in Armour's words, was a risky and potentially very costly distraction from the company's main focus on meatpacking. MacDowell eventually won Armour's reluctant consent.[22]

Furnished with an initial budget of $100,000, MacDowell began to treat bones with acid in long exposed boxes. Of course, MacDowell did not "dip into the chemical kettle" with his own hands. Instead, he "hired some strong-lunged Polacks and placed them on the windward side of the boxes," where they stirred the corrosive slurry of bone and acid with iron hoes. The work would remain dangerous as the operation grew in scale, but it became more highly mechanized when the company built additional warehouses and ordered industrial mixers

[22] Claire Leavitt MacDowell, *Two Ears of Corn by Way of the Chemical Pot: The Life of Charles H. MacDowell* (Stonington, CT: The Pequot Press, 1954), 45-47, 77. This biography was co-written by MacDowell himself and Claire MacDowell, who completed and published it posthumously. It is a biography based in large part on MacDowell's diaries and recollections. In short, it is a problematic source that gives a sense of large fertilizer manufacturers from the period. On Chicago's meatpacking industry see Cronon, *Nature's Metropolis*, esp. 207-259.

that contained the chemical reactions of sulfuric acid and phosphates in tall, enclosed hoppers. Armour Fertilizer Works was soon involved in a host of ancillary pursuits that extended its business dealings into complex national and international markets and environments. Making sulfuric acid to treat the bones brought Armour into the costly ancillary businesses of mining and refining sulfur. At the same time, bone and blood byproducts became insufficient to meet the market demand for fertilizers. In a step towards vertical integration, the Armour Fertilizer Works purchased phosphate mines in Florida and Tennessee to help meet their needs. They secured nitrates, in part, from ammonium sulfate, a nitrogen-rich but relatively scarce byproduct of coke production. Finding potash meant doing business with the Prussian Kali Syndikat, which had almost total control on Germany's potassium deposits. Bones alone weren't enough to support their fertilizer business.[23]

Another loss was the shipping costs between Chicago and the largest fertilizer markets in the East, and especially the South. In 1899, MacDowell began expanding the Chicago fertilizer works and opened another plant in Baltimore to save on shipping. The fast-paced Chicago firm also had to adjust to the peculiarities of the southern credit market and agricultural calendar. MacDowell initially insisted that all company transactions were conducted exclusively in cash, but quickly learned that the up-to-the-second pace of economic life that permeated Chicago's futures markets was totally incongruous with the southern agricultural economy, where long-term guano notes and crop liens reigned. Armour was forced to adopt the business practices of its southern

[23] Ibid, 66-68, 45-48.

counterparts, and its fertilizer business moved south into branch houses and subsidiary companies. By 1915, Armour had become the third largest producer of fertilizers in the country. It owned and controlled some 41 ostensibly independent fertilizer companies outright, as well as twelve subsidiary companies. With businesses scattered across 19 states, along with several mining properties, Armour illustrates the increasing influence of northern firms over an industry that the South had long claimed as a regional industry.[24]

In its early years, the company had advertised its services with the following diagram: "Armour—The Farmer—Armour," implying a revolving flow of nutrients between farm and factory. By the 1910s this was no longer an accurate portrait of their relationship with farmers. Even for companies that sought to make money from byproducts, fertilizer production was becoming an extractive enterprise that drew from materials from all over the world to serve a market across much of the United States east of the Rockies. What had enticed Armour as an economical solution to disposing of industrial wastes became a complex and decentralized enterprise involving distant mining operations, acid manufacture, and a new distribution network that operated independently of the company's meat business. It may have been profitable, but under scrutiny it was far from a circular flow of nutrients between country and city, as byproduct fertilizer manufacturers often liked to boast.

Unlike the prized but scarce guano deposits of the South American coast, bone fertilizers seemed to provide a convenient source of raw materials that

[24] MacDowell, 73-76; Federal Trade Commission, *Report on the Fertilizer Industry, August 19, 1916* (Government Printing Office: Washington, D.C., 1916), 203-206.

companies could easily obtain from domestic sources. As byproducts of other industrial processes, bones appealed to the "recycling mentality" that was central to the development of America's fertilizer industry. The raw materials for superphosphate were both cheap and abundant. But as byproducts of highly industrialized activities, produced, transported across new sprawling rail networks, and turned into fertilizer by processes contingent upon heavy mineral and energy inputs, these were hardly recycled materials. Instead they were only a part of what was becoming a vast, energy intensive and organizationally complex system that drew upon raw materials from far beyond the agricultural hinterland of city factories. Instead of seeking sources of phosphate across space on the rangelands and ranches of the plains, fertilizer manufacturers drilled down into the geological strata of the earth in search of mineral sources of plant food.

The Mineral Nutrient Regime and Blind Spots of Empire

From a geopolitical perspective, one advantage of the organic nutrient regime had been that fertilizers could usually be obtained locally. Although waste materials and byproducts were often bulky and much less nutrient dense than mineral fertilizers, gathering them usually did not entail doing business with foreign partners. By contrast, in the mineral regime, natural history and political divisions made all the difference. Sir William Crookes had underlined the precarious situation that nitrate minerals presented in the Age of Empire. But what about the other two points in the trinity of plant nutrition? As for domestic American sources, potash was in short supply, as we will discuss in more detail below. When it came to phosphate, however, at the turn of the century, American

fertilizer interests believed they could never run out. Or so it seemed. Following the opening of the Charleston phosphate beds in the late 1860s, the discovery of rich phosphate deposits in Central Florida was a milestone in the mineralization of agriculture, as well as an event that helped structure the fertilizer industry. As the previous chapter examined, the southern phosphate industry would have long-term impacts on not just the South, but also for the global agricultural outlook at the dawn of the twentieth century.

It seemed like the United States had an almost unlimited supply of agricultural phosphate, and for a time, a near monopoly on the world phosphate market. Practically in response to the opening of the Florida beds, after 1894 the U.S. also became the dominant force in the global sulfuric acid market. That year, the petroleum engineer Herman Frasch created revolutionary new process to extract and refine elemental sulfur from deep deposits along the Gulf Coast. This discovery broke a centuries-old Sicilian monopoly on sulfur production, and is arguably as consequential a technical breakthrough as the Haber-Bosch nitrogen fixation process. This new cheap source of acid helped reduce the cost of rendering hard rock and pebble phosphates into water-soluble plant food. American phosphate production was booming.[25]

As much as the southern phosphate beds represented a windfall for America's entry into the mineral fertilizer regime, it is important to note that foreign investment played a significant role in getting the phosphate out of the ground. In fact, the phosphate boom did not ensure a commanding role for

[25] Williams Haynes, *The Stone That Burns: The Story of the American Sulfur Industry* (New York: D. Van Nostrand Co., 1942).

American firms in the global nutrient economy, or even necessarily within America's domestic fertilizer market. German and British fertilizer interests had dominated the Pacific Coast guano and nitrate trades since the early 1800s, and American firms often had to deal with European wholesalers to obtain mineral nitrate. These foreign interests were already major players in the mineral fertilizer trade by the time American firms came on the scene, and the European firms were better equipped to exploit the phosphate beds. In the 1890s British investors bankrolled the Florida Phosphate Company, which quickly became one of the largest companies in the state. Germans had substantial investments as well, including the Schmidtmann's International Agricultural Chemical Company. As much as American interests touted their native phosphate beds as a bright spot in the nation's agricultural outlook, European investment accelerated mineral phosphate development in the United States. [26]

In stark contrast to the phosphate situation, at the turn of the twentieth century, the United States was beholden to Germany for fertilizer potassium, known as "potash." In the early nineteenth century, America produced its own potash from tree ashes boiled and refined by settlers in eastern hardwood forests and exported it to Europe. George Washington issued the young nation's very first patent for an improved process of manufacturing potash in 1790, which suggests the material's value and scarcity even before it was used as fertilizer. Potash would become a flashpoint of economic conflict before and during the Great War, but in the 1890s, there was relatively little anxiety that Germany held

[26] Wilkins, *The History of Foreign Investment in the United States to 1914*, 276; Duncan Maysilles, *Ducktown Smoke: The Fight over One of the South's Greatest Environmental Disasters* (Chapel Hill: University of North Carolina, 2011).

a monopoly on the global potash market. The German potash deposits were the evaporite remains of an ancient marine environment trapped hundreds of feet below the ground until they were first mined extensively beginning in the 1860s. By the 1880s the mine owners had transformed these alkaline crystals into a highly coveted global commodity, operating their business as a syndicate with protection and assistance from the German government. The *Reichstag* strictly enforced low domestic prices and high export prices. Replete with extensive, exclusive deposits and tightly coordinated trade practices, the German potash industry thrived and was well equipped to peddle their products in foreign markets.

The American face of the potash syndicate was the German Kali Works, a branch house based in New York City. The Kali Works developed a marketing technique that was so effective that it earned the admiration, and eventually, the ire of American fertilizer manufacturers. Beginning in the early 1890s the German potash syndicate began distributing free samples of potash fertilizer to experiment stations and agricultural colleges around the U.S. They encouraged American agronomists to run field tests and to report the results in their bulletins and journals. These efforts appear to have been most concerted in the South, which the Germans quickly identified as the nation's largest fertilizer market. Experiment station directors were beguiled with colorful wall charts illuminated by brilliant German inks illustrating the agricultural benefit of potash. The syndicate also printed large runs of long, detailed pamphlets that nimbly blurred the line between science and advertising. In Georgia, the experiment station director read one of the potash pamphlets—a 48-page treatise called "Potash and

Paying Crops"—and found "nothing in its pages of an objectionable character" and distributed 10,000 copies to farmers and reprinted it under the state imprimatur. In North Carolina, the Kali Works lavished so much funding on the State Horticultural Society's experimental farm that a representative of the potash syndicate sat on the group's board. Taking into account that American fertilizer companies were spending more time and money fighting over analytical standards and in court with state agricultural experts, it is no surprise the German potash peddlers found such a warm reception.[27]

Likely because of their longer history of working with experiment stations at home, German fertilizer manufacturers knew that befriending state agricultural experts was a simple matter of good business. They had a clear sense that providing good and accurate information, samples, and even funding was a surefire way to win over beleaguered scientists in remote posts that were starved for funds by their state legislatures. For their part, American fertilizer interests were growing and adopting new trade practices by combining and forming trusts, but for years they were unable to match the dynamic business practices of their German counterparts. It was not long before American fertilizer manufacturers realized that they would need to organize in order to protect their interests and more importantly, expand their market. These efforts had impacts on the nation's agricultural and political landscapes alike.

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[27] R.J. Redding, *Second Annual Report of the Georgia Experiment Station, 1890* (Atlanta: 1890); Edwin E. Slosson, *Creative Chemistry* (New York: The Century Company, 1919), 49. On the work of early experiment station scientists, see Rosenberg, Charles E. "Science, Technology and Economic Growth: The Case of the Agricultural Experiment Station Scientist, 1875-1914," *Agricultural History* 45, no. 1 (1971): 1-20.

Trust Issues: Fertilizer Trade Associations and their Critics

By about 1900, the basic structure of the American fertilizer industry had taken shape as a three-tiered system. Brokers and importers of primary nutrients focused on marketing of one or two of the three main fertilizer minerals. They mined, imported, and gathered the minerals necessary to supply their subsidiaries and customers. Generally, the largest of these firms specialized in regional markets, and owned many branch houses and smaller subsidiaries to cover their region. The second tier was made up of bulk mixers and wholesalers that purchased a combination of materials from top-tier producers and then mixed, bagged, and shipped their goods to retailers, usually in 200-pound burlap or cotton bags. The third tier sold their products directly to farmers. Retailers in the South tended to be country merchants and ginners, while northern dealers sold their products at farm supply stores alongside agricultural machinery. Large consolidated fertilizer companies relied on local merchants that competed with small regional fertilizer manufacturers who sold directly to farmers. Yet in spite of the economic and industrial might behind these large companies, small, regional concerns were locally competitive with the so-called "Big Seven" fertilizer companies. Closer to their customer base, regional manufacturers enjoyed lower shipping costs, and also benefited from price wars between the large firms that often had to dump surpluses below market rates.[28]

[28] Williams S. Haynes, *American Chemical Industry: The World War I Period, 1912-1922* (New York: D. Van Nostrand Company, Inc., 1945), 164-181.

In spite of these variations within the industry, farmers and journalists often referred to a shadowy "fertilizer trust," as though it was a single entity. In 1899, for example, a Georgia newspaperman sounded the alarm that the newly formed Virginia-Carolina Chemical Company was the trust that would control all of the fertilizer output from Virginia to Georgia. In fact, this was just one of the seven firms that dominated the American fertilizer market. The industry as a whole was not coordinated, at least not at first. Among the combinations and trusts of the Gilded Age, what people referred to as the fertilizer trust was certainly not among the most powerful financial actors in the American economy. In 1904, the influential financial analyst John Moody listed it as one of the "lesser industrial trusts" in his index of large American businesses, where it was nestled between the piano trust and the brake-shoe trust. None of the Big Seven was an industrial titan on par with U.S. Steel and Standard Oil, but these businesses were big enough to face their share of scrutiny.[29]

In 1905 the Department of Justice brought charges against several fertilizer manufacturers. Referring to the southern companies targeted in the suit, the *Cotton Trade Journal* lamented that "our one poor ewe lamb of a fertilizer trust, if, indeed there be such a trust, is to be sacrificed." Luckily for them, the Supreme Court was not in the bloodletting mood and threw the case out. A 1915 Federal Trade Commission inquiry into accusations of price fixing found that competition between the Big Seven was sufficient to keep prices fair. These firms and their subsidiaries controlled more than half of the national market, but

[29] "How to Beat a New Trust," *Atlanta Constitution*, November 17, 1899; Moody identified the American Agricultural Chemical Company (AACC) as the sole member of the fertilizer trust in Moody, *The Truth About the Trusts* (New York: Moody Publishing Company, 1904).

consumer prices were not exorbitant. The FTC noted both in this case, and again in 1923, that inflated credit prices in the South were unfair to farmers. It did not pursue regulatory action in either case.[30]

The industry was able to avoid penalties for anti-competitive trade practices, for a time. But these investigations and other challenges the industry faced helped convince fertilizer executives that they needed to begin to work together, even though doing so would only reinforce the public suspicion that they were in collusion. Beside their antitrust issues, fertilizer manufacturers also believed that their trade was subjected to cruel and unusual regulatory pressures by the highly variable state-by-state fertilizer inspection laws and guidelines. As the head of Chicago Northwestern Fertilizing Company claimed to a sympathetic audience in 1894, "No business under the entire canopy of heaven is so bled, hampered and annoyed by legislation" as the fertilizer industry, and in spite of the costs they incurred to pay fertilizer inspection fees they were still "treated like frauds and cheats." United by their grievances and motivated by the benefits of collaboration, fertilizer manufacturers created trade associations.[31]

There were a few abortive fertilizer trade associations in the 1880s and '90s, but by about 1900, the National Fertilizer Association became the dedicated mouthpiece of the industry. Not to be outdone, in 1906, the Southern Fertilizer

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[30] The Federal Trade Commission listed seven firms as the largest fertilizer firms, namely AACC, the Virginia-Carolina Chemical Company (VACC), the Armour Fertilizer Works, the International Agricultural Corporation (IACC), the F.S. Royster Guano Company, Swift & Company, and Baugh & Sons Companies in Federal Trade Commission, *Report on the Fertilizer Industry* (Washington: Government Printing Office, 1916), xvi-xvii; "Fertilizer Trust Case," *Wall Street Journal*, Oct. 23, 1906.

[31] "The Requirements of the Fertilizer Industry in the United States," *The American Fertilizer* III No. 5 (Nov., 1895): 262. There are conflicting accounts of what year the National Fertilizer Association was formed as a lasting entity.

Association formed, although the two groups shared so much personnel that they eventually merged under the banner of the National Fertilizer Association in 1926. These trade associations served many of the same, largely mundane purposes of the many other professional and trade associations that America's mushrooming corporate bureaucracy formed during this period. These included the typical goals of professionalization: they created industry-wide standards and practices; compiled and published data about trade volume and freight rates; tallied energy, mineral and organic inputs; valuated the tonnage of finished products. The members of the associations also wanted to improve their image and expand their market beyond its largely eastern and mostly southern confines. In many ways, the activities of the National Fertilizer Association are fairly unremarkable among other trade associations being formed at the time.[32]

In the case of fertilizer trade associations, however, the banal language of sales and standards belied the role of these professional actors as powerful *ecological* actors in their own right. Insofar as the records of these early fertilizer associations are footnotes in the annals of business history, when they are read as environmental history they are quite revealing . Considering the broader implications of these organizational impulses brings into focus the ways that these business "networking" activities were also integrating networks of material, capital, and power that touched landscapes across the nation and around the globe. After all, fertilizer companies were not just in the business of selling products: by the nature of their industry, expanding their market meant that they

[32] On professionalization and the formation of trade associations, see Robert H. Wiebe, *The Search for Order: 1877-1920* (New York: Hill & Wang, 1967).

were selling new agricultural practices that had lasting consequences. Trade associations created a venue for self-definition that provided fertilizer manufacturers and salesmen a common language that translated the principles of agricultural science into a compelling sales pitch intended educate farmers and ward off accusations of graft by consumers and chemists. As one advocate of the National Fertilizer Association wrote, it provided a forum for manufacturers, brokers, and dealers to "meet, exchange views, frankly and fully, air all grievances," and agree upon ways to define their role in society. This role, as they understood it, was usually expressed as a bulwark against both agricultural and, by extension, social decline.[33]

Notably, the racial mores of the fertilizer industry's most important market during this period inflected the ways that these businessmen defined their role in the national political economy. At an Atlanta meeting of fertilizer salesmen, a speaker limned the fertilizer industry as a guardian of civilization in explicitly racial terms. J.N. Harper asserted that, "No country has ever remained permanently wealthy after its soils have become depleted and infertile." He went on to describe how communities that had once flourished had collapsed for lack of attention to their soils. Speaking to a hall of men who extended credit and sold fertilizer to the impoverished cotton and tobacco regions of the South, Harper insisted that "once flourishing communities" had "had passed into the hands of negroes," because of the failure of white landowners to apply fertilizer in proper quantities. This rhetoric runs even deeper than the bogus implication of some innate connection between poverty, poor soil, and black skin. Meetings of the

[33] "The Requirements of the Fertilizer Industry of the United States," 266.

National Fertilizer Association such as this helped reinforce the idea that the industry performed a socially beneficial role by helping to support crop production, and therefore the economic health and even the nutritional needs of the nation. In turn, the idea that the industry fed the nation and served the common good served as a ready-made defense against criticism. National Fertilizer Association advertisements and letterhead reinforced these ideas, often boasting that, "Fertilizer Feeds the Plants that Feed the World." But the industry's concentration in the South made it clear that such a claim was aspirational—during the first two decades of the twentieth century, fertilizer was disproportionately applied in areas dominated by inedible staple crops.[34]

The trade associations provided a way for the fertilizer industry to define its own role in American society, but it also provided a chance for fertilizer manufacturers to try to define what role the agricultural state would play. Through the activities of the trade associations, fertilizer manufacturers set about influencing state agricultural experts at a time when those experts were still defining their own roles in American society. By trying to influence these actors to advantage, manufacturers were playing a "shadow" role in shaping and building the fledgling agricultural state that has evaded scholarly understanding of the growth of public agricultural institutions. This was particularly true in the case of the National Fertilizer Association's propaganda arm. Taking a cue from their German competition, in the early 1900s the fertilizer associations took dead aim on agricultural scientists as the first target in a program of market expansion.

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[34] Southern Fertilizer Association, *Southern Fertilizers: Science of Manufacturing, Selling, and Economic Use of Fertilizers in the South and Addresses before the Southern Fertilizer Salesman's Meetings, October 15-20, 1917* (Atlanta: Southern Fertilizer Association, 1917), 83-84.

They worked fastidiously to enlist state agricultural experts to support their endeavors and to try to discredit and challenge them when their research or positions did not support the industry's goals. These activities, along with public relations campaigns and political lobbying, would become the trademark of the fertilizer associations in the coming decades. The National Fertilizer Association's first such enterprise was the Chicago-based Middle West Soil Improvement Committee, which opened in 1911 under the direction of the former University of Maine agronomist, Henry G. Bell.

Under the aegis of their Soil Improvement Committee, the NFA funded research that promoted fertilizer use. In the words of the longtime NFA executive, Charles Brand, the committees employed "expert agronomists who could give unbiased information," which the NFA's "propaganda committee [would] intelligently, aggressively, and properly [use to] defend the industry against unfair attacks." One might suggest that these dual aims were at cross-purposes. Most of the committee's work consisted of fairly mundane studies that investigated the best methods of fertilizer distribution, but in many ways the committees anticipated the "merchants of doubt" employed in the late twentieth century by tobacco and fuel corporations to challenge federal regulation with biased scientific studies. The Soil Improvement Committees, as well as some large manufacturers, operated privately funded experiment farms to promote agricultural methods favorable to the fertilizer industry. Their choice to open the first Soil Improvement Committee office in the capital of the Corn Belt indicates that they were keen to pursue a market that had long been in the sights of the fertilizer industry. Over the years Soil Improvement Committee research would

occasionally supplement and sometimes subvert the publicly funded research conducted by the agricultural state. The National Fertilizer Association had taken the German marketing model to new heights.[35]

One of the first goals of the fertilizer trade associations was to challenge the practice of home mixing fertilizers, a campaign that laid a foundation for their long running propaganda activities. Beginning in the 1890s, many agronomists urged farmers to mix fertilizer materials themselves so they could tailor their fertilizer to meet specific chemical needs of their soil and crops. Home-mixing advocates also argued that purchasing individual fertilizer nutrients wholesale would save money by cutting out the middle man—a term reviled by fertilizer mixers. An NFA spokesman reached for the unlikely fashion metaphor to condemn the practice, arguing that the government's support of home mixing was akin to teaching girls to sew their own clothing to punish the garment industry. There were a number of reasons that home mixing failed to catch on. Farmers lacked chemical expertise, and mixing fertilizer required hard work, special tools, and storage facilities. Most importantly, farmers could not obtain wholesale fertilizer materials without cash and connections. Unless farmers could organize themselves and buy goods wholesale, home mixing was impractical.[36]

As agricultural experts encouraged home mixing, they were also advocating cooperative purchasing, which had the potential to usurp the business

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[35] Brand "The National Fertilizer Association," 38; Nelson, *History of the U.S. Fertilizer Industry,* 146; Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury, 2010).

[36] For an early study of home-mixed fertilizers, see Louis A. Voorhees and John P. Street, *Analysis and Study of Home-Mixed Fertilizers and Fertilizing Materials; New Jersey Experiment Station Bulletin 93* (New Brunswick: 1893). Charles J. Brand to C.W. Warburton, 1 January 1931, Box 1597, "Fertilizer," entry 17, RG 16, NARA II.

of local fertilizer merchants. Furthermore, efforts to educate farmers about acceptable fertilizer grades also carried the possibility of leading them to demand highly concentrated fertilizers that most manufacturers were unable to produce. Making highly concentrated fertilizer products was not just a matter of turning a knob on an industrial mixer. Small fertilizer companies, in particular, did not have the resources to upgrade their plants easily, and their products were often drawn from streams of readily available byproducts and minerals. Home mixing could have disrupted both their trade practices and threatened to render their facilities obsolete. It was no surprise that it spurred the industry to action. As early as 1898, the editor of *The American Fertilizer* railed against experts that vaunted the cost-effectiveness of manure and home-mixed fertilizers. Arguing that these professors used their status and state imprimatur to deceive farmers, the editor urged fertilizer dealers to discredit them and disabuse misguided farmers through deceit. "Ridicule is the only means of reaching such men, and it is to be used unsparingly, for the good of agricultural progress. Honest argument is quite useless." Such invective offers a sense of what home mixing represented to the industry.[37]

Following this impulse, in 1910 the Atlanta-based Southern Fertilizer Association launched the monthly journal *Commercial Fertilizer* to promote the interests of southern manufacturers from its home on "fertilizer-reclaimed southern soil." Self-consciously a propaganda publication, the journal began its anti-home mixing campaign to "educate the farmers the fallacy and false economy of trying to do something they know nothing about." The journal hired a

[37] *The American Fertilizer* VIII, No 2. (Feb. 1898), 117

cartoonist to provide visual illustrations of the fallacies of home mixing that could be reproduced in local newspapers and journals. The editor of *Commercial Fertilizer* insisted that their intention was not "betraying any selfish animus or ridiculing the deluded home-mixer," but rather to educate the public about the important role of fertilizer manufacturers.[38]

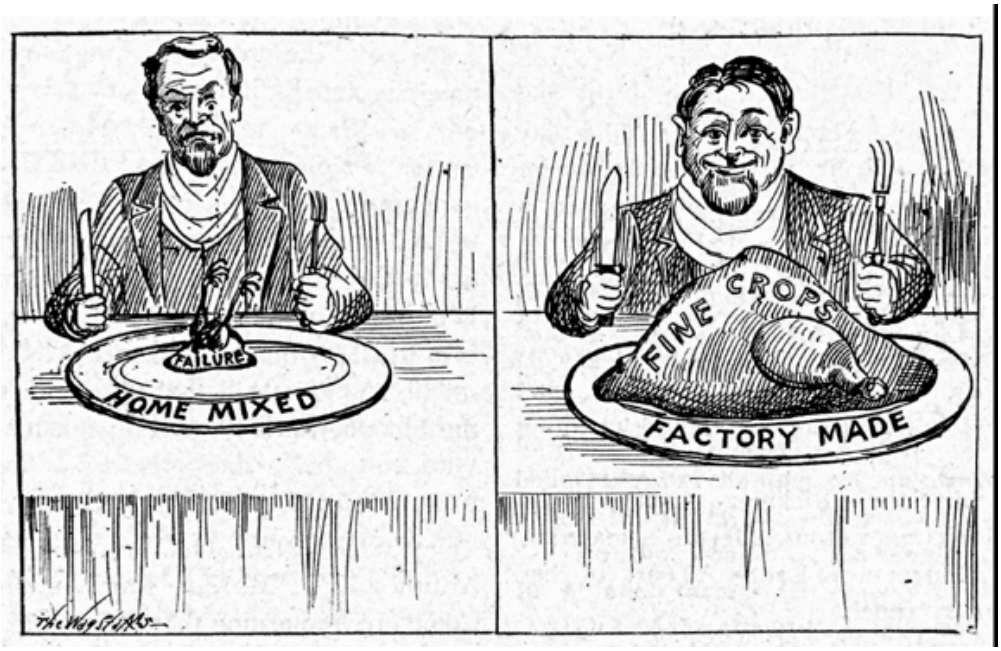

Figure 2.7. Anti-home mixing comic, 1910. (*Commercial Fertilizer* I, no. 4 [Nov, 1910], 9)

It is important to emphasize that a major piece of the fertilizer associations' activities was to build upon and curry favor and support among scientists while at the same time attempting to silence voices they deemed hostile. If the proliferation and growth of fertilizer as a mainstay of agriculture seems inevitable in hindsight, it did not seem as such to the fertilizer manufacturers who saw fit to build a sophisticated propaganda machine, complete with its own experiment

[38] "Our Bow," *Commercial Fertilizer*, (Aug. 1910), 1; "Fertilizer Manufacturers' Home Mixing Campaign," *Commercial Fertilizer* (Oct. 1910).

stations and publications. With these tools at the ready, the trade associations endeavored to win the support of state agronomists and hoped that they could become champions of their cause. It is not surprising that the activities of the Soil Improvement Committees and the anti-home mixing campaign raised a certain amount of suspicion from the scientific community.

The rise of the fertilizer associations and their often heavy-handed tactics to influence agricultural scientists did not go unnoticed. The most renowned antagonist of the fertilizer trade associations was Cyril G. Hopkins, a Cornell-trained chemist and a pioneering researcher of hybrid corn seed at the University of Illinois. An advocate of what he called "permanent agriculture," Hopkins was part of a movement of agricultural conservation that infused nineteenth century agricultural improvement with cutting edge scientific research. Like earlier reformers, Hopkins and his followers cautioned farmers against the high cost of commercial fertilizers and urged them to treat their farms as closed units by "living at home"—that is, by focusing on their identity as producers to avoid becoming consumers. At the same time, Hopkins believed that new applications of agricultural science could help create "farms that won't wear out." For example, he was a strong advocate of applying crushed phosphate rock as an alternative to what he believed were overpriced and ineffectual fertilizers. He argued that the "greedy fertilizer agent has persuaded [the farmer] to buy his patent soil medicine and has taken $100 of the farmer's money and given him in return only $10 worth of what he really needs to buy." With his columns syndicated in agricultural magazines across the country, Hopkins was the standard-bearer of a small movement of farmers, scientists, and editors who saw the machinations of

the fertilizer trust as a conspiracy against farmers. The fertilizer trade press never missed an opportunity to denounce Hopkins as a false prophet. The Chicago-based Soil Improvement Committee was well positioned to try to discredit Hopkins from its office in his home state.[39]

As fertilizer trade associations continued their campaign to influence farmers and land grant scientists, Hopkins was not alone in his belief that the fertilizer industry was more than a trust, and even a vast conspiracy. From his office at the Connecticut Agricultural College, William Esten claimed that the "commercial fertilizer people" had threatened his job because he had pursued experiments that had shown how farmers could rely on legumes, organic material, and phosphate rock, thus avoiding the need for commercial fertilizer. He also detailed the influence of fertilizer manufacturers in colleges and experiment stations in Massachusetts and Rhode Island, noting that the executive of the American Agricultural Chemical Company was a trustee of Amherst Agricultural College. Like Hopkins, he believed that the heavy hand of the industry was suppressing free scientific inquiry in universities and that the agricultural press was "completely controlled by the trust." Despite such voices of dissent, in the coming the decades, fertilizer trade associations would continue to converge and coalesce as interest groups that would exert pressure influence American farmers, but also help cultivate America's quickly growing agricultural state.[40]

[39] Cyril G. Hopkins, *The Farm that Won't Wear Out,* (Champaign, IL, 1913) https://archive.org/details/cu31924003695636
[40] W.M. Esten, 12 March 1918, Box 1126, "Fertilizer," entry 17, RG 16, NARA II.

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In the decades since the Civil War, the American fertilizer industry had grown to help prop up the production of some of the most important global commodities, which elevated the status of fertilizer minerals to become essential commodities themselves. Taken together, all of these materials were engines of economic growth in the empires of the North Atlantic, including the United States. As it became apparent that fertilizer minerals were becoming crucial to the economic health of nations, the uneven distribution of these resources, separated by oceans and borders, generated new liabilities in an era of escalating geopolitical tension. Perceptions of resource scarcity and Malthusian collapse forced the United States, which had always relied on its territorial largesse to meet its needs, to come to grips with the reality that the national domain might not be able to supply the raw materials that fed America's most valuable crops.

These questions of agricultural autarky came to bear during a period of transition within the fertilizer industry, as many older firms that derived their products from byproducts could not compete within the emerging mineral nutrient regime. Although these manufacturers, and many agricultural experts, believed that America's crops could be fed with reliable, domestic sources of plant food, the recourse to mineral-based fertilizer was becoming an imperative of national security, in spite of its costs and liabilities. Beyond the problems of relying on foreign products in an era of imperial competition, the growing fertilizer industry also wrought havoc upon the landscapes that supplied the minerals and the bodies of laborers that transformed the raw goods into fertilizer.

Fertilizer manufacturers were not held to account for these costs, yet the growth of the fertilizer industry exposed it to new scrutiny from regulators, as well as skeptics.

In a bid to protect the industry from external threats and to consolidate its power, fertilizer manufacturers formed trade associations. These organizations reveal the ways that the fertilizer industry set about defining its social worth as a bulwark against agricultural decline. Manufacturers touted the industry's value to society while at the same time seizing upon their vaunted role to inoculate themselves against criticism. The National Fertilizer Association followed the example of German fertilizer dealers and set upon the growing ranks of the agricultural state to promote their interests and discredit their critics. These tactics started on a relatively small scale, but the coming chapters will detail how the National Fertilizer Association would follow the same pattern to become a powerful lobby, and an important, largely forgotten, shaper of America's agricultural policy in the coming decades. This began with participation of fertilizer executives in the coming war effort, which brought the geopolitical liabilities of the mineral regime to a head, as naval warfare and embargoes slashed through the networks of the global nutrient economy.

CHAPTER 3

DIPLOMACY, DISCOVERY, AND DENIAL, 1914-1919

In 1917, a president who had campaigned for reelection only a year before under a banner reading "He Kept Us Out of War" was forced by circumstance to enter the conflict he had hoped to avoid. Wilson tried to galvanize the population around the idea that the war would be won at home, and penned a widely syndicated proclamation that set the tone for his administration's wartime ambitions by informing citizens how they could "Do their Bit" for the war. Those who would not see combat would be tasked with the duty of supplying food not only for themselves, but also for the rest of the world. Fertilizer was merely one of what Wilson referred to as the "Thousand Needs for Victory" outlined in his address, but he nevertheless promised that the government would do everything possible to expedite the delivery of fertilizer to help achieve the goal of maximum wartime production. This was a promise that his administration would fail to keep in the short term, but in its failure, would set in motion a host of changes that would ultimately help revolutionize the nation's agricultural system. In the process, it would become apparent that fertilizer was not only an agricultural commodity: it was part of the national infrastructure without which its survival would be threatened.[1]

[1] Woodrow Wilson, "Do Your Bit for America," April 15, 1917, accessed June 30, 2016, *http://www.firstworldwar.com/source/doyourbit.htm*.

World War I was, as Timothy Mitchell has suggested, the world's first truly carbon-fuelled conflict. Fossil fuels helped escalate the scale and magnitude of warfare to terrifying new heights. Yet because belligerent nations also depended on mineral fertilizers to produce food and fiber, the war was also the first great conflict in the mineral fertilizer regime. And while the belligerent nations entered the war with a fairly clear sense of the carbon resources needed to power their war machines, the mineral basis of their nutritional demands posed its own set of complex, unprecedented logistical challenges. This was partly because the global fertilizer map was beset with asymmetries: Even if a nation was endowed with an abundant supply of one of the three primary fertilizer nutrients, usually at least one of the other two came from far afield—to say nothing of the ancillary materials needed to process them like sulfur. As we have seen, in the decades since 1840 when the chemist Justus Von Liebig identified the three nutrients essential to plant growth, commercial networks spanning the globe emerged to supply farms with nitrogen, phosphorus, and potassium. By 1914 Germany had advanced nitrogen synthesis and a virtual monopoly on potassium, but it lacked domestic sources of phosphorus. Britain and the United States had access to phosphates but relied heavily on Chilean nitrate and German potash. In a sense, policymakers had to reckon with the brutal calculus of Liebig's law of the minimum on a global scale. Warring nations struggled to protect existing supply chains and to seek other domestic resources in pursuit of nutritional autarky.[2]

[2] Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (New York: Verso, 2011), esp. 61-66.

Even though Woodrow Wilson suggested that "there is not a single selfish element, so far as I can see, in the cause we are fighting for," in so many ways, the crisis of war offered extraordinary opportunities for fertilizer manufacturers to advance their position in the American political economy. The same businesses that had been the subjects of anti-trust investigations and were regarded as little more than agricultural patent drug salesmen now enjoyed an unprecedented market for their goods and extraordinary positions of power within the wartime state. Embracing their role as a key part of the war effort, fertilizer executives were able to cast aside their image as fly-by-night bone collectors and clothe themselves in patriotic armor that protected them against longtime critics, especially the contingent within the USDA that championed agricultural improvement over costly off-farm inputs. While there was an international fertilizer war, there was also a domestic dispute about the soul of agricultural modernization. While some called for the self-reliance of living at home, others called for government to double down on mineralization and chemicalization.

As minerals and chemicals served as the material basis of the new global war, the epistemologies underpinning principles of agricultural chemistry moved from academic debates into the political sphere. Without warning, Liebig's "law of the minimum" began to shape the policy of the belligerent nations and manifest itself in political discourse in unexpected ways. Wartime markets buoyed crop prices and afforded farmers a rare opportunity to plow a share of their proceeds back into their soil with commercial fertilizers. Doing so, as both the state and the fertilizer industry exhorted them, was part of their patriotic duty to grow more and better crops. And yet the very same war that shored up their

newfound purchasing power also undermined the ability to obtain fertilizer. Further complicating things, all three of the fertilizer minerals were also essential to arms production and a host of other industrial processes. While businessmen and the Wilson administration saw and seized upon the war as an opportunity to gain commercial traction in foreign markets and expand American enterprise, geographical realities collided with these ambitions as America labored to transform how it fed itself.[3]

As the U.S. and other nations faced the limiting effects of nutrient embargoes, they pursued three approaches to avoiding the law of the minimum that can be broadly categorized as *diplomacy*, *discovery*, and *denial*, and these three concepts provide the chapter's organizing framework. Although each category is treated separately in the chapter below, they largely occurred simultaneously, with each having especially significant moments throughout the war. They are not intended to represent a progression as much as they are useful to identify and contextualize the contrasting strategies that Americans pursued to sate the unanticipated appetites of industrial war.[4]

Broadly, diplomacy describes the actions of those businessmen and politicians who hoped to maintain the pre-war fertilizer regime by trying, in vain, to separate the nutritional needs of nations from their war-making capacity. The section on discovery discusses America's efforts to escape dearth by unlocking

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[3] The more influential Liebig is usually credited with popularizing Phillip Carl Sprengel's concept of the Law of the Minimum, Donald Sparks, "Historical Aspects of Soil Chemistry," in *Footprints in the Soil: People and Ideas in Soil History,* ed. Benno P. Warentkin (New York: El Sevier, 2006), 308.

[4] This framework is my own, but it is inspired by Albert O. Hirschman's classic theory of bureaucracy, *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States* (Cambridge: Harvard University Press, 1970).

hidden troves of fertilizer nutrients within the nation's borders. This project led people to exploit untapped natural resources or to try investing unprecedented amounts of capital and labor on experimental new processes of synthesizing chemicals—all of which had the unintended consequence of deepening the government's investment in cutting edge agricultural research. Denial came from those who repudiated the value of commercial fertilizer to agriculture altogether. This group was driven by two very different impulses: Those who alleged that fertilizer use had been driven by a "vast Teutonic conspiracy," and still another group that perceived the government's calls on its citizenry to conserve as a force that could be used to push farmers to embrace the principles of agricultural conservation.

The International Law of the Minimum

During his bid to reclaim the presidency in 1912, Theodore Roosevelt explained to readers of *The Outlook* how he became a Progressive, paying special attention to his views about the connection between conserving vital natural resources and the long-term prosperity of the nation. He argued that keeping the country's soils productive was an especially high priority, since the history of civilization was full of cautionary tales of societies that had fallen victim to agricultural decline. To account for his beliefs, Roosevelt described how he had "always been impressed with Liebig's statement that it was the decrease of soil fertility, and not either peace or war, that brought about the decadence of nations." Roosevelt could scarcely have foreseen the severity of the coming war, let alone the war itself, but it is noteworthy that he invoked the Prussian chemist,

Justus von Liebig, to justify his convictions about the relationship between national security and agricultural productivity. Roosevelt lost the election, but his rival, President Woodrow Wilson would have to reckon with Liebig's ideas about agricultural decline as well as his most famous principle of agricultural science more than any American leader before, or since.[5]

Justus von Liebig was best known for popularizing the "Law of the Minimum" to explain plant nutrition. Expressed simply, the law states that a plant's growth is limited by that nutrient which it lacks the most. Put differently, a plant might be supplied with ample nitrogen and phosphate, but if it is starved of the potassium it needs to grow, it will not thrive. All soils are different, as some soils are rich in certain nutrients and deficient in others, just as some crops need certain nutrients more than others to flourish. All of this was relatively clear and mostly undisputed in scientific circles before World War I, but because crops and minerals played central roles in political and economic spheres, this scientific principle took on new dimensions in very short order. As America encountered a global war, like other fertilizer-dependent nations, it faced an "International Law of the Minimum" in which the nation's agricultural stability was limited by its access to vital plant foods.[6]

The outbreak of war did not immediately evince impending deprivation because war was good for American business. Commodity prices soared as the war generated voracious demand for food as well as cotton and tobacco. The price

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[5] Theodore Roosevelt, "How I Became a Progressive," *The Outlook*, Oct. 12, 1912, 295; John Bellamy Foster, "Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology," *American Journal of Sociology* 105, no. 2 (1999): 366-405. Foster discusses Liebig's ideas about the rise of cities and their manure waste, which run counter to Liebig's characterization as a fertilizer manufacturer and financially driven scientist.
[6] Donald Sparks, "Historical Aspects of Soil Chemistry," 308.

and the acreage devoted to cotton and tobacco all reached their highest levels since the Civil War. Woodrow Wilson implored southerners to resist the economic incentives of high cotton prices and demonstrate their patriotism by growing more food. In spite of this plea, southerners invested even more heavily in these staples, and the region continued to consume the most fertilizer during the war. Regardless of where the fertilizer went, the President's urgent plea for larger crops grown with more fertilizer, revealed at once the expansiveness, as well as the frailty, of the mineral nutrient regime in a number of surprising ways. First and foremost, the havoc created by German submarines and Allied blockades disrupted the complex multidirectional flow nutrients and chemicals between nations. Shipping woes were exacerbated by the massive reordering attendant to war mobilization, as the normal channels that carried fertilizer minerals were squeezed out by other war materials including food and materiel. Between America's domestic turmoil and international debate, railcar and shipping shortages clogged the channels that had once pulsed nutrients across space at reasonably predictable intervals. Unlike America, however, Germany had planned ahead to try to avoid such a situation.[7]

In the early twentieth century German farms were unquestionably the most productive in the world, thanks largely to heavy fertilizer applications. Germany also imported about 25 percent of its food before the war, but the mostly-landlocked nation was not caught unaware. Their military leadership understood that their allotment of mineral imports would certainly be cut off by

[7] Alan L. Olmstead and Paul W. Rhode, "Cotton, cottonseed, shorn wool, and tobacco – acreage, production, price, and cotton stocks: 1790–1999 [Annual]," Table Da755-765 in *Historical Statistics of the United States*; Wilson, "Do Your Bit for America."

war, but by 1914 Germany had already become the world's most efficient producer of nitrogen-rich ammonia for crop production and munitions thanks to the work of Fritz Haber and Karl Bosch. Other nations were aware of the principles of the revolutionary Haber-Bosch nitrogen process, in which high-pressure gas tanks forced hydrogen and nitrogen through a catalyst to make ammonia. Yet without technical details of the secret process, the rest of the world was left guessing as to how Germany had answered the nitrogen question so decisively. It was an industrial breakthrough that would have long-term impacts on the global agricultural outlook, ultimately transferring the competition for fixed nitrogen away from geopolitical tussles over mineral supplies into a technical arms race with very high stakes. While Germany forged ahead, the United States still relied on mineral nitrates and the vulnerable shipping lanes between Chile and American ports.[8]

The first major naval engagement of the war between the German Imperial Navy and the British Royal Navy underscored the global nature of the conflict and its potential impact on the flow of nutrients around the world. In November 1917, Germany's East Asia Squadron sunk two British destroyers of the coast of Central Chile in the Battle of Coronel. Historically, the engagement is overshadowed by later naval engagements that included Germany's controversial use of U-Boats to attack non-military vessels, including the infamous sinking of

[8] Avner Offer, *The First World War: An Agrarian Interpretation* (Oxford: Clarendon Press), 53, 63; On the Haber-Bosch process, see Vaclav Smil, *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (Cambridge: MIT Press, 2001), 83; Hugh S. Gorman, *The Story of N: A Social History of the Nitrogen Cycle and the Challenge of Sustainability* (New Brunswick, NJ: Rutgers University Press, 2013). Ammonia was also a byproduct in coke production, but it was not a large enough source of fixed nitrogen to meet all of the nation's needs.

the *Lusitania*, which served as a tipping point that drew America into the war against Germany. But the location of the war's first major naval engagement underscores the strategic significance of Chile's nitrate fields and the sea-lanes that connected them with Europe.

The Pacific theater was also a venue of other geopolitical contests, especially those involving Japan. Japan joined the war on the side of the Allies after German and Austrian ships refused to disembark from ports on the Chinese mainland that supplied coal for Pacific fleets. Since the reform and centralization of power attendant to the Meiji Restoration in 1868, Japan's commercial interests were increasingly global in scope, as were the nutrient networks that supported its intensifying agricultural economy. At the 1912 meeting of the National Fertilizer Association held in Atlantic City, Japan's Commissioner of Livestock, Issa Tanimura, explained how his nation's stake in the global nutrient economy was growing by the year. American superphosphates and Chinese seed oil cakes were supplanting manure and night soil to feed Japan's rapidly industrializing economy. As an island nation like Britain, Japan's booming industrial sector included a major textile industry that depended on raw materials and markets accessible only through global shipping lanes. For all nations hoping to avoid economic and agricultural decline, naval power had become a precursor not only to military success, but also to protecting the networks that supported the diets and economies of the industrial cores of empire and capital.[9]

[9] Issa Tanimura, "Agriculture and Fertilization in Japan," in National Fertilizer Association, *Proceedings of the Nineteenth Annual Convention* (Atlantic City, NJ: 1912), 49-52.

The war created chaos in the global economy, but for some, the disruption created opportunities. From the outset of the war in Europe, the Wilson administration saw America's position outside the fray as a favorable occasion to open new foreign markets during and after the war. Secretary of Agriculture David F. Houston projected confidence about America's prospects as other industrial powers had their influence in global trade diminished by their overwhelming commitment to war. Their fundamental weakness, he believed, would be their lack of access to raw materials. Houston suggested that it was "unthinkable" that Europe would be able to compete with the United States after the war, and that it was "impossible that there should be in any of those nations a great reservoir of useful commodities which the nations themselves have not long ago consumed." Since the colonial era, the wealth of natural resources had served as the cornerstone of the American economy, but the war would elevate the value of these resources from the merely commercial to strategic levels. American abundance and neutrality, it was assumed, would help increase the nation's power and prestige on the global stage.[10]

But for all of America's vast natural wealth, certain vital resources were in short supply. Secretary of the Interior Frank K. Lane stressed that the war had made Americans confront "the interdependence of nations in the matter of food supply." By extension, nations were also interdependent for fertilizer supply. With the triad of fertilizer minerals, however, America did not hold all the cards, and with higher prices goading farmers to increase crop production, securing

[10] David Houston, "European Competition After War," quoted in David M. Kennedy, *Over Here: The First World War and American Society* (New York: Oxford University Press, 2004), 37.

these resources became a new priority. The start of the war immediately upended the delicate international balance of power in fertilizer production kicking into motion a frenzy of activity that would redefine the relationship between the fertilizer industry and the expanding agricultural state.[11]

Diplomacy

In fall 1914, the Philadelphia *Farm and Fireside* longingly described Germany's potash deposits as "one of the greatest natural blessings of this planet." Yet Germany's wartime isolation from global markets meant that the American crops would soon be deprived of Germany's endlessly coveted mineral bounty. Many believed that unless there could be some renewal of relations with the Imperial Government America would face a "potash famine." Confident observers of the fertilizer industry often suggested that America contained large reserves of untapped but undiscovered potash, but in the short term many believed that opening a line of communication with Germany might provide the simplest way to restore the flow of this vital mineral to the United States. In dramatic fashion, the *Farm and Fireside* advised the United States against the route of mineral isolationism: "This is a world in crisis in many respects. It is the despair of the little man and the opportunity of the statesman. Where is the potash statesman of the United States?"[12]

One of the first of many self-styled nutrient diplomats to step forward during the war was Horace Bowker, an executive at the massive American

[11] George Otis Smith, *Our Mineral Resources: How to Make America Industrially Independent*, US Geological Survey Bulletin 599 (Washington, D.C.: Government Printing Office, 1914), 6.
[12] Undated clipping enclosed with letter from Herbert Lane to Carl Vrooman, 4 September 1914, Box 136, "Potash," Entry 17, RG 16, NARA II.

Agricultural Chemical Company, a commercial empire spanning from Maine to California to Cuba. A Harvard graduate and officer of the National Fertilizer Association, Bowker led a campaign to maintain trade relations with Germany, the biggest consumers of minerals drawn from his company's sprawling 150-square mile complex of Florida phosphate quarries. Aside from losing key markets, Bowker and his counterparts also needed Germany's potash, and he pressed his contacts in Washington to try to prevent a mineral embargo with Germany. In letters to members of the Wilson administration and the USDA, he suggested that maintaining the transnational flow of fertilizer minerals was "an opportunity for diplomacy," because all parties had a shared interest in keeping supply lines open. Bowker also penned newspaper editorials calling for Washington to extend the olive branch, if not to Germany, at least to the cartel that supplied the United States with the potash it needed to grow its crops. After all, the production of crops was not a matter of waging war, but rather a normal part of life that need not be framed in relation to the unpleasant—and hopefully short—disturbance to business across the pond. At the time, the U.S. had a potash stockpile that could last about four months.[13]

As with any wartime diplomatic enterprise, however, a litany of complicating factors lurked beneath the surface. In this case, fertilizer statesmen like Bowker were bedeviled by the fact that these farm commodities were also crucial ingredients in arms production. Potash was critical to the production of

[13] Williams Haynes, *American Chemical Industry Vol. VI: The Chemical Companies* (New York: D. Van Nostrand Company, 1949), 14; Federal Trade Commission, "Report on the Fertilizer Industry" (Washington, D.C.: GPO, 1916), 202; Horace Bowker to George Otis Smith, 4 September 1914, Box 136, "Potash," entry 17, RG 16, NARA II; Horace Bowker, "Will Germany Exchange potash for Phosphates?" *Boston Herald*, September 1914.

smokeless powder and an array of other wartime products, and Germany was predictably leery about promises that their mineral products would only be used for peaceful purposes. The British blockade made it nearly impossible for Germany to continue its overseas trade for all but the most high value goods. In July 1916, for instance, the German U-Boat *Deutschland* surfaced unexpectedly in Baltimore Harbor and delivered a small shipment of synthetic dyes. Yet, this display was less about commerce than it was about the optics of power.[14]

In contrast to the faction of American businessmen who saw commerce as a potential avenue of exchange, from the outset Germany recognized mineral resources as literal and figurative weapons of war. Replete with its own mineral and chemical supplies and a stockpile of imported phosphate laid by before the war, Germany estimated itself to be in a strong position. This confidence shaped their nutrient diplomacy. "America went into the war like a man with a rope round his neck which is in his enemy's hands and is pretty tightly drawn" declared the renowned German Chemist Wilhelm Ostwald. "It is in Germany's power to dictate which of the nations shall have plenty of food and which shall starve." Clearly, Germany had no intention of opening its potash reserves and closed down its export trade in January of 1915. Potash prices spiked from $76 a ton to $314 as imports dropped precipitously.[15]

As America prepared to enter the war with the Allies in 1917, other issues of nutrient diplomacy came to the fore, and the commercial activities of the fertilizer industry were politicized as never before. Fertilizer manufacturers were

[14] Kathryn Steen, *The American Synthetic Organic Chemicals Industry: War and Politics, 1910-1930* (Chapel Hill: University of North Carolina Press, 2014), 1-3.
[15] Wilhelm Ostwald quoted in Edwin E. Slosson, *Creative Chemistry* (New York: The Century Company, 1919), 60; Nelson, *History of the U.S. Fertilizer Industry*, 168.

tasked with the delicate business of rationing and divvying up vital minerals among the allied powers, as well as deciding whether they should be channeled towards farm production, arms production, or towards other industrial uses. Wilson decided that those best qualified to make these decisions would be a group consisting of businessmen whose industries served war needs along with government experts. In his embrace of the hybrid of government and business cooperation later termed "associationalism," Wilson pushed high-ranking members of the business community into positions of power in the wartime state. These appointments included many fertilizer executives. In October 1917, for example, congress formed the National Research Council to streamline the nation's scientific community to serve the military. Homer J. Wheeler, a research chemist at American Agricultural Chemical, led the NRC's fertilizer division. Separately, Horace Bowker formed a consortium of manufacturers called the "Chemical Alliance" to streamline the activities of the chemical industry "both for the benefit of the Government and for the aid of the Industries involved." At the War Industries Board, Armour Fertilizer Company executive and National Fertilizer Association President Charles McDowell reported to Bernard Baruch as the head of the Chemical Committee. These networks of voluntary administrators wielded tremendous power in the wartime economy, and their service during the war would pay dividends in the postwar years.[16]

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[16] Bernard M. Baruch, *American Industry in the War: A Report of the War Industries Board* (New York: Prentice-Hall, 1921 [1941 reprint]); Ellis W. Hawley, *The Great War and the Search for a Modern Order: A History of the American People and their Institutions, 1917-1933* (New York: St. Martin's Press, 1979); Paul A.C. Koistinen, "The 'Industrial-Military Complex' in Historical Perspective: World War I." *Business History Review* XLI, no. 4 (1967); Oswald Schreiner to William A. Taylor, October 9, 1917, Box 5, "National Research Council, Subcommittee on Chem. of Fertilizers," entry 139, RG 54, NARA II; Charles J. Brand, "Some

The wartime state created tantalizing opportunities for the always-enterprising fertilizer manufacturers, and this close relationship with the government undoubtedly benefitted the fertilizer industry in countless ways. Industry critics were quick to level accusations of collusion. One skeptic expressed outrage that "the biggest men for fertilizer trust" appeared to be "attempting to control things under the guise of helping out." Even if it did provide opportunities, their task in the war effort was nevertheless quite difficult. Managing the nation's industrial metabolism entailed balancing a dizzying array of competing priorities, adding new layers of governance and oversight to processes that had been—at least in the American case—squarely within the province of the private sector. In particular, weighing the relative importance of where and how to direct material resources became a hotly contested and politicized process. Nowhere was this more apparent than in the case of fixed nitrogen compounds. Fixed nitrogen in its mineral and chemical forms was a key element in many different industrial processes, but it was especially central to manufacturing high explosives, fertilizers, and refrigerants. Obtaining and rationing the Chilean nitrates to supply these competing needs was a matter of diplomatic negotiation between America's allies, trading partners, and within and between the domestic industrial and agricultural economies.[17]

Prioritizing competing claims on limited resources assigned new values to commodities, creating winners and losers in the process. In a letter from October

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Fertilizer History Connected with World War I." *Agricultural History* 19, no. 2 (1945), 104-113; "The Chemical Alliance, Inc.: Charter, Constitution and By-Laws," Box 548, "Fertilizer Jan.-Feb.," entry 17, RG 16, NARA II.

[17] W.M. Esten, 12 March 1918, Box 1126, "Fertilizer," entry 17, RG 16, NARA II.

1917, a group of eighteen farmers from Kershaw County, South Carolina wrote to President Wilson demanding that he deliver "some plan by which nitrate of soda can be supplied" to prepare their fields. The wartime economy buoyed food prices and provided farmers with newfound purchasing power for fertilizer, along with other investments in new equipment. Yet as these farmers learned, munitions production was squeezing supplies. Cottonseed meal, once a staple fertilizer in the South, was almost entirely unavailable to farmers as gin operators sold it for higher prices as a high calorie feed to meatpackers. Refrigerated ships, carrying meat and other high-calorie perishable food to the Western Front, siphoned off a third of the chemical ammonia supply that could have been used in fertilizer production. When mineral nitrate was available it came at inflated costs because of the extraordinary war demand for munitions. In spite of all of the cross-pressures on the fertilizer supply chain that the war created, the Wilson administration was unwavering in their calls for farmers to use more fertilizer, especially through provisions of the Lever Food Control Law.[18]

Among historians, the Lever Food Control Law is best known for creating the wartime Food Administration. Under the direction of Herbert Hoover, the Food Administration employed a combination of voluntarism and social coercion to rearrange the American diet to serve the nation's wartime project without resorting to outright state control of the marketplace. If one were to ask a farmer at the time to name the most notable part of the Food Control Law, however, they most likely would have picked the law's $10 million appropriation to distribute

[18] Kershaw County Farmers to Woodrow Wilson, 10 October 1917, Box 1, "Jan. 1917," entry 10, RG 83, NARA II; John E. Pickett, "Our Fertilizer Needs," *The Country Gentleman*, September 9, 1918; on the history of refrigeration, see Susanne Freidberg, *Fresh: A Perishable History*. (Cambridge: Harvard University Press, 2009).

sodium nitrate to farmers at wholesale prices. To carry out the mandate, Secretary of Agriculture David Houston planned to deploy agents from the new Extension Service to take orders and disburse the fertilizer to farmers in their counties. An exciting proposition for farmers, this provision was a headache for the USDA and a troubling precedent for fertilizer companies that were ever wary of federal intrusion.[19]

To the relief of fertilizer manufacturers and the chagrin of the USDA, several problems converged to prevent the nitrate from arriving before farmers planted their crops in the spring of 1918. This was nothing short of a public relations disaster for the USDA and its brand new Extension Agency. Secretary of Agriculture David Houston tried to reassure the public as letters demanding nitrates piled up alongside memos explaining why the nitrate shipments were repeatedly delayed. South Carolina senator "Pitchfork" Ben Tillman fired off a volley of salty letters to Houston lambasting him for "hesitating and dilly-dallying" while his constituents languished waiting to plant their crops. Soon after, the War Industries Board head Bernard Baruch passed along the unwelcome news to Houston that he had redirected nitrate-laden ships to France to supply the Allies with munitions for the spring offensive because it was best to "take it from the farmers for powder, than from powder for farmers." Houston begrudgingly accepted the decision, lamenting that it would "seriously discredit the department in the eyes of the farmers." Bradford Knapp, Director of Southern

[19] Helen Zoe Veit, *Modern Food, Moral Food: Self-Control, Science, and the Rise of Modern American Eating in the Early Twentieth Century* (Chapel Hill: University of North Carolina Press, 2013); United States Department of Agriculture, "Nitrate of Soda for Fertilizers," *Weekly Newsletter,* October 10, 1917, Box 4, "Fertilizer Situation, General 1917," entry 139, RG 54, NARA II.

Extension Work, feared that this decision would be the undoing of the fledgling Extension Agency, which was the culmination of his father's life's work. County agents had worked nights helping farmers fill out their orders for nitrates, and in many cases, these had been the first encounters between farmers and their local agents. Knapp believed that this failure would almost certainly undermine his agents' reputations as they tried to build trust with their communities. The USDA finally delivered a portion of the nitrates in the late spring, and after the war's end suggested that the farmers' "sacrifice" had helped win the war.[20]

In the final analysis, however, Houston and his agency had to fall on a sword not because of their own failings, but rather because of failures of diplomacy. As the war effort created new and unprecedented demands for fertilizer minerals, producers had difficulty meeting the virtually insatiable demands for the strategic minerals that fed both cannons and crops. Negotiations between the Allies over how to manage their most strategic resources threatened to undermine shared objectives. Administrative problems thwarted the best-laid plans of the United States as it fought an uphill battle against labor shortages, unrest, and severe freight limitations on both land and sea. In this case, diplomacy proved a largely ineffective weapon to combat the politics of scarcity.

[20] Benjamin Tillman to David F. Houston, 17 January 1918, Box 548, "Fertilizer Jan.-Feb.," entry 17, RG 16, NARA II; Bernard Baruch to David Houston, 29 March 1918, RG 16, Box 838; David Houston to Bernard Baruch, 6 March 1918, Box 549, "Fertilizer March-May 16," entry 17, RG 16, NARA II; Bradford Knapp to David Houston, 29 March 1918, Box 549, "Muscle Shoals Nitrate Plant," entry 17, RG 16, NARA II; War Industries Board, "Report on Nitrate of Soda," 27 December 1918, Box 1, "Council of National Defense," entry 10, RG 83, NARA II; Gladys Baker, *The County Agent*. (Chicago: University of Chicago Press, 1939); Roy V. Scott, *The Reluctant Farmer: The Rise of Agricultural Extension to 1914* (Urbana: The University of Illinois Press, 1970).

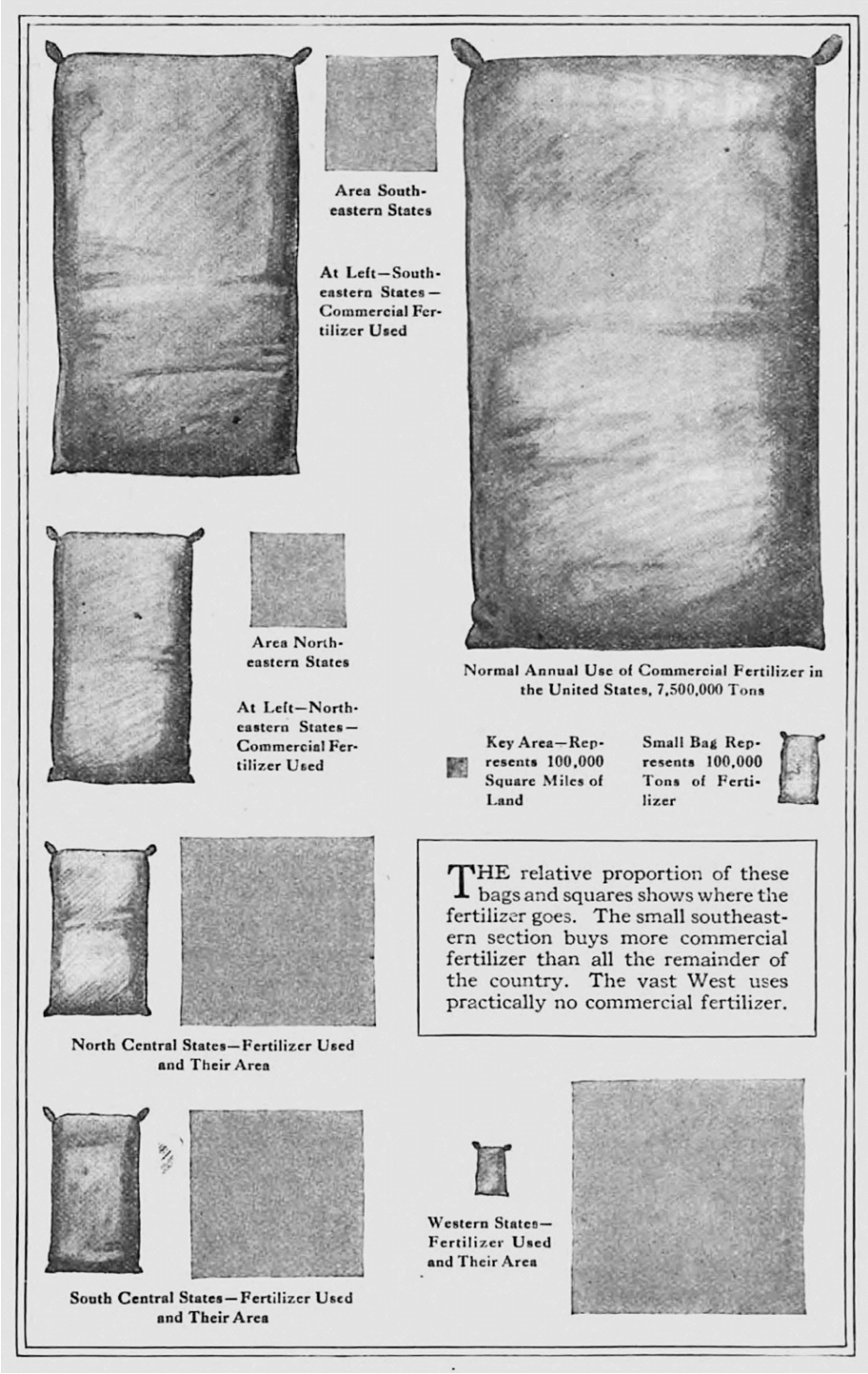

Figure 3.1. Diagram of regional fertilizer distribution, 1918. America's fertilizer budget gained unprecedented visibility as part of the war effort. This imprecise but illustrative diagram shows the respective distribution of fertilizer around the United States in 1910s showing the comparatively high input in the Southeastern region. (*The Country Gentleman*, February 2, 1918)

Figure 3.2. National Fertilizer Association Wartime Preparedness Advertisement, 1918. The National Fertilizer Association used the Wilson administration's calls for increased production to hitch their industry to the patriotic cause of war. Suggesting that, "Fertilizer Feeds the Crops that Feed the World," here in the pages of Commercial Fertilizer, the NFA had developed a now familiar strain of advertising that cast chemical companies as warriors against global hunger, casting themselves as the only reliable bulwark against Malthusian collapse. (Soil Improvement Committee News Bulletin II, no. 15 [Oct. 31, 1918])

Discovery

In 1917, John W. Turrentine, a chemist from the USDA's Bureau of Soils, set out from Washington for Summerland, California to oversee a cutting edge wartime project. A recently minted chemistry Ph.D. from Cornell and native of Alamance County, North Carolina, Turrentine brought considerable scientific expertise with him as he set out to build a facility to develop new processes to extract chemicals from Pacific kelp. First discovered in the 1700s by Scottish chemists who could not obtain wood ash, manufacturers occasionally looked to the high seas to gather kelp as a raw material to produce potash. Turrentine's improbable seaweed project took place amidst a small but intense wartime kelp boom along the California Coast where ships harvested more than 400,000 tons of kelp between 1917 and '18, much of it for smokeless powder production. The Hercules Powder Company—a portion of the DuPont de Nemours Company shorn off by a 1913 antitrust ruling—cut and processed enough kelp to become the largest foreign supplier of smokeless powder for the British during the war. Unlike the other kelp interests, Turrentine's mission was to forage the underwater forests not for weapons but for fertilizers.[21]

As a combination of domestic resource exploitation and technological experimentation, Turrentine's kelp quest neatly encapsulates the path of discovery as a response to fertilizer scarcity, even if it was only one small piece of a broader trend of state-led mobilization. Turrentine had already gotten his hands dirty when he oversaw the USDA's surveys of American fertilizer resources

[21] John W. Turrentine, *Potash: A Review, Estimate and Forecast* (New York: Wiley & Sons, Inc., 1926), 61; Peter Neushul, "Seaweed for War: California's World War I Kelp Industry," *Technology and Culture* 30, no. 3 (1989), 561-583.

in 1913, carefully calculating the fertilizer value of experimental nitrogen synthesis processes, industrial fish scrap, city garbage, and sewage waste. During the war, Turrentine, along with many other bureaucrats and entrepreneurs, frantically sought new ways to use raw materials, industrial byproducts, and undervalued mineral resources to unlock sources of fertility that lay dormant and ignored within the nation's borders. Driven by a sense of impending deprivation, government encouragement, and potential profit, these nutrient explorers hoped to help American farms escape the Law of the Minimum by looking inward. Turrentine's kelp project is also representative of the wartime discovery impulse because it was a spectacular failure in the short term that sowed the seeds of long-term change. In fact, even though Turrentine's kelp experiments yielded mixed results, he parleyed his reputation as a potash expert into a position as the head lobbyist for American potash producers until his retirement in 1948.[22]

Spurred to action by the high price of fertilizer materials, nutrient prospectors in the private sector scoured the West in a quest for potash, creating a trail of ecological disturbance in their wake. In the Mojave Desert, the American Trona Company, a nearly bankrupt borax producer at the start of the war, found new life during wartime by extracting mineral potash from alkaline brines of Searles Lake. Other companies popped up along the shores of other alkaline lakes throughout the West. Yet their success was short-lived. Not only were their products relatively impure compared to most German potash, USDA

[22] Turrentine, "Nitrogenous Fertilizers Available in the United States," (Washington, Government Printing Office, 1913); Turrentine, "The Fish Scrap Fertilizer Industry of the Atlantic Coast," (1913); Turrentine, "The Preparation of Fertilizer from Municipal Waste," (1914); John William Turrentine, 1880-1966, accessed June 23, 2016, http://www.herbarium.unc.edu/Collectors/Turrentine.htm.

investigations showed that many of the minerals were tainted by impurities that made them toxic to plants. Kelp harvesters ran aground on a different set of problems because of overharvesting. Runaway demand outpaced the rate of regeneration, leading harvesters to range ever-greater distances to load up with kelp. With fuel scarce and costly, cutting and processing the six tons of wet kelp needed to fill a small wheelbarrow with finished potash did not pay the bills. Many companies shuttered their doors before war's end. The businesses that were lucky enough to make it through the war were dismayed to find that their patriotic endeavors earned them no trade protection against German competition after diplomatic relations resumed. The owner of the Liberty Potash Company in Lincoln, Nebraska complained that his wartime investments received no peacetime support despite reassurance that his endeavors had been key to the war effort. His company closed their doors in 1919 when the influenza epidemic swept through the factory and German potash flooded back into the American market. Ironically, Americans would soon discover a substantial domestic trove of potash, first in subterranean deposits in Carlsbad, New Mexico, and later in other formations around the West.[23]

The impetus to discover new fertilizer and military resources also drew the government into the unfamiliar terrain of funding and overseeing new fields of scientific research, especially in pursuit of new sources of nitrogen. Since the government itself was not in the business of performing this brand of advanced

[23] Turrentine, *Potash: A Review*; Conference with the State Fertilizer Control Officials at the U.S. Department of Agriculture, 5 January 1920, Box 1, entry 201, RG 54, NARA II; "Liberty Potash Company," 1918 Fertilizer Survey Schedules, Box 3, entry A1 28, RG 54, NARA; Turrentine, "Memorandum for the Secretary of Agriculture in re the American Potash Situation," 21 December 1918, Box 589, "Potash," entry 17, RG 16, NARA II.

research, domestic electrochemical corporations seized upon the new wartime inroads to federal support. Although the United States lagged behind Germany in nitrogen fixation, a number of American companies offered promising evidence that they would crack the code and unlock the vast supply of inert nitrogen in the atmosphere to "make bread from the air." American engineers had started commercial ventures to fix nitrogen through the experimental electric arc and Cyanamid processes, each of which required tremendous amounts of electricity to be financially viable. The cheap hydropower available at Niagara Falls enticed a handful of American entrepreneurs that hoped to cash in on the promising nitrogen synthesis market. Under the leadership of Frank S. Washburn, the American Cyanamid Company successfully operated a small plant on the Canadian side of the falls in 1910, allowing them to circumvent American regulations that prevented damming rivers without congressional permission. An entrepreneur blessed with a keen nose for pork, Washburn's goal was to entice American investors and lawmakers to back an even larger dam-powered plant in the United States, ideally at a rocky stretch of the Tennessee River in northern Alabama known as "Muscle Shoals."[24]

In the spring of 1916, the exigencies of America's entry into the war helped nudge a nitrogen fixation project into serious discussion in Congress. The Senate began drafting a bill for war preparedness that Progressive politicians believed would need to include a government-led plan for manufacturing munitions as part of the nation's plan of defense. As Congress debated how to prepare the

[24] Samuel P. Hays, *Conservation and the Gospel of Efficiency* (Cambridge: Harvard University Press, 1959), 114-20.

nation for its entry into what many still referred to as the "European War," Muscle Shoals boosters and American Cyanamid leaned on Alabama Senator Oscar Underwood to make the case for developing a nitrogen plant in Alabama to manufacture wartime munitions and peacetime fertilizer. Underwood introduced a document penned by American Cyanamid's Frank Washburn warning that, "without fixed nitrogen the earth would soon become an inhospitable waste." If Malthusian scare tactics were not enough, Underwood capitalized on public resentment towards the DuPont Company, which was derisively known as the "Powder Trust" because of its virtual monopoly on gunpowder and explosives. He argued that DuPont was lobbying to stop any legislation that might disrupt its control of the explosives market. Of course, Underwood did not refer to the heavy investments by developers from his home state who were lobbying to steer a massive federal project in their own direction.[25]

Many congressmen smelled something foul in Underwood's fertilizer plan. Rarely had the federal government been asked to invest so many resources and to ease conservation regulations to benefit a large business in such a direct manner. Most Republicans were leery of expanding federal spending on such a large scale, and during debates over the bill Iowa Senator William S. Kenyon wondered why legislation that was intended to reorganize the army would include a provision that called for the manufacture of fertilizers. He lamented that the preoccupation with war preparedness "seemed a vehicle to carry everything through Congress"—even what appeared to be a private grab of public funds and waterpower. But in

[25] *Congressional Record,* Senate, Oscar Underwood, 53rd Cong., 1st Sess., Mar. 30, 1916, 5152-53; Engineering Association of the South, *America's Gibraltar, Muscle Shoals: A Brief for the Establishment of Our National Nitrate Plant at Muscle Shoals on the Tennessee River* (Nashville: Muscle Shoals Association, 1916), 60.

spite of these suspicions, Underwood and his allies successfully won a twenty million dollar earmark to manufacture explosives for wartime and fertilizer for peacetime. Section 124 of the National Defense Act granted the President the authority to "determine the best, cheapest, and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers." This included the construction of two government nitrogen fixation plants—one an experimental Haber plant after the German model, the other a Cyanamid plant—as well as a hydroelectric dam to provide the necessary supply of power. President Wilson was left to choose the site of the facilities and the private contractors to operate them.[26]

Thus, tucked into an expansive law that included, among other things, the reorganization of US armed forces and the creation of the Aviation Section of the Signal Corps of the Army, which eventually would become the Air Force, was a provision that brought the federal government into the experimental field of nitrogen research. But without any definite plan for how the project would proceed or where it would be built, the large earmark for explosives and fertilizers went far to drum up interest in the bill all across the country. So, too, did the process by which President Wilson selected the site for the plant. In a move to make the project's site selection process appear impartial, in January 1917 Wilson created an interdepartmental board consisting of the secretaries of war, agriculture, and the interior to travel the country and inspect waterpower sites for the nitrogen plants. From the Northwest to the Southeast, riverside communities eagerly provided detailed information about the relative advantages

[26] *Congressional Record,* Senate, William S. Kenyon, 53rd Cong., First Sess., Apr. 8, 1916, 5705.

of their area for the new dam and nitrogen plants. After considering the board's recommendations, in November 1917 Wilson settled on Muscle Shoals, where the government would fund two publicly owned and privately operated plants. One was to be a Cyanamid plant, operated by Frank Washburn's American Cyanamid Company. The other would be an experimental plant, in which the General Chemical Company would attempt to replicate the German Haber-Bosch process. The highly publicized selection process generated tremendous interest in nitrogen fixation across the country. The interdepartmental board had served as a de facto whistle stop tour that advertised the promise of the massive nitrogen project and nurtured widespread expectations that the government would manufacture cheap fertilizer to help out farmers at war's end.[27]

The Muscle Shoals project was the most costly and closely watched campaign of wartime exploration, so much so that it evoked frequent comparisons to the construction of the Panama Canal in the press. The government's Herculean effort to build Nitrate Plants One and Two stoked an explosion of interest and activity in what had long been a flood-prone backwater of the Tennessee Valley. The population of the tiny hamlet of Muscle Shoals zipped from 300 to 21,000 over six months in 1918 as federal contractors built an entire town to staff the construction of the dam and two nitrogen plants. And while the contractors executed the project with verve, it was not an immediate success. By the time of the ceasefire in fall of 1918, the Cyanamid plant was running below capacity, and the Haber-Bosch style plant operated by the General

[27] Newton D. Baker to David Houston, 18 January 1917, Box 838, "Muscle Shoals Nitrate Plant," entry 17, RG 16, NARA II; "Summary and Conclusions of a Report Submitted to the Secretary of War by the Committee on Nitrate Supply of the National Academy of Sciences," Mar. 1917, Box 838, "Muscle Shoals Nitrate Plant," entry 17, RG 16, NARA II.

Chemical Company was inoperable—even though the company's engineers had gleaned important insights about the German process in their failure. What would later be called the Wilson Dam on the Tennessee River was not completed until 1924. Chapter Four will address the controversy about the postwar fate of the Shoals in greater detail, but it is worth noting here that the short-term failure of this discovery project only served to keep Muscle Shoals alive in the public imagination by affixing a long-term federal commitment to fertilizer research in the Deep South.[28]

Denial

In contrast to diplomacy and discovery, others pursued a third pathway to nutritional sovereignty by denying the signal importance of fertilizers to the stability of the American economy. The champions of this set of ideas drew their inspiration from an uneven combination of xenophobia and conservationism. One group consisted of anti-German forces that conflated plant science and potash with German imperialism, leading them to question not only the agricultural value of potassium and even the basic principles of agricultural chemistry itself. The other main group was composed of agricultural thinkers critical of the fertilizer industry who believed that wartime shortages could be used as a force to gently push farmers back towards the efficiencies of the late organic economy, leading Americans to finally embrace compost and manure and make good on the mostly unrealized prescriptions of agricultural improvement.

[28] Daniel Schaffer, "War Mobilization in Muscle Shoals, Alabama, 1917-1918," *The Alabama Review* XXXIX, no. 2 (1986): 127.

Since the 1840s, a steady body of knowledge had grown about the science and practice of plant nutrition and for improving approaches to feeding plants. While there was no end to disagreement between scientists, regulators, and manufacturers about the qualities of specific fertilizers and their value to plants, very seldom was the use of fertilizer or Liebig's triad of plant nutrients called into question. In the distressed political atmosphere of World War I, however, what had long been understood as a stable framework of scientific knowledge was destabilized when potash became a politicized topic outside of the rarified circles of scientific thought.[29]

In this case, what rattled the American scientific establishment was the fact that America was at war with a nation that was at once the progenitor of agricultural chemistry, the most advanced practitioner of fertilizer-fueled agriculture, and the exclusive gatekeeper of the world's potash supply. A nutrient that is especially useful for resisting disease and insect attacks, potash was highly valued during the war, when cotton demand was high, and the boll weevil loomed as a grave threat to the South's most valuable crop. These circumstances played into the tides of anti-German hysteria that gripped the nation as America entered the war. Germany's tight control of its potash supply had been a point of frustration among fertilizer manufacturers before the war, but it became new evidence of German propaganda and connivance among the broader public once America entered the fray. From the pages of the *Wall Street Journal*, a fertilizer executive charged that American farmers had been duped by German hype into

[29] On the history of the science of plant nutrition see Rossiter, *The Emergence of Agricultural Science*; on regulation and chemical standards, see Marcus, *Agricultural Science and the Quest for Legitimacy*.

believing that "potash exerted an almost magical influence on crop production" because the syndicate had spent millions of dollars "booming the potash creed." As a corrective to this supposed deception, they argued that the war offered a chance to prove that American farms could get by without Germany's mineral bounty.[30]

Few agricultural scientists took seriously the idea that the importance of potash to plant nutrition was part of a "vast Teutonic conspiracy." Any experiment station scientist along the Eastern Seaboard understood the vital role of potash to cultivating potatoes, tobacco, cotton, and market garden crops on the sandy soils of the Coastal Plain. Still, the combination of the potash embargo and calls to study farming without potash created enough political pressure to lead scientists to pursue hasty experiments that were skewed by the politics of denial. In a confidential memo circulated among top-level USDA officials, the Chief of the Bureau of Plant Industry W.A. Taylor begrudgingly heeded calls to investigate whether or not the value of potash had been skewed by a German propaganda. Scientists pursued experiments to test how potash deficiencies affected a number of important cash crops, and discovered what they already knew—namely, that potash was indeed crucial to crop growth on nutrient poor soils.[31]

For others, denial was not about xenophobia, but rather denying the sense that agricultural chemicals were foreordained as the future basis of the food system. Building upon the admonitions to save and conserve by the Food

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[30] On the boll weevil, see James C. Giesen, *Boll Weevil Blues: Cotton, Myth, and Power in the American South* (Chicago: University of Chicago Press, 2011); Robert J. Bradley *Wall Street Journal*, July 27, 1918.

[31] Confidential Memo from William A. Taylor, 23 February 1918, Box 7, "Potash Hunger," entry 139, RG 54, NARA II; Oswald Schreiner to Wm. A. Taylor, 25 February 1918, Box 7, "Potash Hunger," entry 139, NARA II.

Administration, many critics of the fertilizer industry believed that the nutritional crisis of war created an opening for a renewed call for conservation on the farm. Within the USDA, those sympathetic to this idea bristled at what they saw as war profiteering on the part of American fertilizer manufacturers, whose own wartime sales pitch carried the selfsame whiff of propaganda and opportunism that had been leveled against their German counterparts. In 1918, the National Fertilizer Association asked USDA scientists to endorse their call for farmers to apply as much fertilizer as possible on every crop as an act of patriotism. Bureau of Plant Industry chief, W.A. Taylor, rejected what he believed was a "very dangerous line of argument" that would turn his scientific bureau into a puppet of the industry. An agronomist at the Connecticut Agricultural College suggested that the NFA's wartime campaign was not driven by patriotism but rather by an abiding fear that wartime scarcities would prove to farmers that they could get by without fertilizer.[32]

In contrast to the frantic search to discover new sources of fertilizer, however, many of the loudest voices believed that the problem of wartime shortages could be solved with conservation. Rather than revolutionizing the food system by unlocking novel sources of fertility, people like Assistant Secretary of Agriculture Carl T. Vrooman argued fervently that the war presented an opportunity for Americans to return waste to the soil as compost, and in the process, restore a lost sensibility of conservation and economy. A main proponent of the Victory Garden program, Vrooman sermonized his countrymen to

[32] W.A. Taylor, Memorandum for the Secretary, 20 February 1918, Box 548, "Fertilizer Jan.-Feb.," entry 17, RG 16, NARA II; W.M. Esten to David Houston, 12 March 1918, Box 1126, "Fertilizer," entry 17, RG 16, NARA II.

eliminate waste and to put it to productive ends on their vegetable plots and farms. These actions, he suggested, "may turn the balance upon which hangs our very existence as a free people." Tallying the numbers at his desk, Vrooman figured that Americans had wasted manure and compost worth “twelve hundred million dollars—once and a half the value of the country’s 1916 wheat crop.” But like others before him, Vrooman idealized the efficiencies of the late organic economy, and even the politics of denial and scarcity were not enough to reinvigorate the recycling mentality.[33]

Unfortunately, they discovered that many of the same roadblocks that had impeded agricultural improvement before the war were only made worse by the conflict. The biggest impediment was the dismal mathematics of manure. In preceding decades, American farms had become more specialized, and large concentrations of manure were becoming geographically isolated as dairying and meatpacking operations coalesced around regional hubs. On top of this, the decline of small-diversified farms and the rise of monoculture in the South, along with the decline of draft animals in cities, and later in the country, meant that manure was quickly becoming a highly regionalized resource. One ton of wet manure contains about the same amount of nutrients as a 100-pound sack of typical 1910s fertilizer. This is well and good if that manure is very close to where it will be spread, but as manure is 85 percent water, transporting it is a costly affair even at very short distances.[34]

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[33] On the recycling mentality, see Wines, *Fertilizer in America*, passim; Carl Vrooman, “Home Preparedness,” 28 April 1918, Box 416, “National Defense,” entry 17, RG 16, NARA II; “Carl Vrooman, Wartime Aide of Woodrow Wilson, Dies at 93,” *New York Times*, Apr. 10, 1966, 76.
[34] On the regional specializations in agriculture and transportation see Shane Hamilton, *Trucking Country: The Road to America’s Wal-Mart Economy* (Princeton: Princeton University Press,

Wartime conservationists hoped that manure would provide a measure of relief for farmers, but plans were dashed as the nation's railways were constipated by wartime freight and labor stoppages. In the bitterly cold January of 1918, there was scarcely enough freight space to ship the coal needed to warm homes and power factories. With such crises afoot, the wartime Rail Administration likely had little sympathy for the truck farmers of Virginia's Eastern Shore, who complained that the regular movement of manure from Philadelphia had become completely stopped up by February of 1918. Virginia's Commissioner of Agriculture begged Washington for a measure of relief, but to no avail. This wartime reprioritization of commodities slashed some of the few remaining city-country nutrient loops that had survived into the twentieth century. Commercial fertilizers provided higher nutrient density goods that, unlike manure, were still shipped by rail during the worst transportation disruptions of the war. Thanks to their influence in Washington, fertilizer executives were able to win a special dispensation from the Fuel Administration to keep factories running in the winter of 1918 when it ordered all of the factories east of the Mississippi to shut down to alleviate the coal and freight shortage. Despite the apparently low cost of organic nutrient supplies, the war cemented the central importance of fertilizer minerals to the American economy, even in a pinch.[35]

2008). David Pimentel, "Conservation of Fertilizers and Livestock Manure: Pollution Prevention," *Conservation* 3 (Oct. 1997): 2. Pimentel's calculation is based on a 5-10-5 bag of fertilizer, which was a common grade at the time of World War I.

[35] On spatial politics, see Richard White, *Railroaded*, 140-178; Kennedy, *Over Here*, 125; Correspondence Regarding Manure Shipments from Philadelphia to VA Eastern Shore, Box 548, Fertilizer Jan.-Feb., entry 17, RG 16 NARA II.

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As the federal government threw its weight behind efforts to meet America's nutrient needs, it revealed how the fertilizer industry had become fundamental not only to America's economic stability, but even to its national security. The eruption of World War I forced a close accounting of the connections between the United States and the world. Blockades and naval war threw up new boundaries between nations whose economies had grown interdependent in hitherto underappreciated ways. Some of America's most important export crops, especially cotton and tobacco, were affected by the new barriers to trade not for lack of foreign markets, but rather because of problems attendant to importing fertilizer minerals. These problems became even more acute as crop prices rose and the federal government called on farmers to raise bumper crops to meet domestic needs, as well as the needs of overseas allies. The possibility of losing supplies of Chilean nitrates or German potash carried the chilling prospect of falling victim to the International Law of the Minimum. To avoid privation, the U.S. pursued three main pathways to protect its nutritional sovereignty, all with varying success.

Diplomacy offered a pathway to protect trade with important partner nations by stressing the mutual benefits of exchanging important materials. Advocates of diplomacy clung to the hope that America's neutral status at the start of the conflict might preserve its ability to do business with other nations, even as war raged in Europe. Once the United States entered the war, new diplomatic challenges emerged over questions about how to best allocate mineral

resources between different industrial uses and between different countries. In these contests, farmers that had been promised government-subsidized fertilizer were disappointed as federal administrators redirected ships laden with fertilizer minerals to feed weapons on the European front. Farmers did not soon forget the promise that the government had made to provide assistance with fertilizers. At the same time, the government's wartime policy of welcoming executives into positions of power helped manufacturers discern new opportunities by cooperating with, or even coopting the bureaucracy of the agricultural state. As we will see in the following chapters, Charles Brand, the most powerful executive at the National Fertilizer Association in the coming years launched his career as an alfalfa breeder who went on to serve as the Chief of Bureau of Markets at the USDA during World War I.

Discovering new ways to produce fertilizer without foreign assistance was another important pathway the United States followed to avoid agricultural decline during the war. Virtually all of the new projects undertaken to discover new sources of fertilizer fell short during the war, but many had lasting impacts. By drawing the government into new exploratory roles and by providing assistance and encouragement to private industry, as it sought new raw materials and technological processes, the federal government started a program of direct and indirect subsidies for fertilizer companies. Of course, some projects were abortive, including the costly experimental program to manufacture potash from Pacific Kelp at the USDA's Summerland, California facility. The National Defense Act of 1916 launched a new fertilizer program based in Muscle Shoals, Alabama, where local boosters and a burgeoning electro-chemical industry took on the

project of nitrogen fixation in an ambitious gambit to feed weapons and farms with new synthetic compounds. Again, this project fell short of its aim during the war years, but the project served as both a model and a blue print for new state structures that would help shore up private fertilizer production with federal support.

Finally, some Americans denied the central role of fertilizer in the nation's political economy by challenging the scientific thinking behind plant nutrition. Anti-German jingoism was so pervasive when America declared war that it even seeped into the otherwise staid realm of agricultural chemistry, as critics assailed the nutritional value of potassium to plants as evidence of a conspiracy hatched by German potash salesmen. The USDA begrudgingly heeded calls to investigate the extent to which crops could withstand a potash famine on important crops, laying bare the political nature of federally funded science, as well as the new roles that state actors were asked to play in the mineral nutrient regime. At the same time, among the ranks of the agricultural state, there were still many actors that challenged the growing dependence on mineral fertilizers on the basis that waste materials still offered the most economical and efficient approach to supporting America's farms. Their prominent role as critics of the shifting agricultural paradigm indicated that other visions of the "future of farming" were far from marginal.

Indeed, the volleys over the importance of fertilizer to American farms did not completely cease with the shooting at end of the Great War—in fact, other movements to transform agriculture were already still in the offing. For example, Milwaukee's municipal Milorganite sewage fertilizer plant stands to this day as a

monument to the successful adaptation of twentieth-century industrial efficiencies to nineteenth-century conservation impulses that were typical of the organic nutrient regime. But this is an exceptional case. In the coming years, the question shifted from whether or not farmers needed fertilizers to who would be selling them and on what terms. The generative pressures of wartime had burned with such fire and intensity that they effectively reshaped and reframed the roles and relationships between the state and the private sector, as well as what the public expected of each. In any case, the politics of scarcity had elevated the status of the fertilizer industry and its leadership during the war.

The Armistice helped bring an end to the politics of scarcity, but it had cemented the notion that controlling fertility was a crucial task to national security in a modern industrial society. Thanks to the National Defense Act of 1916, one of the lasting effects of the war was a new commitment on the part of the state to pursue and perfect the chemicalization of agriculture, especially by developing advanced systems that could deliver the powerful chemicals needed to increase production in peace and war alike. Perhaps there is no greater illustration of the outsized role that these chemicals would play in global technopolitics than the content of a confidential memo from the Allied Reparations Commission in May 1923, which set the prices for the Germans to pay off their crippling war reparations with ammonia—a form of fixed-nitrogen—in lieu of gold. Chapter four will examine how the government and the industry adapted to this postwar reality, as state actors played an ever greater role

performing research and manufacturers continued to shape and exploit the proliferation of America's agricultural state.[36]

[36] Gorman, *The Story of N*, 144.

CHAPTER FOUR

"EVERY FARM IS A CHEMICAL FACTORY," 1920-1930

In a 1926 article in the *Scientific Monthly,* chemist S. C. Lind recounted a striking moment from his laboratory in Washington, DC. Workers were repurposing the barrel of a large naval gun in the laboratory's machine shop, where a team of engineers planned to use it as a high-pressure tank to synthesize powerful new nitrogen-based fertilizers. The spectacle struck Lind as "a twentieth century version of beating the sword into a plowshare." Lind worked at the Fixed Nitrogen Research Laboratory (FNRL), which Secretary of War Newton D. Baker had created at the end of World War I to put leftover explosives and related technologies toward more productive ends in the agricultural sector. In 1921 the FNRL was moved from the War Department to the USDA, which Lind believed was "but a larger expression of the same desire to turn one of the liabilities of war into an asset of peace"—that is, the desire to beat swords into plowshares. This biblical imagery made their research appear a logical, even natural project for federal employees whose work had served the aims of the wartime state. Even if it seemed comparatively innocuous, however, their peacetime project of fertilizer research still held deeply political implications.[1]

[1] S. C. Lind, "The Fixed Nitrogen Research Laboratory," *Scientific Monthly* 22 (Feb. 1926): 169. This chapter draws upon Timothy Johnson, "Nitrogen Nation: The Legacy of World War I and the Politics of Chemical Agriculture in the United States, 1916-1933," Agricultural History 90, no. 2 (Apr. 2016): 209-229.

Just why did federal scientists pursue state-of-the-art fertilizer research during the 1920s, and how was this project so intimately connected with demobilization after the war? Part of the explanation was chemistry. Fixed nitrogen (N_1) is an essential technology in the manufacture of explosives and chemical fertilizers. German scientists had developed a process to manufacture fixed nitrogen before the war, but America's chemical industry lagged. In the 1920s unlocking the secret of nitrogen fixation remained a vital concern for federal experts who dealt with arms and farms alike. Another part of the explanation was cultural. In recent decades, fertilizers have earned a bad reputation as a key ingredient in improvised explosive devices, as the catalyst of industrial disasters like the 2013 plant explosion in West, Texas, and as part of an energy and chemical-intensive agricultural system. In the years during and after World War I, however, this bond between explosives and food was the subject of an exciting field of experimental science that seemed to offer boundless potential. For members of Congress, nitrogen fixation was so promising that they had written it into the National Defense Act of 1916. Section 124 of the law included a twenty million dollar appropriation for munitions plants that would be converted to factories to produce cheap fertilizers when peace returned.[2]

Historians have identified this National Defense Act as the starting point of the protracted Muscle Shoals Controversy of the 1920s, a debate over public-

[2] Many have emphasized the ways that warfare spurred technological change, especially under the aegis of the modern state. Lewis Mumford, *Technics and Civilization* (New York: Harcourt, 1934), 86-87; Merritt Roe Smith, ed., Military Enterprise and Technological Change: Perspectives on the American Experience (Cambridge: MIT Press, 1985); Edmund Russell, War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring (New York: Cambridge University Press, 2001); on the industrialization of agriculture, see, Deborah Fitzgerald, Every Farm a Factory: The Industrial Ideal in American Agriculture (New Haven: Yale University Press, 2003).

versus-private ownership of the wartime plants in Northern Alabama that led to the creation of the Tennessee Valley Authority in 1933. Yet this law was not merely an "antecedent to the TVA." Hidden amidst the tangled legislative machinery of this long political debate were the makings of an explosive agricultural transformation. The National Defense Act laid the groundwork for the FNRL, which helped deliver a blast of powerful and cheap chemical fertilizers in the United States for the first time in the late 1920s. For this reason, the National Defense Act could be one of the most important pieces of agricultural legislation in the nation's history, although it is rarely counted among them. It also established a model for disarmament and agricultural intensification that the federal government used after World War II on an even grander scale.[3]

Federal fertilizer research during and after World War I represents a major, albeit under-appreciated, change in agricultural policy on the part of the American state. The National Defense Act hitched nitrogen synthesis to the project of national security. This helped shatter limits on agricultural production by hastening the manufacture of cheap, abundant nitrogen-based fertilizers in the United States helping usher in a new era of highly concentrated fertilizer products. Crucially, personnel embedded in the federal bureaucracy made decisions largely outside of the public view that would have wide-ranging implications for fertilizer companies and for farmers. Public debate about the matter centered on the future of wartime facilities at Muscle Shoals, Alabama, where people had expected the government to produce cheap fertilizer at war's

[3] Preston J. Hubbard, *Origins of the TVA: The Muscle Shoals Controversy, 1920-1932* (Nashville: Vanderbilt University Press, 1961). Hubbard provides a detailed account of the Muscle Shoals imbroglio. Norman Wengert, "Antecedents of TVA: The Legislative History of Muscle Shoals," Agricultural History 26 (Oct. 1952): 141-47.

end. However, it was not in Alabama, but rather at the laboratory in Washington, DC, where FNRL employees made the key decisions about the future of fertilizer production in the United States. Significantly, the leadership at the FNRL ensured that their work would benefit fertilizer manufacturers directly and farmers only indirectly. Many scholars have emphasized highly visible land-grant university scientists and agricultural extension agents as key drivers of America's agricultural modernization in the early twentieth century. However, by enabling the creation of a domestic fixed-nitrogen industry, the "hidden in plain sight" activities of the FNRL also tipped the balance toward an era in which American farms were increasingly fed by chemicals.[4]

The technological enthusiasm that often accompanied the new chemical regime in agriculture, however, stood in stark contrast to the devastating depression that afflicted much of the American countryside during the interwar years. Many agricultural experts perceived the dislocation and displacement attendant to farm mechanization and overproduction as mere "growing pains" long overdue in a lagging sector of the national economy. Other critics targeted this productionist impulse, and sought ways to create economic and social stability for small farmers drowning in a tide of overproduction. These ranged from the establishment of local cooperatives to congressional bills to stabilize crop prices. Caught between these crosscurrents and diminished in status by the end of their wartime promotion, the fertilizer industry—by its very nature, a driver of production—navigated these turbulent waters by streamlining

[4] Brian Balogh, *A Government Out of Sight: The Mystery of National Authority in Nineteenth-Century America* (New York: Cambridge University Press, 2009). Balogh invokes the concept of "hidden-in-plain-sight" government to describe federal power in the 1800s.

operations and redoubling efforts to infiltrate the agricultural state. In 1925, the National Fertilizer Association and the Southern Fertilizer Association merged, abandoning sectional differences as they set their eyes on conquering a larger market across the Corn Belt, and even in the "crabgrass frontier" of the green suburban rings surrounding the nation's cities. With the Muscle Shoals debate dragging out until the election of 1932, fertilizer manufacturers rallied around the cry of "government interference" and redoubled their efforts to perform even more favorable agricultural research, working to alternatively reward and intimidate extension agents and agricultural scientists.

Agrarian Afterlives of the National Defense Act

At the end of the war, the dam at Muscle Shoals remained unfinished and the nitrogen plants were inoperable despite frenzied construction to complete them during the war. The General Chemical Company had spent $12 million of public funds to build the Haber-process plant, known as "Nitrate Plant One," in Sheffield, Alabama, but it failed to manufacture any fixed nitrogen during the war. The lessons learned from the failed plant would prove instructive for the General Chemical Company in the long run. For the second plant, the government had contracted a subsidiary of American Cyanamid to build a plant using the company's special process. The armistice in Europe shut down activities in this second facility, called "Plant Number Two" in October 1918, soon after the plant came online. Questions about how to complete the plants and the dam, and whether a public or private entity would operate them, created a legislative imbroglio that offered no quick solution. For their part, farmers had not forgotten

that the federal nitrogen project was intended to serve their interests by providing cheaper and more powerful fertilizers, and many were still awaiting the nitrates they had requested with the help of their county agents. Overproduction was a main cause of the postwar agricultural depression, but even though fertilizer only served to increase production, individual farmers were desperate to cut their input costs with cheaper fertilizer. For farmers in the Cotton Belt who still consumed the largest share of fertilizer, overproduction and fertilizer debt was hardly new.

There was a remarkable disconnect between the enthusiastic ideology of the incipient chemical nutrient regime and the unglamorous life of rural Americans, especially those in the South. Southern farmers accepted fertilizer as a mainstay but as one paper editorialized, "some farmers paid more for their fertilizer than the value of the selling crop they made with it." Those with the cash or credit to obtain it knew that fertilizer prices usually dropped during the spring, adding an additional consideration to the already complicated business of choosing the perfect moment to plant their crops. "When crop prices and fertilizer prices are in their normal relation to one another, the crop pays for the generous use of the stimulant," but lamentably, no one knew what crop prices would be at the end of the season. These conditions were also very hard on the fertilizer industry, as fertilizer consumption in the nation dropped from eight to 4.5 million tons between 1920 and 1921, a situation that forced fertilizer manufacturers to sell off the stocks of material at distressed prices. Pinched between high input costs and low commodity prices, farmers began to demand that the government find a way to follow through with the fertilizer measure of

the National Defense Act. Desperate letters piled up in the secretary of agriculture's mailroom from farmers in search of relief. Believing that the end of hostilities would ease demands on explosive production, many asked the government to release surplus explosives as fertilizers. Initially the War Department, rather than the USDA, answered the call.[5]

In 1919 President Wilson's Secretary of War Baker established the Fixed Nitrogen Research Laboratory as part of the department's Ordnance Division. Based at the American University in Washington, DC, the laboratory's mission was to conduct research and develop nitrogen fixation processes to follow through with the still incomplete wartime project. But before the laboratory could turn its focus toward experimental processes, the Ordnance Department addressed the demands of farmers who thought that explosives should be turned into fertilizers. This strange assignment was intended to appease the strong public expectation that demilitarization would directly benefit farmers who had lost access to Chilean nitrates during the war. Within the Ordnance Department, the assignment also served the much more prosaic purpose of finding a way to dispose of stockpiles of rapidly decaying explosives in arsenals. Greenhouse tests quickly revealed, however, that these chemicals were of "doubtful value, and

[5] "Nitrate Project Attacked," New York Times, Apr. 5, 1918, 5; *War Expenditures: Hearings before Subcommittee No. 5* (Ordnance), 66th Cong., Second sess., 1920, 2668; M. C. Allgood to Edwin T. Meredith, 31 March 1920, Box 765, "Nitrates," entry 17, RG 16, NARA II; "Fertilizer," Raleigh (NC) Honest Observer, Feb. 14, 1921; Committee on Agriculture and Forestry, *Muscle Shoals: Hearings before the Committee on Agriculture and Forestry,* Sixty Seven Cong., Second sess., 1922, 417; Milton Whitney to Gray Silver, 1 April 1921, Box 2, "Misc. Correspondence," entry 201, RG 54, NARA II.

contrary to the interests of the farmer." To the disappointment of farmers, this avenue of swords-to-plowshares research was a failure.[6]

This particular fixed-nitrogen research initiative may have hit a dead end, but public attention remained focused on questions of when the facilities on the Tennessee River would start up and who would run them. Congressional hearings about the fate of the Muscle Shoals site hinged on the issue of whether the federal government should lease the facilities to private contractors or if the government itself should operate them. Matters became even more complicated in 1921, when auto magnate Henry Ford placed a bid to lease the plants and complete the Wilson Dam on his own. The prospect of another Detroit on the Tennessee generated a media frenzy of epic proportions and spurred a real estate speculation boom the likes of which this remote corner of the South had never seen. Interest groups including the American Farm Bureau and the Farmers' Union came out in support of Ford's proposal, believing it would be the quickest way to bring the fertilizer plants online and help farmers climb out of the deepening postwar agricultural depression. Ford offered to build new factories and towns and to produce cheap fertilizer along with automobile parts. Crowds roared with applause as Ford toured the Southeast with the renowned inventor Thomas Edison in tow, making speeches that conjured images of a southern industrial corridor to surpass even the German Ruhr Valley. Bullish newspaper editors spun Ford's grand rhetoric into utopian visions of a benighted region transformed by the industrial wizard's wand. The *Atlantian* estimated that Ford

[6] Oswald Schreiner to Maj. J. Herbert Hunter, 6 August 1919, Box 4, "Explosives and fertilizer," entry 139, RG 54, NARAII; Asst. Secretary of War to Secretary of Agriculture, 9 July 1918, Box 549, "Fertilizer 3 of 3," entry 17, RG 16, NARA II.

would “develop 800,000 horsepower and give work to 800,000 men.” A *New York Times* headline claimed that Ford would build a city “75 miles long” on the Tennessee River beginning at Muscle Shoals. With such sensationalism crowding headlines and stirring the public’s imagination, the work of the chemists at the Fixed Nitrogen Research Laboratory largely evaded the public eye.[7]

The Ford offer added an air of sensationalism in the press that was met with equally grandiose challenges from state actors who opposed his plan. In his condemnation of Henry Ford’s offer, former Secretary of War Newton Baker claimed that, "If I were greedy for power over my fellow men I would rather control Muscle Shoals than to be continuously elected President of the United States.” This level of overstatement underlines not only the level of concern about Ford’s offer, but also the caliber of public discourse and the stakes that had been attached to Muscle Shoals in the public imagination. Facing opposition both within and outside of Congress, Henry Ford withdrew his bid in 1924, citing the pernicious influence of Wall Street and the Power Trust over American politics. But even with the removal of Ford and all of the sensationalism he bestowed from the conversation, the Muscle Shoals debate was far from complete.[8]

The question about what would happen at Muscle Shoals remained a flashpoint of public debate throughout the 1920s, thanks in large part to Nebraska Senator George W. Norris, a longtime advocate rural modernization. A progressive Republican, Norris led a decade-long crusade to turn the Muscle

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[7] “Henry Ford and Muscle Shoals,” *Atlantian* XIII, no. 142 (Apr. 1922): 5; “Ford Plans a City 75 Miles in Length,” New York Times, Jan. 12, 1922. For a comprehensive look at the role of local businesses and boosters courting federal investment in northern Alabama, see Matthew L. Downs, *Transforming the South: Federal Development in the Tennessee Valley, 1915-1960* (Baton Rouge: Louisiana State University Press, 2014).
[8] Hubbard, *Origins of the TVA*, 146, 139.

Shoals facilities into the hub of a regional planning experiment in rural electrification and soil conservation. With a deep conviction that a government guided by technological expertise could build a more stable rural society, Norris's dream won the approval of New York Governor Franklin Delano Roosevelt, who would build upon it to create the Tennessee Valley Authority when he became president. Norris was skeptical of the companies that had lodged bids to lease Muscle Shoals. For Henry Ford and American Cyanamid both, Norris believed that their true aim was not delivering cheap fertilizer, but capturing a free source of power from the Wilson Dam and using it to power new factories for their own private gain. In Norris's view, carrying out the mandate of the National Defense Act would include government-run fertilizer production at Muscle Shoals as a service to farmers, rather than as a subsidy to industry.[9]

Not surprisingly, fertilizer manufacturers recoiled at the mere suggestion that the government oversee any type of fertilizer production. The National Fertilizer Association lobbied aggressively to stifle Norris's plans for Muscle Shoals, which they believed would create a "Paralyzing Monopoly" that might destroy the fertilizer industry. Their fear was grounded in the sense that federal programs might Because the fertilizer industry had itself been accused of price-fixing and had been the subject of two Federal Trade Commission investigations since the 1910s, its membership was wary of any additional federal interventions in their industry. Like much of the public, the National Fertilizer Association focused its attention on the plans to operate the Muscle Shoals nitrate plants,

[9] Ibid, passim; Sarah T. Phillips, *This Land, This Nation: Conservation, Rural America, and the New Deal* (New York: Cambridge University Press, 2007); Philip Selznick, *TVA and the Grass Roots: A Study in the Sociology of Formal Organization* (New York: Harper & Row, 1966), 82;

rather than on the work of the chemists at the FNRL who were studying how to fix nitrogen in their Washington, DC, laboratory. As it turned out, in many ways, the FNRL had the fertilizer industry's best interests in mind.[10]

Many of the scientists and engineers who worked in the Fixed Nitrogen Research Laboratory had used their expertise for destructive purposes during the war. They would attack the more productive postwar task of agricultural research with the same sense of mission. A case in point was the laboratory's director beginning in 1920, Richard Chace Tolman. An MIT and German trained chemist, during the First World War Tolman served in the Chemical Warfare Service. There, Tolman invented candles that dispersed toxic smoke, along with masks designed to protect soldiers from their deadly fumes. Luckily the war ended before the four million candles the government manufactured were put to use. Tolman oversaw the transfer of the FNRL from the War Department to the USDA in 1921. He and his peers understood the peacetime applications of nitrogen to be just as pressing as its wartime applications. Certain members of the press agreed. In a piece about the FNRL in 1921, the *Washington Sunday Star* reported that

> During the next few years nitrogen will become a prolific source of debate in Congress and all state legislatures as the tariff, equal suffrage and prohibition have been in past years. Why? Simply because the future supply of daily food for the men, women, and children of America practically depends upon the use of nitrogen as a fertilizer by the farmers of the United States.

A federal report echoed this sentiment, declaring that, "Man has passed through the bronze age, the iron age, and now is in the nitrogen age." The staff at the FNRL believed that they would serve the public interest by using synthetic

[10] *The United States Daily*, May 4, 1928, 5.

fertilizer to forge a path into a brave new world of abundant food and fiber. If conserving manure had been a priority among many USDA employees during the war effort, the research at the FNRL was evidence that the department was moving in a new, chemical-intensive direction. With the potential to effectively eliminate nitrogen deficiency, one of the greatest limits on crop production, Tolman and his staff believed that their work had the power to change the world.[11]

[11] On the Chemical Warfare Service, see, Russell, War and Nature; H.O. Bishop, "Greatest Chemical Research Laboratory on Western Hemisphere Is Located in the District of Columbia," *Washington Sunday Star*, Apr. 3, 1921; Nitrate Division, Ordnance Office, War Department, Report on the Fixation and Utilization of Nitrogen (Washington, DC: GPO, 1922), 201; Committee on Agriculture and Forestry, *Muscle Shoals: Hearings before the Committee on Agriculture and Forestry*, 67th Cong., Second sess. (May 6, 1922), 409.

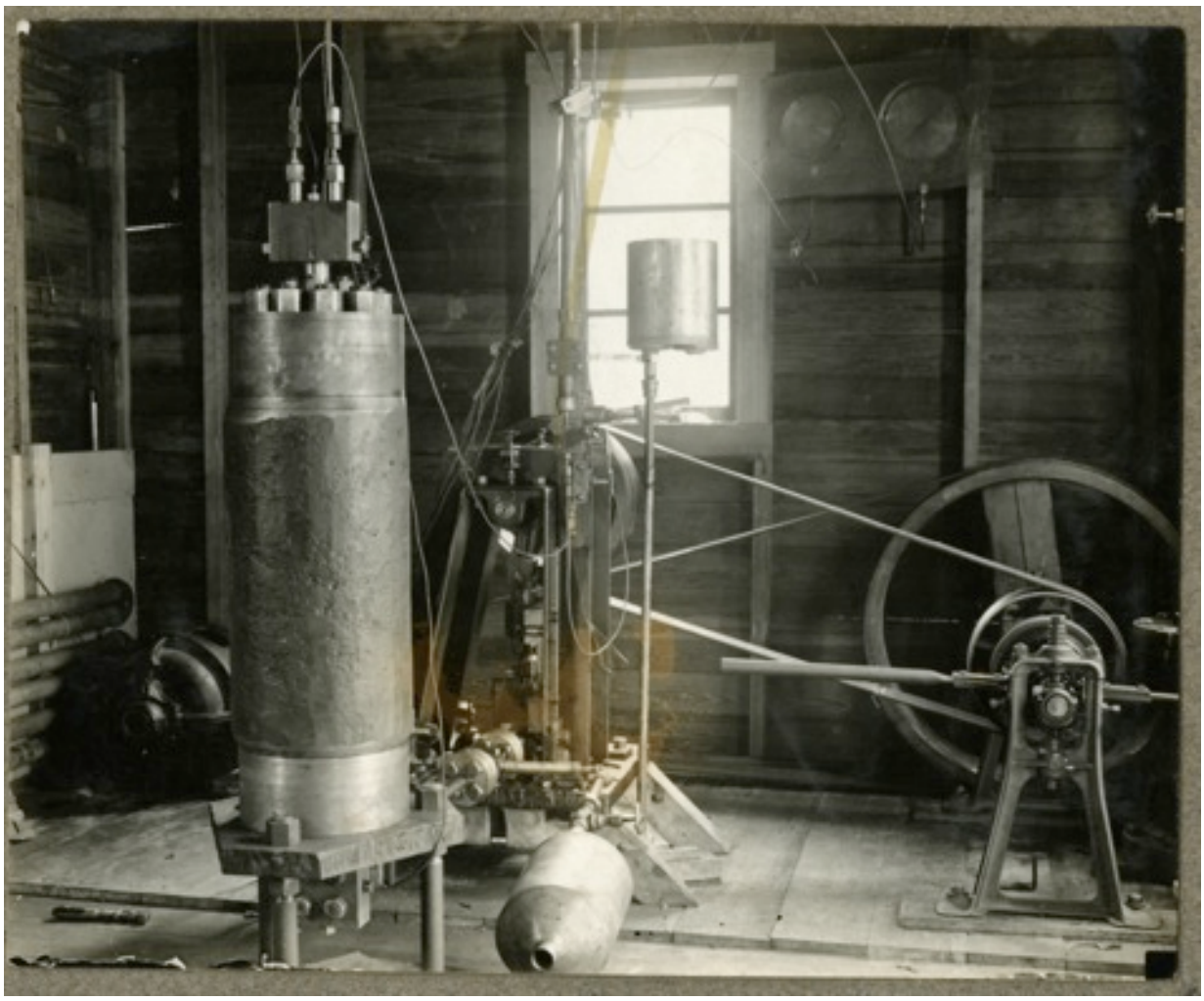

Figure 4.1 Cannon barrel fashioned into high-pressure tank, c. 1925. Swords to plowshares: Engineers from the FNRL fashioned this high-pressure gas tank from cannon barrels decommissioned after the World War. The *bricolage* of destructive materials put to use in pursuit of productive technologies captured the imagination of intellectuals and journalists who seized upon the imagery in techo-utopian narratives, as well as politicians who wanted to repurpose wartime facilities into the hub of new federal utilities projects. These discussions stoked expectations that public research would result in fertilizer subsidies during a period of severe agricultural depression. (Travis Hignett Collection, CHF)

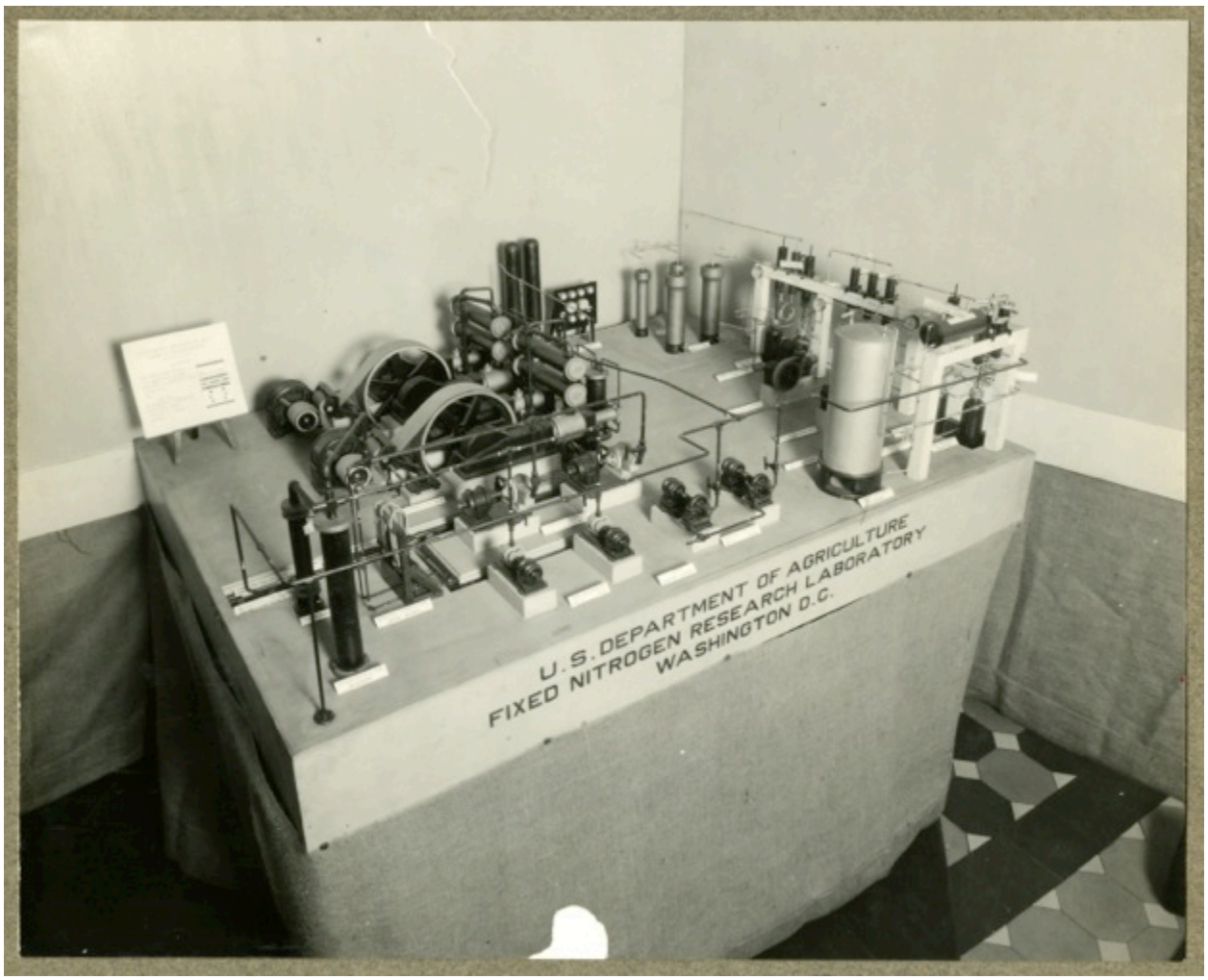

Figure 4.2. Model nitrogen synthesis plant, c. 1925. The FNRL produced model nitrogen synthesis plants with the intention of quickening the widespread adaptation of fixation technologies by American companies to compete with Germany. (Travis Hignett Collection, CHF)

Bringing America into the "nitrogen age" was no simple task. Even though the war was over, Tolman believed that America's military, industrial, and agricultural prospects were all riding on the success or failure of the Fixed Nitrogen Research Laboratory. After its abortive attempt to turn explosives into fertilizers in 1919, the FNRL began working in earnest to test known nitrogen fixation technologies, develop new ones, and to measure their cost and utility for

growing better crops. The laboratory staff hovered around eighty employees, and it operated on an annual budget of $300,000, or about $4 million in 2013 dollars. They also had the benefit of access to patents and trade secrets that had been seized from Germany during the war by the alien property custodian, A. Mitchell Palmer, who was better known for his controversial activities as attorney general. In Tolman's words, their mission was "furthering the nitrogen fixation industry of America," not only so the nation would become independent of Chile for mineral nitrates, but also to transcend Germany's more advanced chemical industry. Big money was on the line, so much so that Germany was able to pay a portion of its war debts with ammonia in the place of gold. With synthetic nitrogen fetching such a high premium, it was clear that mastering nitrogen fixation stood to benefit those who wielded its power. The close relationship between the FNRL and major American chemical engineering firms made it clear who would benefit.[12]

In the public sphere, many people still thought that the federal government itself, rather than fertilizer companies, would manufacture and deliver fertilizers to farmers. Throughout the 1920s Norris used his chairmanship of the Senate Committee of Agriculture and Forestry to try to ensure that the

[12] The most comprehensive discussion of the Fixed Nitrogen Research Laboratory is Margaret Jackson Clarke, "The Federal Government and the Fixed Nitrogen Industry, 1915-1926" (PhD diss., Oregon State University, 1976). The funding figure comes from 1925, a year in which the entire budget of the USDA was forty-four million dollars, see *Report of the Secretary of Agriculture* (Washington, DC: GPO, 1925), 98, the historical price calculations are based on the Consumer Price Index. The low figure is four million dollars, while a project cost of three hundred thousand dollars may actually be calculated as high as sixty-three million dollars according to http://www.measuringworth.com (accessed Dec. 4, 2014). Regarding the relationship between World War I and the American chemical industry, see, Kathryn Steen, *The American Synthetic Organic Chemicals Industry: War and Politics, 1910-1930* (Chapel Hill: University of North Carolina Press, 2014); on fertilizers for reparations, see, "Confidential Memo from Sec. of State to Sec. Of Agriculture," 15 May 1923, Box 984, "Fertilizers," entry 17, RG 16, NARAII.

massive federal expenditure in Alabama would directly serve American farmers. How, and whether the federal government would ever be able to make good on this prospect was difficult to say. Nevertheless, giddy reports in the press helped keep the dream of a federally owned and operated fertilizer plant alive. In 1925 *Popular Mechanics* called Muscle Shoals "the greatest hydraulic development in the world, and a task of engineering second only to the Panama Canal," that could create "fertilizing materials for the needs of almost any demand."[13]

In reality, however, by 1925 the staff of the FNRL had all but abandoned research on the hydro-powered cyanamid process, which produced fertilizer that did not perform well in field tests. Their research had focused on an improved version of the Haber ammonia synthesis process, a far more energy efficient technology that yielded more concentrated fertilizers. Researchers at the FNRL were especially successful in finding more effective and economical materials for catalysts in the fixation process. These new avenues of research effectively dissolved the connection between fertilizer production and hydropower among engineers, but politicians had sold hydropower as a key part of the federal plan to produce and sell cheap fertilizers. Farmers continued to buffet the secretary of agriculture's office with letters asking for fertilizer directly from the USDA as they thought was their right—especially as farmers struggled to purchase fertilizer during the grinding agricultural depression of the 1920s.[14]

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[13] "What Muscle Shoals Means," *Popular Mechanics* 42 (Aug. 1924): 293-96.
[14] *Report of the Secretary of Agriculture: 1925* (Washington, D.C.: Government Printing Office,1925), 70. Fertilizer consumption dropped more than two million tons between 1920 and 1921 because of poor credit conditions, according to Victor Murdock et al., *Report of the Federal Trade Commission on the Fertilizer Industry* (Washington, DC: GPO, 1923), 7.

The leadership of the Fixed Nitrogen Research Laboratory had a different vision of the public good, and the way they made good on this vision would have profound implications for US agriculture far beyond the 1920s. They decided to subsidize chemical companies, not farmers. The issue hinged on patents. Throughout his tenure at the FNRL, Tolman petitioned leadership in the War Department and the USDA to make it easy to share any and all breakthroughs they made with private companies, even to the extent that the government would provide cash incentives to companies along with patents. This was difficult when the laboratory was under the direction of the War Department, when much of the research of the FNRL was classified. In 1921, an executive order moved the FNRL from the War Department to the USDA; Tolman's wish was granted, and his employees began the work of retooling the way that American farmers would feed their plants for the foreseeable future. In a memo to the USDA Press Service, Tolman indicated that his staff was "in a position to advise with private industry," and that interested US companies would gain the benefit of "any information possessed by the Laboratory." As his researchers developed prototypes of the high-pressure tanks, gaskets, and catalysts used to convert compressed nitrogen into useful products, the small-scale work developed in the laboratory became large-scale industrial processes in private factories. This path toward democratizing technology operated under the assumption that private gain would automatically translate into public benefit. The USDA was open for business.[15]

[15] Richard Tolman to J. H. Burns, 9 February 1921, Box 1, "February 1921, entry 206 RG 54, NARA II"; Tolman to Arthur Linz, 21 June 1922, Box 2, "June 1922," entry 206, RG 54, NARA II"; Tolman to Press Service of the USDA, 24 April 1922, Box 2; Frederick Gardner Cottrell to A. H. White, 7 August 1922, Box 3, "August 1922," entry 206, RG 54, NARAII.

The free exchange of patents with private companies was not the only evidence of the close relationship between the FNRL and US chemical concerns. In many cases, the laboratory provided materials they had manufactured directly to the chemical industry, including large samples of experimental catalysts made at the lab, free of cost. Beyond that, the FNRL staff built a model ammonia production plant in Sheffield, Alabama, in 1924, which they shared with American chemical interests. The General Chemical Company—which had built the failed Nitrate Plant Number One during the war—adapted technologies from this model plant in their own facilities, and as a result became the largest producer of ammonia in the United States until World War II. That same year, staff from the FNRL walked the National Ammonia Company step-by-step through the construction of nitrogen synthesis plants in Seattle, Washington, and another plant run by the Midland Ammonia Company in Michigan. Building upon these successful models, in 1928 the Shell Oil Company broke ground on a plant in Pittsburgh, California that would be the first to successfully use natural gas as a feedstock for ammonia production creating a lasting connection between petroleum and food production that remains to this day. Tolman's plan had worked: research from the FNRL quickly proliferated and transformed the American nitrogen market by performing research that private industry had been either unwilling or unable to perform themselves. By the time it became part of the Chemical Division of the USDA in 1926, the short-lived FNRL had successfully distributed federal largesse based on experimental research that was both costly and publicly funded.[16]

[16] Tolman to Donald W. Kent, 25 January 1922, Box 2, "January 1922," entry 206, RG 54, NARA

The effort to share research findings so freely with large US corporations was not unique among federal agencies during and after World War I. The work of the FNRL was in keeping with what Ellis W. Hawley referred to as the "associative state" of the 1920s. Pioneered by Herbert Hoover's leadership of the Department of Commerce, state actors, including scientists, were expected to act as "enlightened bureaucrats" who served the public good by performing work that encouraged or directly served American businesses. Indeed, as in other departments, scientists who patented their research at the FNRL relinquished most of the profit that they might have accrued if they had developed technologies either individually or possibly in the research department of a large company. Tolman himself was a founding member of a consortium of scientists and academics known as the "Technical Alliance." A driving force in the burgeoning technocracy movement, the alliance sought to broker ties between professional engineers and organized labor. Even though directly passing the work of the FNRL to large industrial firms seems a bit incongruous with this project, the lab's approach made an impact. Thanks in large part to the free proliferation of FNRL research, importers of Chilean nitrates found themselves losing their share of the fertilizer market as mineral nitrogen was edged out by fixed nitrogen made in new chemical plants. Fixed nitrogen prices fell by 50 percent in 1925 alone—a savings that was passed to farmers buying fertilizer. The White House approved of this aid to private industry: Republican Presidents

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II; Clarke, "The American Fixed Nitrogen Industry," 160; L. F. Haber, *The Chemical Industry, 1900-1930: International Growth and Technological Change* (Oxford: Clarendon Press, 1971), 226; Adam D. Romero, "From Oil Well to Farm: Industrial Waste, Shell Oil, and the Petrochemical Turn," *Agricultural History* 90, no. 1 (2016): 70-93.

Coolidge and Hoover both vetoed bills that would have turned the Muscle Shoals site into a publicly owned fertilizer plant. Both presidents saw federal subsidies to fertilizer manufacturers as the most effective path to helping farmers.[17]

At the same time, the connections between federal employees and chemical engineering firms were so close that farmers felt that they had been left out of the process. The 1920s saw the proliferation of new technologies that promised to transform the agricultural sector in myriad ways, but as tractors, high-yield seeds, and more powerful fertilizers began to play a more expansive role on the American farm, most farmers did not see a commensurate increase in profits or quality of life as a result of the improvements. Furthermore, the corresponding rise in technical expertise required to develop these new agricultural technologies only served to widen the gulf between agricultural experts at the USDA and the farmers they were ostensibly supposed to serve. When a farmer from Clarks, Louisiana, wrote a letter to the FNRL inquiring as to how he might obtain nitrogen fixation techniques from the lab for his farmers' cooperative, Tolman could do little more than explain that the technical details of nitrogen fixation were far too complicated for regular farmers to grasp and much too expensive to take on. Surely, Tolman was not misleading the farmer with this statement. Fixing nitrogen was nothing if not a complex technical process understood by only a small cadre of experts in the 1920s. At the same time, the very fact that the inquiring farmer penned his letter to the FNRL underscores the

[17] Williams Haynes, *American Chemical Industry: The Merger Era* (New York: D. Van Nostrand, 1948), 85; Ellis W. Hawley, "Herbert Hoover, the Commerce Secretariat, and the Vision of an 'Associative State,' 1921-1928," *Journal of American History* 61 (June 1974): 116-140; Report of the Secretary of Agriculture: 1925, 70; Tolman to D. A. Macinnes, 25 February 1921, Box 1, "February 1921," entry 206, RG 54, NARA II. Members of the Technical Alliance included Thorstein Veblen, Frederick Ackerman, and many other prominent advocates of technocracy.

expectation that personnel at the USDA like Tolman ought to be servants to farmers first and corporations second.[18]

In the end, the fertilizer provision was only a small part of the National Defense Act, yet its effects were expansive. Because of the law and the creation of the FNRL, both in theory and in practice, by the mid-1920s the USDA had a mandate to promote chemical-intensive agriculture on the American farm. The USDA's Bureau of Chemistry helped manufacturers deliver more concentrated and effective plant foods after it absorbed the FNRL in 1926. In 1928 the *Report of the Secretary of Agriculture* included the following claim: "Operations of plant and animal life are chemical processes upon the control and stimulation of which agriculture is coming increasingly to depend. Every farm is a chemical factory." The fertilizer industry's mission of making chemical-input agriculture appear to be the only way forward for American farmers had finally won the imprimatur of the federal government. The fight over Muscle Shoals, however, was only the beginning of a renewed effort by the merchants of sprout to extend their influence from America's back roads to the halls of congress.[19]

Boundary Work: The National Fertilizer Association and the USDA in the 1920s

The incredible advances in fertilizer production during the 1920s often evoked utopian visions of agricultural abundance vanquishing hunger and—if

[18] On the connection between patent law and chemical engineering, see, David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977); Tolman to Joseph C. Fritchie, 25 March 1922, Box 2, FNRL, entry 206, RG 54, NARA II.
[19] *Report of the Secretary of Agriculture: 1928* (Washington, DC: GPO, 1928), 81.

idealists like George W. Norris had his way—creating a more free and democratic rural society. Yet there was an incredible gulf between the high-flying technics and ideology of the incipient chemical nutrient regime and life on the ground in rural America. The economic uncertainty of individual households also roiled the fertilizer industry as farmers were forced to cut costs, leading to decisions that collectively challenged the seemingly powerful momentum moving America towards the chemical nutrient regime. The expanded production and postwar glut had lowered crop prices and raised new questions about the economics of what had become an indispensible tool on farms across the South and, increasingly, in other regions. What role, exactly, would an industry that sold itself as a fuel of production play in an agricultural economy defined by overproduction? As an organization that prioritized market expansion, the National Fertilizer Association hoped that it would be an even larger one, even though the coming years would be fraught with uncertainty for farmers and fertilizer manufacturers alike.[20]

Fertilizer manufacturers had found opportunities for growth in the preceding years by cultivating new power and prestige in the wartime state. But the postwar climate presented a host of new challenges that led manufacturers to reassess their relationship with the agricultural state during the 1920s. Led by the National Fertilizer Association, they expanded upon their prewar program that targeted state actors to help pursue the industry's priorities. Aside from their assault on the Muscle Shoals plan, these activities included subverting the USDA

[20] Committee on Agriculture and Forestry, *Muscle Shoals: Hearings before the Committee on Agriculture and Forestry*, Sixty Seven Cong., Second sess., 1922, 417; Milton Whitney to Gray Silver, 1 April 1921, Box 2, "Misc. Correspondence and Papers," entry 201, RG 54, NARA II.

when it presented challenges, rewarding those in government who supported their objectives, and constructing the industry's own "shadow USDA" to perform and propagate flattering agricultural research and information. In turn, the geographically decentralized network of state agricultural workers offered local contacts that the NFA. With its agents dispersed farming communities across the country, the Cooperative Extension offered a new and especially valuable asset for the NFA's plans. And while law prohibited collusion between the Extension Service and private interests such as the National Fertilizer Association, county agents found it difficult to resist their influence and inducements.[21]

For its part, the depression set the USDA down new pathways in search of remedies for the ills of rural life, many of which targeted the fertilizer industry. The most persistent thorn in the side of fertilizer manufacturers came in the shape of a single individual, the Chief of the Bureau of Soils, Milton Whitney. During his career at the USDA that lasted from 1894 until 1927, Whitney occupied an impressively controversial role in the down-to-earth field of soil science. In particular, his unorthodox beliefs about the "permanency of soil fertility" led to a number of bitter professional disputes, leaving a trail of resentment among his employees and fellow scientists who bemoaned his dogmatic ideas and vindictive attitude to those who dared to question them.[22]

Whitney also had a longstanding grudge with fertilizer manufacturers, who he believed were bilking farmers like so many patent medicine drummers. In

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[21] Pete Daniel, *Breaking the Land: Transformations in Cotton, Tobacco, and Rice Cultures Since 1880* (Urbana: University of Illinois Press, 1985), 17.

[22] Paul Sutter, *Let Us Now Praise Famous Gullies*, 37-61 provides an excellent account of the politics of American soil science during this period.

contrast to the staff at the Fixed Nitrogen Research Laboratory who sought technical pathways to improving fertilizers, Whitney believed the government should wield its regulatory powers to usher in the chemical nutrient regime as a service to farmers. Whitney's commitment to reducing fertilizer prices for farmers was so great that he often admonished phosphate mine owners to slash wages for their already restive employees. He suggested as much at a meeting with fertilizer manufacturers in 1921, after of violent strikes in the Mulberry phosphate fields in Florida. Whitney wrote and doggedly promoted a national fertilizer law, modeled after the Pure Food and Drug Act. Such a law, he argued, would streamline the state-by-state patchwork of fertilizer regulations, standardize fertilizer formulas, and raise the nutritional content of fertilizer by setting federal guidelines. Accusing fertilizer manufacturers of selling farmers products diluted by inert fillers, he insisted that the fertilizer business was little more than "a scavenger industry" that needed to operate on "a strictly chemical basis."[23]

Some of the largest fertilizer producers, like the packinghouses Swift and Armour, were among the most sanguine supporters of his proposed law because a national law would mean an end to the Byzantine state-by-state regulatory regime, and also because their highly capitalized operations were best equipped to meet the law's guidelines. These details support the contention that regulation unintentionally provided competitive advantages to the largest firms. But

[23] The wartime fertilizer provisions of the Lever Food Control Law were not fully lifted until March 1921, and Whitney used his position as the main fertilizer license administrator to try to reshape the industry according to his own dictates for three years after the war; Milton Whitney, *Soils of the United States*, USDA Bulletin 55, 1909, 66-80; Committee on Agriculture and Forestry, *Muscle Shoals: Hearings before the Committee on Agriculture and Forestry*, Sixty Seven Cong., Second sess., 1922, 409.

Whitney's proposed law drew strong opposition not only among smaller fertilizer concerns, but also among state departments of agriculture in the South. Nine southern state commissioners of agriculture signed and circulated a full-throated denunciation of the proposed law on the basis that it would pinch out their fertilizer inspection revenue and because it was yet "another encroachment on our few remaining State rights." Because the states drew revenue from fertilizer inspection the proposal never gained legislative traction, and state-level regulations remain in effect to this day.[24]

In spite of Milton Whitney's efforts to overhaul the industry through regulation, fertilizer manufacturers avoided any strong regulatory challenges in the business friendly political climate of the 1920s. They did face another set of challenges from farm cooperatives. A 1923 FTC investigation cleared the industry of any major trade violations, with the glaring exception of the persistence of high-interest guano notes. The cost of fertilizer debt remained substantial problem for consumers across much of the South, but the FTC did identify the emergence of new cooperatives as a bright spot in an otherwise dim agricultural economy. Spanning back to the Grange and the Farmers' Alliance in the late nineteenth century, cooperative buying and selling arrangements were hardly a new trend among farmers. In California, the Fruit Growers Exchange had

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[24] A.G. Rice, "Fertilizer Control Bill Travel Report," 17 October 1924, Box 1, "Proposed National Fert. Law, Misc. Papers," entry 201, RG 54, NARA II; "Leaving the Borders Unprotected," *Oil, Paint & Drug Reporter*, June 13, 1921, 21; Summary of Whitney's conference with fertilizer manufacturers, 12 January 1921, Box 1, "Proposed National Fert. Law, Misc. Papers," entry 201, RG 54, NARA II. On the advantages of regulation for big businesses, see Gabriel Kolko, *Railroads and Regulation, 1877-1916* (Princeton: Princeton University Press, 1965); Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge: Harvard, 1977). "Circular of Southern State Departments of Agriculture in Opposition to National Fertilizer Law," RG 54, Box 1, NARA II.

demonstrated how well capitalized farmers could pool their resources to negotiate input prices and develop national markets. Farmers trying to organize cooperatives in the political economy of the Cotton Belt, on the other hand, still faced serious obstacles decades after the collapse of the Populist movement of the 1890s.[25]

In 1913, Charles J. Brand, a young physiologist at the Bureau of Plant Industry completed an extensive multistate study of cotton marketing and had pointed to California's citrus farmers as an example that cotton farmers in the South would do well to follow. Brand acknowledged that southern farmers were ensnared in prohibitive local conditions, and that they "share with too many middlemen profits that are rightly theirs." Lifting a plank straight off of the Populist Party platform, he recommended legislative action to protect cooperative buying and purchasing arrangements. In the years after the First World War, the expansion of the Cooperative Extension Service and the new American Farm Bureau Federation had nurtured cooperatives in other sections of the country. By purchasing large tonnages of goods in bulk, groups like the Grange League Federation Co-Operative of Ithaca, New York allowed its members to buy fertilizer, coal, seed, and other necessities at wholesale prices by "cutting out the middle man." The middlemen were not pleased, and ironically, Charles J. Brand had become their chief advocate. A longtime employee of the USDA who had gotten his start as an specialist in breeding legumes, Brand

[25] FTC, "Report of the Federal Trade Commission on the Fertilizer Industry," 1923; Postel, *The Populist Vision* (New York: Oxford University Press, 2007); Steven Stoll, *The Fruits of Natural Advantage: Making the Industrial Countryside in California* (Berkley: University of California Press, 1998); Woeste, *The Farmers' Benevolent Trust*), passim.

assumed the role of Executive Secretary of the National Fertilizer Association in 1926, making cooperatives one of his main targets.[26]

If Muscle Shoals represented the threat of being outmaneuvered by high-tech government competition for the largest fertilizer corporations, for local dealers and companies focused on regional markets, cooperative buying represented a threat from below. In the realm of local politics, organizing cooperatives signified much more than consumers looking for the best prices. In practice, cooperatives offered the promise of escaping guano notes, high credit prices, and even a reprieve from the often suffocating and sometimes oppressive dictates of merchants. Fertilizer dealers were almost always more than mere clerks: they were creditors, local power brokers, and sometimes, political bosses. What had been true in the post Civil War period remained true in the 1920s South—in local economies fertilizer was a node of power relations. Even though fertilizers were still advertised as a panacea, the expansion of local fertilizer companies and dealers had not upended local power structures, in fact, they had only helped cement them. As social scientist Frank Tannenbaum observed in 1924, "The creditor class dominates the rural community. They own the fertilizer-plants, the oil-mills, the banks, the warehouses. They dictate what shall be grown by whom. They are the politicians, and control the political destinies of the community." The idea of farmers muscling in on their business and cutting

[26] H.E. Babcock to G.L.F. Shareholders, 29 January 1924, Box 2, "Assorted 1924 Fertilizer Prices," RG 54, NARA II; Charles J. Brand, "Improved Methods of Handling and Marketing Cotton" in *Yearbook of the United States Department of Agriculture 1912* (Washington, D.C. GPO: 1913), 443-462.

merchants out of the equation was not something such men were going to abide.[27]

These local fertilizer dealers had strong allies in the National Fertilizer Association, which took up their case in Washington with a campaign to undermine cooperatives. Indeed, Charles J. Brand, knew exactly what a disruptive force that cooperatives could unleash in the Cotton Belt because he had studied and advocated on their behalf when he had worked at the USDA. As early as 1918, the Southern Extension Director, Bradford Knapp, started to receive reports from county agents complaining that fertilizer manufacturers charged special fees to farmers who tried to bypass local merchants through direct sales. The executive of the American Agricultural Chemical Company, Horace Bowker, defended the practice, asserting that fertilizer dealers deserved protection from cooperatives because of the services they provided and the risks they assumed by extending credit to farmers. Bowker rebuffed allegations that the NFA had an unofficial policy of discouraging cooperatives, which he dismissed as "loose gossip."[28]

If the National Fertilizer Association claimed to have no opposition to farmer cooperatives in public, it certainly worked to undermine them in private. The NFA responded to letters from local dealers who reported the names of any county agents they found organizing cooperatives or showing farmers ways to cut fertilizer costs. Armed with local intelligence, NFA operatives dispatched fiery missives to the Secretary of Agriculture and the Director of the Cooperative

[27] Frank Tannenbaum, *Darker Phases of the South* (New York: G.P. Putnam's Sons, 1924), 126.
[28] Horace Bowker to R.A. Pearson, 26 February 1918, Box 548, "Fertilizer Jan.-Feb.," entry 17, RG 16, NARA II.

Extension Service, threatening legal action, and singling out the offending agents by name. It was unacceptable, they complained, that public servants should interfere with private enterprise. This was the case in the winter of 1925 when the NFA received reports that agents in Alabama were helping farmers organize fertilizer cooperatives. In response to threats of legal action from the NFA, the Cooperative Extension Service Director Clyde Warburton sent a hasty telegram to the state director at Auburn University informing him that the USDA would withdraw funding from agents who did not immediately distance themselves from the co-ops. Yet when County Agents passed grievances to their superiors in Washington about unscrupulous fertilizer dealers, the NFA balked. In 1929, Clyde Warburton wrote to Charles Brand after receiving a complaint that merchants had charged steep credit prices to farmers even though they had paid with cash from USDA seed payments specifically intended to help them avoid the credit trap. Brand rebuffed the charge, denying that he had any relationship with local fertilizer dealers.[29]

[29] Telegram from L.N. Duncan to C.W. Warburton, 21 February 1925, Box 1125, "Fertilizer files re county agents," entry 17, 16, Box 1125, RG 16, NARA II; C.W. Warburton to L.N. Duncan, 23 February 1925.

Figure 4.3. Image of a county agent comparing cotton plant sizes with and without fertilizer in Greenville County, Virginia, c. 1925. The growth of the Cooperative Extension Service promised education and assistance to farmers, but the county agent quickly became a target of the fertilizer industry, either as a threat to industry priorities or as a prospect to be courted. (Bureau of Agricultural Economics, NARA II)

Figure 4.4. Nitrate Agencies Company Advertisement, 1929. Fertilizer advertising sometimes reflected some of the darkest stereotypes of the South, but it also hints that the seemingly revolutionary qualities of fertilizers would not revolutionize race and class relations—instead, they reinforced them. In this ad, the common racialized imagery of the period is overlaid with even more violent strains suggestive of the horrors of lynching. (Ephemera Collection, Duke)

The National Fertilizer Association's ongoing efforts to cultivate the growing USDA were not limited to pruning the unwanted branches. Like any good gardeners, they also offered assistance to train their plant and make sure it would grow in desirable ways. For many years, the NFA had offered agents and professors free passage to their annual conventions, as well as opportunities to speak at regional sales meetings. In 1925, the Southern Fertilizer Association merged with the NFA allowing the new organization to pool resources and ramp up its campaign to influence agricultural experts and farmers across the country—activities that now included funding fellowships at agricultural colleges. From the pages of *The Fertilizer* Review—the NFA's glossy monthly magazine that boasted a circulation exceeding two million in 1927—the organization promoted "Soil Improvement Contests." These competitions encouraged county agents and farmers to map out fertilization programs, particularly in new markets such as the Corn Belt. Participants in these contests were usually furnished with free fertilizer. The winners of the contests won all-expense paid trips and opportunities to speak at NFA conventions held at resort destinations. In 1929, Extension Director Clyde Warburton had seen enough. He wrote to Charles Brand complaining about the NFA's unscrupulous gifts of free fertilizer and trips to his agents, as well as the NFA's continuous complaints about the organization of cooperatives, home fertilizer mixing demonstrations, and their support of manure-application. He organized a meeting with manufacturers where he reiterated the illegality of government employees accepting gifts and prizes from private corporations. The boundary between private influence and

the state was expansive and difficult to police, and shrewd actors like the NFA were always on the lookout for weaknesses that could serve to advantage.[30]

Facing these setbacks, the NFA pursued other routes to expand their influence and open new markets. Realizing that the agricultural state could not be wholly relied upon to do their work for them, so fertilizer manufacturers redirected their attention to building their own "shadow USDA." Besides trying to influence public scientists, during the 1920s the NFA expanded their own agricultural research programs to arm themselves with favorable findings and statistics for public relations campaigns. Aping the techniques of federal demonstration programs, the largest fertilizer companies had their own experimental farms where they tested new products and advertised their products to local farmers. The American Agricultural Chemical Company credited these practices with helping win over large growers on the West Coast. The NFA's own research arm, the Soil Improvement Committee, grew considerably in the 1920s, boasting a larger staff of agronomists in its Chicago and Atlanta branches. Their stated research program was investigating improved application techniques, but their implicit aim was opening new markets. The Director of the Soil Improvement Committee, H.R. Smalley, believed that his research was so harmonious with the aims of the agricultural state that he submitted a formal request to the USDA asking for an annual $50,000 earmark to support the work

[30] H.R. Smalley to C.W. Warburton, 4 August 1925, Box 1126, "Fertilizer," entry 17, RG 16, NARA II; "Ten Years of Results Win 1927 Soil Contest," *The Fertilizer* Review (Vol. II, November 1927), 1; C.W. Warburton to Charles J. Brand, 8 March 1929, Box 1418, "Fertilizer," entry 17, RG 16, Box 1418, NARA II.

of his agency's own shadow USDA. The request was denied, but it was far from the last time that the industry would seek federal assistance.[31]

Notably, what would become one of the fertilizer industry's most lucrative new markets came of age during the 1920s on the "crabgrass frontier" of suburbia. In these rings of verdant tree-lined affluence gathering about the perimeters of American cities, new professional classes sought to distance themselves from the sights and smells of industrial capitalism. The staff at the *Fertilizer Review* understood the impulse to project affluence through the exterior of the family home when they ran an article asserting that, just like a handshake or one's clothes, the "Front Lawn Reflects Owner's Personality Same as Calling Card." They appealed to the insecurities of the upwardly mobile Babbitt by chiding the inconsiderate neighbor who dared to apply unseemly manure to a suburban yard. Doing so threatened to turn their neighborhood into a "cow-lot" and to lower one's status among his peers by staining one's trousers with unsanitary reminders of the organic nutrient regime. Manure was best left to "the wide open spaces," but fertilizer was tidy and inoffensive. Anticipating later attacks by the fertilizer industry against the suburban-centered organic movement, the NFA was shrewdly staking its claim in one of the fastest growing ecological landscapes in the United States: lawns.[32]

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[31] Haynes, *American Chemical Industry Volume IV*, 14; H.R. Smalley to A.F. Woods, March 28, 1929, Box 1418, "Fertilizer," entry 17, RG 16, NARA II.
[32] "Front Lawn Reflects Owner's Personality Same as Calling Card," *Fertilizer Review*, II (Feb. 1927), 2; Kenneth T. Jackson, *Crabgrass Frontier: The Suburbanization of the United States* (New York: Oxford University Press, 1985); on lawns and social anxiety see the excellent Paul Robbins, *Lawn People: How Grasses, Weeds, and Chemicals Make Us Who We Are* (Philadelphia: Temple University Press, 2007).

Affluence may have grown in and around American cities, but in the countryside depression dragged on into the fall of 1929 as politicians, economists, and rural sociologists worked desperately to answer questions about the nature of agricultural modernization and the persistence of economic stagnation. The stark contrast between the "productionists" and the "economists" were akin to a battle over the soul of agricultural modernization. As farmers' organizations contemplated the benefits of a cotton holiday and lawmakers weighed the benefits of various programs of farm relief, the fertilizer manufacturers could be counted among the most ardent productionists. None of their advertisements or trade materials implicated the fertilizer industry in agricultural overproduction in any way, although they occasionally argued that using fertilizer allowed farmers to retire eroded land, which served as a conservation measure. Instead they suggested that farmers should no longer think of fertilizer as a tool to maintain consistent soil fertility, but instead as a stimulant to increase fertility to keep pace with the nation's rapidly expanding industrial economy. In 1927 the *Fertilizer Review* warned that "The producing plant—be it a farm, factory or mine—which does not increase its output per unit, acre, man or horsepower—is standing still, or worse, going backward in the ever-intensifying competition of the modern day." If farms were factories, then they were overdue for a speed-up.[33]

In June of 1929, the stock brokerage of Hartshorne, Fales & CO. sent a letter to potential investors offering stock in the American Agricultural Chemical Company, which they regarded as "one of the best and most conservatively

[33] "The Old Order Changeth," *The Fertilizer Review* II (Apr. 1927), 1.

managed of American industrials, and certainly by all odds the best managed in the field." The inevitability and essential nature of the fertilizer market was their main selling point: "The fertilizer business is of so fundamental and basic a nature that the return to the country's 'normal' consumption of the Company's products is far more sure and certain" than that of other commodities. Indeed, "nothing can be more constant and certain than the demand for foodstuffs and agricultural commodities, and consequently for such commodities as assist in their economical production." The agricultural depression had, after all, been the first time in the fertilizer industry's history that had not seen continuous growth. With the rest of the American economy thriving, the fertilizer business was surely a conservative investment, indeed. Or perhaps not. In October, the stock market crashed, bringing the rest of the economy into a state of panic and turmoil that would initially destabilize and ultimately cement the chemicalization of American agriculture for the foreseeable future.[34]

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The years following the First World War were a study in contrasts. Farmers struggled against falling crop prices while those in cities enjoyed the benefits of a booming consumer economy. Amid the shifting economic terrain of the nation's political economy during the 1920s, the size and scope of the agricultural state grew in new, unanticipated ways. First and foremost among these, the incomplete wartime power and nitrogen fixation project at Muscle

[34] Hartshorne, Fales, and CO, 6 June 1929 in "Annual Report of the American Agricultural Chemical Company," CHF.

Shoals, Alabama became the flashpoint of debates about what role the government should play in providing fertilizer to American farms. During the war, lawmakers and bureaucrats came to terms with the vital importance of procuring reliable nutrient resources for the production of staple crops. Yet, by writing a federal commitment to fertilizer production into law, the National Defense Act created a legislative imperative to draw America into the chemical nutrient regime. As such, a law created for war preparedness inadvertently became one of the most significant pieces of agricultural—and by extension, environmental—legislation in American history, in spite of its relatively obscure origins.

Many lawmakers framed their decision to include the fertilizer provision in the National Defense Act as a type of subsidy to support American farmers at war's end, which drew interest among farmers and anger from fertilizer manufacturers. Enlivened by an offer from Henry Ford to lease the Muscle Shoals plants to manufacture cars and cheap fertilizer, the question of what would happen at Muscle Shoals became the subject of national interest after the war. Fertilizer companies banded together to reject Ford's bid, as well as plans by Progressive lawmakers to turn Muscle Shoals into the hub of a regional conservation agency. Outside of the frame of these animated discussions, scientists operating under the aegis of the National Defense Act in the Fixed Nitrogen Research Laboratory quietly investigated new processes to manufacture nitrogen compounds. Their plan was to determine the most efficient way to manufacture new nitrogen compounds that could be put to use once the debate over Muscle Shoals had been settled. Instead, the leadership at the laboratory

decided to share its discoveries freely with American chemical companies. Thus, the research performed by these scientists functioned as a subsidy for large firms rather than a fertilizer subsidy for farmers.

The 1920s also saw a changing relationship between fertilizer manufacturers and the agricultural state, which was growing in other ways as agencies such as the Cooperative Extension Service and the American Farm Bureau Federation began to form a newly significant political infrastructure that came in direct contact with rural Americans throughout the country. The National Fertilizer Association emerged as a powerful mouthpiece for the industry, as manufacturers wrestled with the challenges and benefits presented by the burgeoning farm bureaucracy. One challenge came from a renewed push from within the USDA to create a national fertilizer law that would have set minimum N-P-K values for fertilizer products, but state level fertilizer regulators were able to forestall the law. Another development that was particularly troublesome to small fertilizer concerns and local merchants was a new wave of farmer cooperatives, spurred on in large measure by extension agents. In retaliation, personnel from the NFA threatened legal action against the offending agents for trying to disrupt the trade of their members. The NFA intimidated transgressive agents, but also invented new ways of enticing and inducing cooperative agents to support their interests, enlisting them to help cultivate new fertilizer markets outside the Cotton Belt. Leadership from the USDA had to navigate alternating blows of reprisal and co-option at the hands of the fertilizer industry. The following chapter will discuss how these new relationships

progressed in the face of an unprecedented proliferation of government bureaucracy.

CHAPTER FIVE

SHADOWS OF THE AGRICULTURAL STATE, 1930-1946

For Charles J. Brand the New Deal began with fireworks. During the first 100 days of Franklin Delano Roosevelt's presidency, Secretary of Agriculture Henry A. Wallace tapped him and the farm relief advocate, George N. Peek, as his co-administrators to lead the new Agricultural Adjustment Administration. The choice of the nation's top fertilizer lobbyist in an agency tasked with curbing overproduction certainly raised eyebrows, but Brand had moved confidently between the USDA and the fertilizer industry since the Theodore Roosevelt administration when he got his start as an alfalfa breeder. By 1924 he had climbed the ranks to become a loyal advisor to Secretary of Agriculture Henry C. Wallace before assuming the leadership of the National Fertilizer Association in 1926. Yet in spite of its auspicious start, his relationship with the New Deal became complicated very quickly. For undisclosed reasons, he resigned from the Agricultural Adjustment Administration before the end of 1933. Worse yet, one morning in February 1939 G-Men arrived at his K Street office pursuing one of the largest antitrust investigations in American history. With marching orders from Roosevelt's lead antitrust attorney Thurman Arnold, the same day a small army of wool-suited federal agents descended upon the file cabinets of more than 100 fertilizer manufacturers. This was the most dramatic scene of a multiyear Federal Trade Commission investigation of violations that included price fixing, price discrimination against farmer cooperatives, improperly influencing

government officials, and predatory lending practices such as guano notes—the same predatory contracts used by southern fertilizer merchants since Reconstruction.[1]

After an exhaustive investigation and a mountain of indictments many companies pled no contest, and a few—including the National Fertilizer Association—went to trial and paid fines amounting to about $260,000 industry-wide. These penalties were light considering the gravity of the charges leveled against fertilizer companies by the Justice Department. In fact, by 1941 Roosevelt had brought his regulatory enforcers to heel because heavy industries like those producing nitrogen for farms and arms needed space to help build Roosevelt's Arsenal of Democracy. The war sheltered the fertilizer industry from serious penalties, but Charles Brand still felt betrayed. It wasn't just the antitrust investigation that had made the New Deal years difficult for the businesses Brand represented. The government was targeting them in other ways. The editor of the *Fertilizer Review* lamented that the federal agencies had distributed nearly 500,000 tons of its own concentrated superphosphate in 1940 for free—some 5 percent of the year's total fertilizer tonnage. Even after the war, when the government was pivoting away from public enterprise and procuring materials almost exclusively through private contractors, there were fresh congressional efforts to build new publicly owned fertilizer factories and to subsidize fertilizer

[1] "C.J. Brand Quits Farm Act Post," *New York Times*, Oct. 19, 1933; "Brand Quits Jardine," *New York Times*, Jun. 14, 1925, 2; Brand, "Experiences of a Trade Association in an Antitrust Suit," *Journal of Marketing* 7, no. 3 (1943): 227-233. On New Deal trade policy, see Ellis W. Hawley, *The New Deal and the Problem of Monopoly: A Study of Economic Ambivalence* (Princeton: Princeton University Press, 1966), esp. 440-441.

on a national scale. Fertilizer manufacturers felt as though they were being singled out.[2]

This chapter examines the negotiations between fertilizer manufacturers, the agricultural state, and farmers through depression and war. As a period of "bold, persistent experimentation," the New Deal's ferment of complex and often contradictory policies created opportunities and challenges for fertilizer manufacturers. Three letters in particular floated to the top of the New Deal's alphabet soup that made them lose their appetite: TVA. The first section of this chapter discusses how the Tennessee Valley Authority's ambitious, but largely forgotten, fertilizer program helped normalize chemical-fueled agriculture far beyond the confines of the valley through its "test-demonstration program." Fertilizer manufacturers also benefited from federal research and development, and, with war, they profited from the resurgence of the farms and arms feedback loop that transferred government arms plants to fertilizer manufacturers for pennies on the dollar. Fearing government encroachment, however, the National Fertilizer Association regarded state-led fertilizer programs with tremendous suspicion. The lobby responded by expanding its research and education work, spending greater amounts to target and influence the New Deal's multiplying legions of agricultural experts and bureaucrats. Drawing on their research activities, the NFA's public relations department turned to new media outlets to sell products and shape practices across the country. This included new efforts to reach out to farm youth with materials targeting 4-H Clubs.

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[2] "Government Distribution of Fertilizer," *The Fertilizer Review*, April 1941, 4; on public enterprise and procurement see Mark R. Wilson, *Destructive Creation: American Business and the Winning of World War II* (Philadelphia: University of Pennsylvania Press, 2016).

The volley of punches and counterpunches between state and business had profound repercussions, but they also draw attention away from deeper structural transformations that pushed the entire American agricultural economy into the chemical nutrient regime during this period. Large chemical companies began to take advantage of advanced fertilizer production technologies and government largesse to become industrial juggernauts. Farmer cooperatives that did business through wholesale chemical purchases began to replace local merchants, as a parallel restructuring saw well-capitalized farmers began to take the place of tenants and smallholders, especially in the South. The year before Roosevelt took office, fertilizer sales had fallen to a thirty-year low. By 1949, that amount had quadrupled and America's agricultural soils were saturated with more—and thanks to federal spending, more powerful—fertilizers than ever. The perfection of new hybrid seed corn, in particular, made fertilizer uptake more efficient in this key crop at the very moment when demand for corn as livestock feed shot up sharply to supply meat for the war effort. As the economy began to improve after the war, meat became a more significant part of the American diet and the combination of new seed varieties and new agro-chemicals supplied the demand. The restructuring of the nutrient economy that made these changes possible had roots reaching back to the National Defense Act of 1916, and even before.[3]

This restructuring of the nation's nutrient supply chains occasioned a restructuring within the fertilizer industry. Since the earliest days of the fertilizer

[3] Alan L. Olmstead and Paul W. Rhode, "Fertilizer—farmers' expenditures, commercial fertilizer consumption, and liming materials used: 1850-1999," *Historical Statistics of the United States*, Millennial Edition Online. Amount noted is by fertilizer tonnage: 4.3 million tons in 1932 and 18.5 million in 1949.

trade associations, manufacturers had formed their own research and propaganda programs with the explicit aim of opening new markets in the Midwest and other areas outside of the cotton and tobacco regions. These activities continued during the New Deal period, but it quickly became clear that the small, regional fertilizer manufacturers and mixers that had supported the production of inedible staples lacked the capital and agility to take advantage of the new markets they had pursued for so long. Tethered to local markets and outdated production facilities, it became impossible for most southern firms to compete with the high-tech petro-chemical conglomerates that were best equipped to excel in the postwar economy. By the end of the 1940s, fertilizer use had spread to every major agricultural region of the country. This should have been cause for celebration at the National Fertilizer Association. Instead, it left behind the sector of the industry that had once served as conduits of minerals and byproducts and creditors to sharecroppers and tenants. Crossroads fertilizer warehouses and mixers that stood alongside cotton gins as monuments to local powerbrokers shuttered their doors, and their greatest champion in Washington, Charles Brand, found himself out of the job.

Feeding Like a State: The Tennessee Valley Authority and New Deal Fertilizer Policy

Fresh out of Harvard and on assignment for *Fortune* magazine, in 1933 the young journalist James Agee returned to his native Tennessee to report on a notable new arrival in his homeland. In May of that year, Franklin D. Roosevelt had broken with his Republican predecessors who had vetoed two separate

Muscle Shoals bills and signed the Tennessee Valley Authority Act. It signaled a new commitment to regional planning shaped by the decade-long debate about the government's Muscle Shoals facilities, including the Wilson Dam. The law went far beyond earlier plans to repurpose the Muscle Shoals site, and now included an even more expansive vision, influenced by Giant Power progressives like George W. Norris, Lewis Mumford, and the conservation-minded New York governor-turned-president. Since his days as governor Roosevelt embraced "New Conservation," an evolution of the Progressive conservation of Theodore Roosevelt and Gifford Pinchot. This philosophy revolved around a belief that public power ownership could serve small farmers and help them adapt soil conservation practices. For them, the Tennessee Valley would be a test of their vision. As Agee reported, the project's aims were many, ambitious, and varied:

> To regulate river flow. To develop navigation to a maximum. To eliminate flood. To develop and use electric power as a yardstick to gauge the practices of private power companies. To distribute as much power as possible as cheaply as possible to as many people as possible. To try to develop cheap fertilizers. To control soil erosion. To classify and improve the soil and put it to its best uses. To promote better farming methods. To conserve the forests. To develop all resources in the valley in good relation to one another.

As Agee traveled the valley he discovered just how ambitious the aims and scope of the Tennessee Valley Authority were during its heady early days as its visionaries surveyed the valley with a "Utopian gleam" in their eyes. Agee was careful to qualify his own optimism about the agency to note that the whole undertaking had an air of overconfidence about it. As he noted, these same

visionaries had "swung a bold foot through the beehive of problems both practical and ethical."[4]

Agee took note of the Tennessee Valley's phosphate beds playing a role in the program, but as with many others who have documented the TVA, in his account the Herculean tasks of dam construction and electrification overshadowed the project's fertilizer component. In spite of the relative lack of attention it has received, the Tennessee Valley Authority's fertilizer program was one of its most far-reaching projects. The program not only researched and manufactured new fertilizer products, but it also distributed them to farmers as part of a soil conservation and flood-prevention policy. Yet while the program's staff tried to inculcate new approaches to farming in the region, its lasting legacy was that it introduced new, concentrated fertilizers to farmers who had not used them before. Many of the TVA's conservation programs would disappear, but the reliance on fertilizer it helped bring to new farming regions would not.

In 1933, however, the shape the Tennessee Valley Authority would take was still open to question. Fastened to the legacy of the 1916 National Defense Act in Muscle Shoals and still tasked with the duty to supply the nation's wartime needs, the TVA law introduced broader plans to remake this benighted region in the heart of the South, but on the edge of the Cotton Belt. The Tennessee Valley

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[4] James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have* Failed (New Haven: Yale University Press, 1998), 4. Scott details the "administrative ordering of nature and society." Hubbard, *Origins of the TVA* (see chap 4, n. 3). Coolidge and Hoover each vetoed bills that would have expanded public power and fertilizer production in Muscle Shoals in 1928 and 1931, respectively. James Agee, "Where Did the Tennessee Valley Authority Come From?," *Fortune* (Oct. 1933). http://fortune.com/2013/04/14/where-did-the-tennessee-valley-authority-come-from-fortune-1933/. Sarah T. Phillips, *This Land, This Nation: Conservation, Rural America, and the New Deal* (New York: Cambridge University Press, 2007). Jack Neely, "The Great Experiment," tva.com, accessed July 1, 2016, http://152.87.4.98/heritage/experiment/index.htm. Neely provides a useful overview of Agee's reporting on the TVA.

was an especially impoverished and isolated region, prone to devastating floods and well outside the main currents of the national economy. Early TVA surveys found some farmers subsisting on less than $150 a year, and others living in tents without any cash income at all. Corn and cotton production had spread through much of the Valley along with fertilizer use, which had helped maintain steady yields but at a heavy cost. Farmers in the northwestern Alabama paid some $1.8 million for fertilizer in 1930, yet their yields for cotton and corn were only slightly better than they had been fifty years before. To remedy the causes of this privation, the agency's leadership set out to bring the valley into the national economy by transforming it into a bastion of conservation-minded smallholders, the world's most extensive hydroelectric system, and a template for similar developments around the globe. It was well intentioned, boundlessly hopeful and ambitious, concerned with engineering both mechanical and social, and complex to the point of contradiction. The seemingly bifurcated vision of agency's leadership encapsulates the inner tensions between its commitment to grass roots community organization and muscular state-led planning.[5]

Arthur E. Morgan and David E. Lilienthal embodied these conflicting ideologies of the Tennessee Valley Authority. A.E. Morgan's commitment to

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[5] Gilbert Fite, *Cotton Fields No More: Southern Agriculture, 1865-1980* (Lexington: The University Press of Kentucky, 1984), 149; Matthew L. Downs, *Transforming the South: Federal Development in the Tennessee Valley, 1915-1960* (Baton Rouge, Louisiana State University Press, 2014), 18. On the leadership and vision of the TVA see Philip Selznick, *TVA and the Grass Roots*; Walter L. Creese, *TVA's Public Planning: The Vision, the Reality* (Knoxville: University of Tennessee Press, 1990); Jordan A. Schwarz, *The New Dealers: Power Politics in the Age of Roosevelt* (New York: Alfred A. Knopf, 1993), esp. 196; Erwin C. Hargrove, *Prisoners of Myth: The Leadership of the Tennessee Valley Authority, 1933-1990* (Princeton: Princeton University Press, 1994); David Ekbladh,"Mr. TVA: 'Grass-Roots' Development, David Lilienthal, and the Rise and Fall of the Tennessee Valley Authority as a Symbol for U.S. Overseas Development, 1933-1973," *Diplomatic History* 26, no. 3 (2002): 335.

building small community support for developing the valley could not have been more different than Lilienthal's embrace of "high modernist social engineering." Although Morgan was an engineer, he envisioned decentralized, community-based initiatives that were informed by the needs and desires of the people. For his part, Lilienthal was content imagining the people's needs himself, even to the extent that he literally assumed their voice in publications. Less concerned with individual communities, Lilienthal wanted to help the region as a whole, by taking on utility companies and bringing publicly owned power to the people. Rather than decentralizing the Tennessee Valley, he wanted to integrate in the national economy. The tension between the two was so great that Lilienthal oversaw Arthur E. Morgan's removal from the agency in 1938. One of TVA's most incisive observers, Philip Selznick, went as far as to characterize the ouster as an act of *gleichschaltung*—the Nazi term for eliminating dissenters and normalizing political ideology.[6]

If this famous antagonism illustrates a tension about the agency's problems and even those of the New Deal more generally, it elides the central role of the third member of the agency's triumverate: Harcourt A. Morgan. H.A. Morgan was the architect of the TVA's expansive fertilizer programs, which reached farmers not just in the Tennessee Valley, but eventually throughout rural areas of the entire country. While scholars have obsessed over the dramatic clash

[6] Daniel Immerwahr, *Thinking Small: The United States and the Lure of Community Development* (Cambridge: Harvard University Press, 2015), 42-46; Selznick, *TVA and the Grass Roots*, 99. For an example of Lilienthal's voice and philosophy, see David Lilienthal, *TVA: Democracy on the March* (New York: Harper & Brothers Publishers, 1944). On A.E, Morgan, see Aaron Purcell, *Arthur Morgan: A Progressive Vision for American Reform* (Knoxville: University of Tennessee Press, 2014). On Lilienthal, see Steven Neuse, *David E. Lilienthal: Journey of an American Liberal* (Knoxville: University of Tennessee Press, 1997).

between his counterparts, they have done so at the expense of understanding H.A. Morgan's role as a powerbroker in the agency, whose influence arguably had the greatest impact on the agency's operations. Between the top down and bottom up approaches of his counterparts, H.A. Morgan occupied a middle ground. A Canadian-turned-Tennessean, Morgan was trained as an entomologist and had worked in the University of Tennessee's School of Agriculture until 1919 when he was appointed as the school's president. Morgan worked at the university's experiment station and had helped nurture the growing agricultural extension program during the '20s. As such, he was convinced that the decentralized structure of the agricultural state that he had helped build provided a ready-made lifeline between communities on the ground and the Tennessee Valley Authority's high-flying ambitions.[7]

According to Harcourt A. Morgan's vision, county agents would work with his TVA operatives and set up demonstration farms where community members could implement conservation practices. These demonstrations would serve as examples for more recalcitrant neighbors. Morgan's brand of conservation was informed by his work as an entomologist, and he thought in ecological terms not just about nature, but also about the human role within it. He called his philosophy "The Common Mooring"—a loosely defined concept that stressed diversity and interconnectedness between people, water, plants, and animals. Lilienthal paraphrased the idea succinctly when he wrote that, "what happens to

[7] For an example of scholarship that focuses on the personal differences between A.E. Morgan and Lilienthal, see Thomas K. McGraw, *Morgan vs. Lilienthal: The Feud within the TVA* (Chicago: Loyola University Press, 1970); "Statement of H.A. Morgan Respecting the Status of the Agricultural and Fertilizer Program of the Tennessee Valley Authority," 25 June 1935, Box 2253, entry 17, RG 16, NARA II.

the forests, the land, and the water determines what happens to the people." In practice, Morgan emphasized a set of agricultural methods inherited from permanent agriculture prophet Cyril Hopkins, who argued that a combination of phosphate, lime, and leguminous cover crops—like alfalfa, lespedeza, or red clover—offered a cheap alternative to commercial fertilizer that made the land productive as well as healthy. In short, Morgan became the champion of the TVA's soil fertility program.[8]

Unlike Lilienthal's well-documented ambition to take on power companies, Morgan never intended to use the fertilizer program to directly challenge the fertilizer industry. The agency's guiding legislation gave it the authority to expand fertilizer production however it saw fit, whether through its own facilities or with private contractors. But neither FDR nor H.A. Morgan was interested in a trade war with the fertilizer industry, and they decided not to focus on large-scale nitrogen fixation. This decision dashed the farm lobby's goal to obtain legislative assurance of continued federal nitrogen production during the Muscle Shoals debate of the previous ten years. Instead, Morgan wanted fertilizer to be just one piece of a comprehensive conservation program focused on erosion prevention and farm self-sufficiency. H.A. Morgan planned to research, mine, manufacture, and distribute fertilizers. But these activities were all intended to serve the broader aim of enrolling local farmers as participants in the agency's conservation priorities, rather than "taking on the fertilizer trust" as the farm

[8] Lilienthal, *TVA: Democracy on the March*, 2; Norman Wengert, "The Land: TVA: And the Fertilizer Industry," Land Economics 25, no. 1 (1949): 11-21. On the connections between agricultural science and the emergence of ecology, see Mark D. Hersey, "'What We Need Is a Crop Ecologist': Ecology as an Agricultural Science in Progressive Era America," Agricultural History 85 (Summer 2011): 297-321.

lobby still hoped to do. Whatever the case, the prospect of any sort of fertilizer subsidy got the attention of farmers, as well as that of the fertilizer lobby.[9]

After two years setting up its fertilizer laboratory and production facilities, in 1935 the Tennessee Valley Authority launched its test-demonstration program, one of its most far-reaching initiatives and the core of its agricultural program. The program had two specific aims. The "demonstration" component was modeled after the extension pioneer Seaman Knapp's demonstration farms. The "test" component delineated the program's intention to gauge both their agronomic and economic value of the TVA's new fertilizer products. To implement the project, TVA personnel relied on county agents from the Cooperative Extension Service to organize meetings in which local farmers elected a community member to serve as the demonstration farmer. The farmer served a five-year stint during which the agent helped the farmer eliminate erosion and plant cover crops with TVA phosphate and lime. The TVA wanted to steer farmers away from row crops like cotton and corn and promote livestock raised on alfalfa pasturage. Foreswearing row crops would allow farmers to conserve soil and help them escape the fertilizer credit trap. To help improve pasturage, farmers paid the shipping costs for TVA fertilizer, a fact that the agency's publications and staff emphasized to suggest that it was not a direct subsidy. This arrangement was in keeping with the broader New Deal objective to

[9] Selznick, *TVA and the Grassroots*, 93. In this chapter, unless an explicit reference is made to a specific farmers' organization, the term "farm lobby" includes the American Farm Bureau Association, the Farmers' Union, and the Farmers' Holiday Association all of which supported government fertilizer production and subsidies, even though they disagreed significantly about other policies.

avoid "the dole" to foster participant pride, but it was also intended to try to inoculate the program against criticism from the fertilizer industry.[10]

If the program failed to live up to its precise mission, measured by the extent of its impact the test-demonstration program was a smashing success. By 1943 demonstration farms represented one out of every fifty farms in the valley counties in Tennessee, with more than 27,000 farms participating altogether. The agency had more than 200 paid employees performing fertilizer-related activities, ranging from laboratory technicians in Muscle Shoals to demonstration workers operating out of county agent offices around the South. Beginning in 1937, the Tennessee Valley Authority also began to collaborate with the Agricultural Adjustment Administration's Agricultural Conservation Program and the Soil Conservation Service, and they began to distribute TVA superphosphate across most of the nation. These conservation programs were modeled on the test-demonstration program, and served as a workaround for the regional limitations set by the TVA legislation. Between 1936 and 1945, the TVA distributed on average one million tons of fertilizer a year, and their factories struggled to keep pace with demand.[11]

It is no surprise that the program was so popular. On average farmers got $50 worth of fertilizer that was far more powerful than anything they had ever used, and it came free of interest. The fertilizer operated as an incentive, and many farmers were glad to get opportunities to upgrade their farms and be part of a new and dynamic government initiative. During the Joint Congressional

[10] Ibid, 124; H.A. Morgan Agriculture and Fertilizer Statement, 1935.
[11] Selznick, 95, 123; John R. Commons, "What I Saw in the Tennessee Valley," May, 1938, clipping in George Norris Papers, Box 559, LoC; H.A. Morgan to Henry A. Wallace, 17 March 1938, Box 2875, "Fertilizer," entry 17, RG 16, NARA II.

Inquiry of the TVA in 1938 instigated by A.E. Morgan's grievances with Lilienthal, the leadership touted the test-demonstration program as one of the agency's great successes. The program's reliance on public outreach and local control was a rebuke to A.E. Morgan's insistence that the agency had disengaged with communities. It served as evidence that H.A. Morgan had made a successful gambit. The familiar face of county agents helped draw communities into a warm embrace with the agricultural state. For many farmers, fertilizer was the first real and tangible evidence of the New Deal, long before TVA-generated power brought electricity to their homes.[12]

This characterization of the Tennessee Valley Authority's grassroots triumph may have satisfied a joint congressional inquiry, but it did not placate a young sociologist studying the TVA for his dissertation research. In 1942, Philip Selznick travelled south from Columbia University with a grant from the Social Science Research Council to study TVA's administrative structure, especially its paradoxical combination of large-scale planning and participatory democracy. Unlike most other students of the TVA who focused on its power activities, Selznick identified the agricultural program as the heart of the agency's activities and its largest concentration of personnel. Through dogged inquiry Selznick cut through the rhetoric and diagnosed that the agency's main weakness was the very thing that it heralded as its greatest success— its commitment to grass roots community engagement. HA Morgan's empowerment of certain local actors and reliance upon existing administrative networks such as the Extension Service

[12] *Hearings Before the Joint Committee on the TVA Investigation* 19-9 (Washington, D.C.: Government Printing Office, 1939); *Report of the Joint Committee Investigating the Tennessee Valley Authority* (Washington, D.C.: government Printing Office, 1939), 207-225, 56-58.

helped reinforce the inequitable power structures of those selfsame roots. It became clear that the administration—so uplifting in outlook and rhetoric—made the calculation that the program would only succeed if it did not challenge the local mores and power relations of the region. As a result black and poor white farmers were left to wither while well-connected white farmers accumulated benefits. The prejudices of the grass roots ensured that black farmers were unmoored from the promise of Morgan's ostensibly democratic vision. They could perhaps observe the progress of a subsidized test-demonstration farm, but barring very special circumstances, they could not operate one. On paper, the TVA was committed to hiring and supporting black employees and serving Valley's black citizens equally. The 1938 congressional inquiry noted that TVA believed "the customs of the community cannot be disregarded." And so black farmers, doubly excluded by race and high tenancy rates, were not envisioned as citizens in the valley of the present or the "valley of tomorrow."[13]

One of the more conservative forces in TVA was John C. McAmis, head of the Agricultural Relations Department and major powerbroker within the organization. A self-described "native hillbilly of east Tennessee," McAmis was a stalwart of the University of Tennessee's extension program and a close ally of H.A. Morgan with an especially high regard for "the customs of the community." And while he was perhaps the greatest champion of the phosphate and pasture program, like his agricultural lodestar, Cyril G. Hopkins, his view of race relations was considerably less progressive than his ideas about agriculture. McAmis was

[13] Selznick, 103. On TVA's race relations, see Nancy L. Grant, *TVA and Black Americans: Planning for the Status Quo* (Philadelphia: Temple University Press, 1990).

committed to maintaining local power structures and was extremely territorial about preventing outside encroachment on the TVA's agricultural programs. At a congressional inquiry in 1938, a senator asked why the TVA was not concerned with the economics of tenancy after the fashion of the Farm Security Administration, which approached the problem of rural dispossession on an intimate community level. McAmis dismissed the agency for micromanaging people's lives. He also opposed farm cooperatives. At a 1943 TVA board meeting, David Lilienthal asked McAmis what steps he was taking to help encourage farmer cooperatives in the Valley. Having recently examined the success of California's farm cooperatives, Lilienthal suggested that as a forward-looking agency, the TVA should be helping the area's farmers compete in a modern agricultural economy. McAmis had no such plans, although, the following year the test-demonstration distributed fertilizers to cooperatives for the very first time. Without any serious interest in challenging the structural inequalities in the region, McAmis epitomized the flaws of TVA's grassroots structure.[14]

Like so many other New Deal agricultural policies, the Tennessee Valley Authority's agricultural programs had the tendency to benefit the well-connected farmers and sideline those marginalized by race, poverty, and local politics. The destabilizing effects of the Agricultural Adjustment Administration's acreage reduction program, for example, allowed landowners to retire land occupied by tenants and sharecroppers, leading to waves of displacement and the loss of livelihood for many poor farmers. AAA crop reduction payments created

[14] *Report of the Joint Committee,* 56-58; *Phosphate Resources of the United States* 75 Cong., Third sess., 1939, 651, 662; Selznick, 106, 110.

incentives for farmers to invest in new machinery and more fertilizer for the acres they kept planted. On top of this, some of the same prominent farmers who benefited from AAA were also the most likely to receive TVA fertilizer, seed payments, and other federal grants-in-aid. Although the language of the legislation and the spirit of the policy made uplift of the downtrodden a central goal, in practice it left the most destitute and needy farmers in the cold. By offering generous fertilizer subsidies, the TVA made astounding inroads into local communities in short order. Certainly the infusion of plant food and new ideas was intended to revitalize rural communities, but in the process these shipments of phosphate and lime only helped calcify the same, stubborn problems that had beset rural America long before the New Deal.[15]

The test-demonstration program also fell short of its ambitious conservation objectives. To be certain, the program helped limit erosion, but it is difficult to argue that the agency was able to transform the Tennessee Valley into a shining example of conservation agriculture. Extension agents were great at pitching new ideas to farmers, but they were often not equipped with the resources, time, or training to oversee their enactment. They were often not properly trained to gauge the economic and agronomic success of the fertilizers that the "test" portion of the program required, and since they were not

[15] The unwritten but widespread race and class biases of New Deal agricultural policies are well documented. See esp. James C. Cobb, *The Most Southern Place on Earth,* 185-204; Gladys Baker, *The County Agent* (Chicago: University of Chicago Press, 1939); Pete Daniel, *Breaking the Land: The Transformation of Cotton, Tobacco and Rice Cultures since 1880* (Urbana: University of Illinois Press, 1985); Idem, *Dispossession: Discrimination Against African American Farmers in the Age of Civil Rights* (Chapel Hill: University of North Carolina Press, 2013); Jack Temple Kirby, *Rural Worlds Lost: The American South, 1920-1960* (Baton Rouge: Louisiana State University Press, 1987); Jason Manthorne, "The View from the Cotton: Reconsidering the Southern Tenant Farmers' Union," *Agricultural History* 84, no. 1 (2010): 20-45.

employees of the TVA they neglected this mandate. And because the program was so large and geographically extensive, the TVA lacked the resources to be certain that the exacting conservation practices of the program were being met. One thing, however, was certain: more farmers who had never before used fertilizer became accustomed to using it. In the coming years, the TVA's ambitious attempt to oversee and implement conservation practices would fade away but fertilizer consumption would not.[16]

The Tennessee Valley Authority survived a federal investigation, and would go on to play a strategic role in the war effort and even serve as a model for international development schemes. It was not, however, so successful a model that it became a template for other parts of the country. In 1937, longtime regional planning champion George Norris introduced a bill in the Senate that would have created seven additional TVA-style conservation authorities for other major watersheds across the country, but the bill never passed. The agency's territorial commitment to doing things its own way had alienated lawmakers and other New Deal programs that could have helped the TVA live up to its stated commitments to conservation and advocacy for smallholders. Thanks to broad opposition many different quarters, a national multiplication of the TVA was at least temporarily on hold. Congress did approve a new power authority on the Columbia River watershed, but its activities were nowhere near as wide-ranging and ambitious as TVA.[17]

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[16] Selznick, 124.
[17] George W. Norris, "A Bill to Provide for the Creation of Conservation Authorities," Norris Papers, Box 412, Conservation Authorities, 1937, LoC.

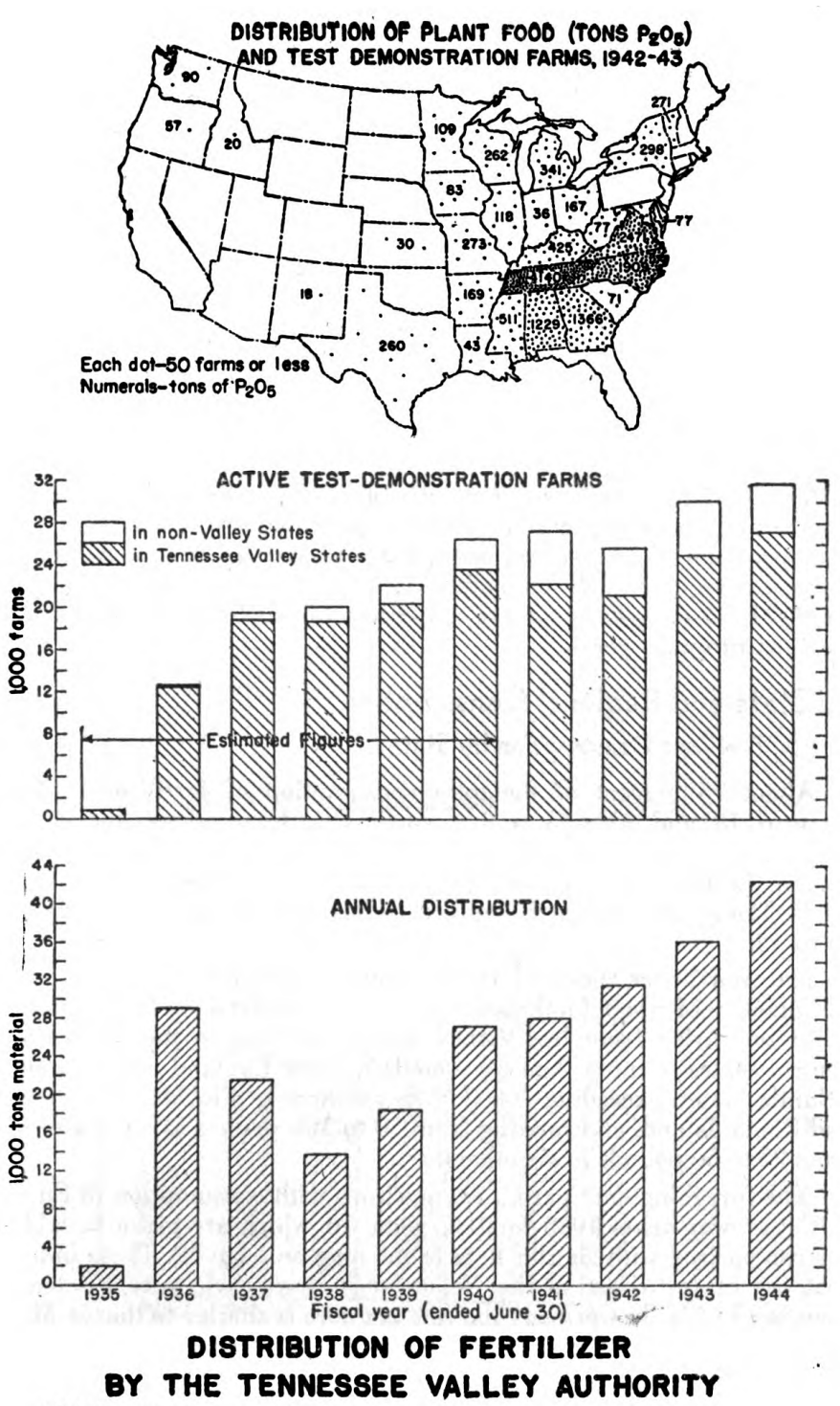

Figure 5.1. Map and chart of TVA fertilizer program, 1935-1944. TVA's fertilizer distribution and test demonstration program touched the lives of farmers in the Tennessee River Valley and throughout the nation, as these charts from a 1946 USDA Report show. (From *Fertilizers and Lime in the United States: Resources, Production, Marketing, and Use*, 1946)

Figure 5.2. Results of TVA phosphate and lime test demonstration, 1942. The TVA abandoned plans to manufacture nitrogen fertilizers from its Muscle Shoals plants, instead pursuing a program of phosphate fertilizer research. While the NFA would continue to snipe at TVA's fertilizer programs, the administration of the TVA saw its fertilizer activities as serving as a public research and development branch of the American fertilizer industry. (Franklin D. Roosevelt Presidential Library)

Figure 5.3. TVA fertilizer distributed through Agricultural Conservation Program, c. 1940. The government distributed and subsidized fertilizer outside of the Tennessee Valley, as well. The AAA Agricultural Conservation Program (ACP) gave participating farmers free fertilizers in return for practicing soil conservation measures on their land and for welcoming their neighbors to inspect their practices. Fertilizer manufacturers viewed these initiatives with suspicion. Ultimately, federal fertilizer demonstrations helped disseminate best practices for fertilizer use in new areas, which bolstered manufacturer's efforts at market expansion. Carefully staged images like this, typical of New Deal-sponsored photography, show how farmers were supposed to embrace these programs, but they do not reflect their uneven enactment. (RG 16, NARA II)

Opportunities and Threats for the Fertilizer Industry

In 1939, W.T. Wright, an executive one of America's largest fertilizer manufacturers penned an editorial in *The American Fertilizer*. Entitled "Let Us Turn and Face the Sun," Wright lauded the Tennessee Valley Authority for developing new varieties of concentrated fertilizer. After the fashion of the Fixed Nitrogen Research Laboratory, the TVA shared its patents freely with manufacturers that were interested in developing new products. The article also noted that the TVA's conservation program was teaching farmers to fertilize pastureland, and that this conservation-minded farming was opening a new market that the industry ought to pursue. Representing the Royster Guano Company of Norfolk, Virginia, Wright saw opportunity in these activities of the agricultural state that many of his peers regarded as government interference. Published in a major trade journal, Wright's admonishment to "face the sun" and accept federal fertilizer programs as beneficial foreshadowed divisions within the fertilizer industry.

These words were gospel to the TVA's chief chemical engineer, Harry A. Curtis. A federal fertilizer researcher in Muscle Shoals since the '20s, Curtis had spent the better part of his life performing highly technical research that subsidized the fertilizer industry without amassing the personal wealth he might have doing a similar job at Dow or DuPont. Finally winning recognition from an industry that continually attacked his work while pocketing its benefits, Curtis commended Wright for penning "one of the sanest and most courageous pronouncements that has come out of the fertilizer industry in years." He pointed

out that every sector of the growing agricultural state was calling in unison for farmers to use more phosphate, which one would think, he supposed, would be good news for companies that owned phosphate mines. “Instead of clearing the decks and getting ready to take advantage” of TVA’s new fertilizers, which they would inevitably be selling in the future, Curtis complained that the industry "spends its energy in bellyaching about this and that." Singling out the executive of the National Fertilizer Association by name, Curtis concluded that, “A highly profitable investment for the industry would be a muzzle for my friend Charlie Brand."[18]

At the time, the National Fertilizer Association executive Charles Brand and the industry he represented were under investigation for antitrust violations. Still, he was never one to don a muzzle. The fertilizer lobbyist had only become a more ferocious presence on K Street since he had mysteriously ended his stint as a top dog in the Agricultural Adjustment Administration. And unlike his more sociable friend who urged the industry to “turn and face the sun,” after having cycled in and out of the USDA since 1903, Brand had finally decided that he was of a breed more comfortable dwelling in the shadow of the agricultural state. Yet he did have good reason to have his hackles up. In the early years of the New Deal, his organization, much like his industry, was struggling. In 1932 fertilizer sales plummeted to a tonnage equal to that of 1907, which was an alarming development for a trade that had grown steadily since the 1850s. Contributing to this trend, the Agricultural Adjustment Administration’s acreage reduction

[18] “Let’s Turn and Face the Sun,” *The American Fertilizer*, Jun. 1939; Harry A. Curtis to W.T. Wright, Aug. 2, 1939, Box 130, Fertilizer 1939-1943 folder, AC-79-008, RG 142; R.L. Copson, “Statement Regarding TVA Fertilizer Developments,” May 31, 1941, Box 21, folder 2C, Chemical Engineering Department, RG 142.

policies had helped cut into cotton production, which had soared to 43 million acres in 1929 and dropped to less than 23 million in 1939. Depression and New Deal policy had taken a bite out of the fertilizer industry's most important market. With the industry tightening its collective belt, membership at the National Fertilizer Association dwindled as many members decided to forego paying their dues.[19]

In the light of these trends, Charles Brand made it his mission to police the boundary between private industry and public initiatives, while never missing an opportunity to exploit a weakness to the industry's advantage. In 1936, for example, the same Harry Curtis who had suggested the muzzle had flung open the doors of TVA's Muscle Shoals fertilizer facilities and had "shown every courtesy" to Charles Brand. Curtis provided a detailed accounting of where TVA fertilizers went and gave Brand a sneak peek of new technologies that his staff was preparing to share with Brand's colleagues. In spite of Curtis's gesture of transparency, at a meeting of the NFA's executive board just weeks after his visit Brand reported back that the TVA was intent on becoming a threat and a "serious handicap" to the fertilizer industry.[20]

Perhaps the length and bitterness of the Muscle Shoals debate had hardened his heart and made Brand so fearful of government encroachment, but the counsel of the American Farm Bureau Federation, Donald Kirkpatrick, offered another theory. A close observer of the NFA, he argued that the lobby's stubborn opposition to TVA was because much of the fertilizer industry would

[19] Historical Statistics of the United States, "Fertilizer—1850-1999"; Ibid, "Cotton acreage and production: 1839-1997."
[20] Charles Brand, Report of the Executive Secretary and Treasurer of the National Fertilizer Association, June 8, 1936, 12, TFI.

actually *not* benefit from it. Barring the largest and most advanced chemical producers, the majority of the industry was struggling economically. They had invested in equipment designed to produce a specific type of goods and they wanted a return without having to upgrade their factories. They had no interest in catering to the demand for new products. With help from the USDA and the farm lobby's push to create farm cooperatives, TVA's program was ginning up national demand for concentrated fertilizer with phosphorus content of 45 to 65 percent. At the time the average P content of standard mixed fertilizers was only eight percent. And as these concentrated fertilizers became more common, large fertilizer companies centered in the Mid-Atlantic States began to close their southern fertilizer mixing plants. Concentrated products cut shipping costs, and it rendered their investment in mixing and bagging facilities in close proximity to their customers into a liability rather than an asset.[21]

Brand was the national spokesman for what was supposed to be a progressive and modern industry, and yet by the 1930s it was becoming clear that his advocacy was most aggressive for the industry's least modern and progressive elements. In his past life at the USDA, at one time Brand had studied and bred nitrogen-fixing legumes and had called for legislation protecting farmer cooperatives. To say that he had changed his position on co-ops since he became the NFA's mouthpiece would be an understatement. As Brand fought to stifle farm cooperatives and protect regional fertilizer dealers, he was also doing work to protect the same set of predatory financial practices from which farmers had

[21] *Hearings Before the Joint Committee on the TVA Investigation, Part 9* (Washington, D.C.: Government Printing Office, 1939), 4053; Maryland Planning; Maryland Planning Commission, *Report on the Fertilizer Industry* (Baltimore: Works Progress Administration, 1938), i-ii.

been trying to escape since the 1870s. This was not only a question of raising the chemical content of products, it was also about preserving a set of economic arrangements and power relations that were far from forward looking.[22]

As evidence of the cost of these trade practices to farmers, one USDA study found that between 1911 and 1943, on average farmers in the South spent fourteen percent of their previous year's income on fertilizer—eleven percent higher than any other region. Astounding as these figures may be, individual cases are even more troubling. In his study of black tenant families in Macon County, Alabama in the early '30, the Fisk University sociologist Charles S. Johnson met farmers whose landlord advanced them $30 for fertilizer on credit, their second largest expense after their $60 rent payment. In spite of raising $300 worth of cotton, they ended up $72 in debt after settling up with their landlord. Products that manufacturers advertised as tools of economic opportunity became weapons of repression in the wrong hands.

All of the nagging aspects of southern agriculture that made it stand out as an economic problem—high rates of tenancy, lack of mechanization, lack of farmer cooperatives, and Jim Crow—were built into the very structure of the southern fertilizer industry's business model. Local fertilizer mixers and local fertilizer salesmen were heavily invested in continuing the economic arrangements that made rural poverty even worse in the South. Insofar as we might see these companies as small businesses squeezed between powerful international corporations and farmer cooperatives, it is important to keep in mind that their businesses were built upon trade practices that profited from

[22] Charles J. Brand, "Improved Methods of Handling and Marketing Cotton," 1912.

farmer debt and commission sales, neither of which created incentives to introduce highly concentrated products. The TVA's insistence that it was in a position to offer technical assistance to the industry offered little comfort to this sector of the industry for which the prospect of a technical breakthrough was a force of disruption, rather than a federal subsidy. On paper, concentrated fertilizers were advantageous because they could reduce freight costs. In practice, the TVA's brand of corporate subsidy appeared as though it portended a major shake up for much of the industry. Brand positioned himself as the firewall to protect the very sector of the industry, which, in a past life, he had decried as perhaps the greatest obstacle to the economic well being of the Cotton Belt.[23]

By way of contrast, chemical companies were far more comfortable chasing government contracts, preferring cooperation and collusion to confrontation. In 1935, for example, representatives from DuPont visited Henry Wallace's office and pitched a program to eliminate low yields in the South by distributing their powerful anhydrous ammonia through the USDA's agents in the field. Armed with charts and brochures with data gleaned from experiment station reports and USDA literature, they tried to enlist the government as a customer for their products. Unlike the NFA, corporation like DuPont were willing to openly pursue the opportunities in the growing agricultural state. They were old hands at negotiating government contracts and were dynamic and flexible enough to seek out different outlets for their goods and facilities. The staff of DuPont's research division stood at the ready to adopt any and all new technologies or processes that TVA's chemical engineers cooked up. Unlike small

[23] Ibid; *Phosphate Resources of the United States*, 1083.

southern companies, they had no real interest in maintaining the existing political economy of the South. Quite the opposite, DuPont presented its products as a silver bullet to remedy the region's ills. For them, government distribution was an efficiency that would spare them the trouble of dirtying their hands with all of the local conditions that plagued the southern market.[24]

Under Brand's leadership, NFA was conservative and outwardly antagonistic to government in many ways, but it was always opportunistic. New developments in the science-focused branches of the USDA created openings that fertilizer manufacturers were very keen to pursue. One of the most promising was the spread of hybrid corn seed. Before he moved to Washington to become Secretary of Agriculture in 1933, Henry A. Wallace was a plant breeder. His Hi-Bred Corn Company (later Pioneer Hi-Bred) was at the forefront of a biotechnological revolution in seed modification. Corn was only the first major crop cross-bred for yield, and eventually every other major crop was added to the list. So too were seeds selected for other qualities beside yield, including pest resistance and later, compatibility with specific pesticides. One of the first traits that seed companies identified in hybrid corn was its ability to efficiently metabolize fertilizer, allowing it to grow faster and more prodigiously than anything previously imagined. The NFA took note. In the spring of 1927, *The Fertilizer Review* reported that Wallace applied fertilizer to his Iowa corn crop for the very first time. Here was an opening in the nation's most significant

[24] DuPont, "Outline of Subject Matter to Be Presented to Secretary Wallace 1935," Box 2107, Fertilizer folder, entry 17, RG 16, NARA II.

untapped fertilizer market.[25]

Thanks in part Henry A. Wallace's background as a scientist and entrepreneur, the New Deal's agricultural policies were not entirely shaped by economic programs intended to curb overproduction. Wallace made a forceful case that USDA should play a leading role in the scientific community by branching out into new fields of advanced research, including hybrid seed breeding. He also believed that public research could help curtail the problems of overproduction by finding better ways to distribute and dispose of the nation's agricultural largesse. Wallace got his wish, and in 1935 FDR signed the Bankhead Jones Act, which provided $20 million in new funds for state-led agricultural science on top of its current research budget. The investment bolstered the extension program and experiment stations, but it also included additional funds for nine new regional research centers around the country. It was a sound investment, and the beginning of an even greater federal investment in the agricultural sciences that had very significant outcomes outside the lab, especially through new varieties of hybrid seed. In 1933 only one tenth of one percent of the nation's corn was grown from hybrid seed. By 1954 more than 90 percent would be. With farmers investing in new fertilizer-hungry crops across the country, the fertilizer industry was finally poised to shift its center of gravity outside of the Southeast.[26]

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[25] On hybrid seed, see James R. Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology, 1492-2000* (New York: Cambridge University Press, 1988), 66-90. Alan L. Olmstead and Paul W. Rhode, *Creating Abundance: Biological Innovation and American Agricultural Development* (New York: Cambridge University Press, 2008); *The Fertilizer Review*, Mar. 1927.

[26] Kloppenburg, 86; Mark R. Finlay, "The Industrial Utilization of Farm Products and By-Products: The USDA Regional Research Laboratories," *Agricultural History* 64, no. 2 (Spring

The new high-water mark of federal agricultural spending came at the nadir for the National Fertilizer Association. The NFA's education and research spending dwindled to $10,000 in 1934, and they were forced to cut back on speaker travel expenses and their large publishing output. Instead, they focused on producing written material tailored as fodder for farm journals and popular magazines. As business improved and the purse grew heavier, NFA set about their biggest expansion of promotional activity yet targeting the foot soldiers of the New Deal's agricultural army as their quarry. Mirroring the new regional expansion of the USDA, the NFA expanded its in-house research branch and opened more of its own experiment stations across the country. By the 1940s, the NFA had twelve Soil Improvement Committees spanning the nation, offering locally tailored advertising under the auspices of research and advice for farmers. Their statisticians gathered and aggregated data, measuring local price indexes so they could promote the return on the dollar for buying fertilizer in different parts of the country.[27]

These new initiatives brought NFA operatives into contact with the public and helped them get a foot in the farmhouse door. The regional committees cultivated relationships with county agents and farm bureaus, commissioned speakers, set up demonstrations, and kept a pulse on local conditions—all the while reporting back to the Washington office as they performed their educational work. The Washington office printed large runs of promotional

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1990): 41-52. On the USDA's programs role in marketing and distribution, see Hamilton, *Trucking Country*. For hybrid seed data, see National Agricultural Statistics Service, "Historical Agricultural Data Now Online." http://www.nass.usda.gov/Newsroom/2013/07_30_2013.asp.

[27] "Report of the Executive Director of the NFA, Nov. 1937, TFI; "Soil Improvement Work," NFA Atlanta Meeting, Nov. 1940, TFI.

material for county agents, free of charge. NFA also organized regional conferences for mixed groups of public and private agricultural workers, mingling salesmen with agents, land-grant agronomists with industry scientists. In 1940 they organized 20 of these gatherings. With the gradual recovery of membership dues during the 1930s, they sponsored research fellowships at land-grant colleges, and continued to organize contests that rewarded farmers for maximum yield-per-acre. At the 1941 NFA convention the national head of the Soil Improvement Committee reported that their investment in "educational work" was paying off, and that manufacturers were "cashing in" on all of the work they had done over the past 30 years.[28]

The industry's shadow USDA was not just growing in scale, it was also finding novel ways to "cash in" through other media outlets. In 1927, the NFA decided that it needed to explore ways to advertise and shape public perception about industry outside of their traditional methods of political lobbying and educational work. First taking to the airwaves, in the NFA produced a series of radio plays featuring a farmer named Hiram Midwest, described as "A well-to-do, capable farmer of middle age, rather large, inclined to be gruff, but he is reasonable and willing to hear the facts." Luckily, this first foray in mass media was followed by a much more ambitious second act on the silver screen. For their next stab at infotainment, starting in 1939 the NFA produced motion pictures that showed the benefits of fertilizer on pastureland for livestock production, and another demonstrating proper application methods. To the delight of the NFA,

[28] "Meeting of the Executive Board," NFA 6, 1941, TFI.

the films became critical darlings of the agricultural state. Higher-ups at the USDA seemed content letting NFA don the hat of the auteur at showings where state employees played the role of projectionist. In 1939, the NFA invested in a car and a projector to take the films on the road, but doing so quickly became unnecessary. County agents, the Soil Conservation Service, and agricultural educators showed the films in theaters and gathering places across the U.S. and Canada. They were tailor-made for meetings of the 4-H Club, where youngsters were eventually treated with colorful industry-sponsored comic books. In the end, the films reached millions of viewers during the 1940s. The National Fertilizer Association could not have been more pleased with their investment. In 1940 NFA's leadership reported that they had incurred no distribution costs thanks to the government's welcome assistance showing the films.[29]

Having moved into the talkie era, the National Fertilizer Association was projecting an image that showcased the industry as an important and modern segment of America's agricultural and industrial economy. They offered their research programs and experimental farms as evidence that the members of the NFA, who sold about 85 percent of the nation's fertilizer tonnage, were helping to usher in a new era for American agriculture. The research at the center of their promotional activities, however, was decidedly self-interested and subtly conservative in nature. Since its earliest days, Soil Improvement Committee had investigated best practices for fertilizer application instead of developing new products. They performed studies that showed farmers how to apply fertilizer

[29] "Hiram's Hired Hands," *Fertilizer Review*, Apr. 1927; "Minutes of the Board of Directors of the National Fertilizer Association," Nov. 1940-1944, 20, TFI.

more efficiently by laying it in certain depths and positions along the furrow. The practices they disseminated in their promotional materials were practical enough, but it was in no way concerned with developing more powerful material as scientists at TVA were doing. The proliferation of more concentrated fertilizer produced at advanced new facilities threatened to transform the entire structure of the industry.[30]

At a congressional hearing Charles Brand insisted that his agency's researchers were equal if not superior to anyone working at the Tennessee Valley Authority. Brand insisted that the industry had performed perfectly well in the 80 years before the federal government had initiated fertilizer research programs. The NFA's opposition to government fertilizer distribution was the organization's main talking point in its efforts to challenge the TVA's fertilizer program. In truth, the greater threat to the less dynamic forces within the industry was the prospect that government researchers would produce new technologies that would render small firms and local fertilizer dealers obsolete. The more powerful chemical fertilizer that federal researchers developed and disseminated during the previous 25 years had been slowly setting the stage for a wholesale restructuring of the fertilizer business.[31]

A process of abstraction accompanied the restructuring of the fertilizer industry. As fertilizers became more chemically concentrated, they also became even more disconnected from their points of origin. Fertilizer had always been a commodity—a product of distinct environments scrubbed of its identity in baths

[30] "Phosphate Resources of the United States," 1094.
[31] Ibid, 1152.

of sulfuric acid and by the labor of workers and mixing machines. But when fertilizer entered the chemical regime it underwent an additional process of abstraction. Farmers no longer sought out trusted brands, but instead looked for the cheapest and most powerful chemicals suited to the needs of their soil and crops. It was less a choice between brands, but instead a choice between processes like anhydrous gas application, granular fertilizer, liquid distribution and compounds such as urea, anhydrous ammonia, or ammonium phosphate. The previous character of the fertilizer industry—with its name brands, logos, crop-specific formulas, and regional manufacturers—was replaced by highly capitalized chemical corporations. Products that had once contained local cottonseed meal or the odd fishbone were gone. The brand names that had once evoked a connection between businesses and their products were replaced by the anodyne language of chemistry.[32]

War, Reconstruction, and Reconversion

Before World War I, handwringing about the blockade of crucial minerals from reaching American soils determined the government's approach to fueling the agricultural element of the war machine. In Washington, the experience of the last war's logistical problems had not been forgotten. During the Second World War, a combination of public investment, industrial development, and new mineral reserves led to a stunning increase in fertilizer production capacity and application across the country. America's nitrogen-fixation capacity tripled

[32] William Cronon, *Nature's Metropolis*, esp. 97-147.

during the war, helping to forestall the agonizing tug of war between farms and arms that had created such ill-will among farmers the last go round. The original guns and butter provision of the 1916 National Defense Act was still built into the structure of Tennessee Valley Authority, which shifted its focus during the war. After Pearl Harbor, the TVA temporarily limited its fertilizer program and offered its technical staff as consultants for ordnance production. The agency repurposed its electric furnaces to produce new forms of red phosphorus for arms production on an industrial scale. The agency also developed a pilot plant that served as a template for other military arsenals across the country to reproduce the TVA's own operation. The practices established by the Fixed Nitrogen Research Laboratory to disseminate public research helped facilitate both public and private contractors during the war.[33]

The economic concern with food overproduction gave way to new wartime admonishments for all-out production on factories and farms. Heeding the call in their own way, the National Fertilizer Association petitioned the government unsuccessfully for prisoner of war labor in fertilizer plants and draft deferrals for key industry personnel. The Food Production Board classified crop types to prioritize fertilizer distribution to supply the nation's wartime crop needs, making sure that corn and cotton received generous fertilizer applications. The Agricultural Adjustment Administration distributed these fertilizers through its Agricultural Conservation Program. Federal agencies also revised the wartime diet. Through rationing, Victory Gardens, and Office of Price Administration

[33] "Fertilizer and Munitions Research and Development," 19 March 1947, Box 21, 2C, Chemical Engineering Department, RG 142, NARA ATL.

price controls, the federal government became more involved in the regular American's diet than ever before. The tangled bureaucracy of food programs told farmers what to grow, told people what to eat, and set food prices. The state's new concern America's diet had mixed results.

Meat, in particular, became a flashpoint of consumer frustration as the War Food Administration reserved a large potion of the nation's high-calorie food to ensure that GIs would be well fed. In 1944, the War Food Administration called on farmers to start applying heavy nitrogen fertilizer inputs not just on staple crops, but also for stock raisers on pasture grasses. As the building block of protein-rich feed, they wanted to try ensure that the nation's vastly expanding nitrogen production capacity would translate into more meat. This was a wartime measure, but it highlights a broader expansion of the chemical nutrient regime and its effect on the American diet. Since World War II, nitrogen production in wealthy countries has become a "fuel" for meat production, as an ever greater share of the world's agricultural nitrogen is set aside to feed the crops that feed the cows and pigs that feed the sector of the global population that need the calories the least.[34]

The massive wartime need for food and the country's newly expanded fertilizer production capacity shifted the USDA's general stance about proper rates of fertilizer application. In spring 1945, Secretary of Agriculture Claude Wickard called for a national policy that would encourage and enable all farmers to increase fertilizer application by 300 percent. With the end of the war in sight,

[34] P.H. Groggins, "Ammonium Nitrate for Direct Application to Pastures," 18 February 1944, Box 1, Ammonia and nitrogen distribution during war years, entry 77, RG 145: Records of the Agricultural Stabilization and Conservation Service, Box 1, NARA. Vaclav Smil, "Nitrogen and Food Production: Proteins for Human Diets," *Ambio* 31, no. 2 (2002): 126-131.

he suggested that the government decommission its war-built nitrogen and sulfuric acid plants and lease them to private industry and cooperatives. This was not out of line with Roosevelt's own wishes for postwar reconversion, which he hoped to pass off to private industry with the explicit hope to avoid the postwar slump that had followed the last war. Long before the end of the fighting, Roosevelt called for the rest of his staff to make preparations for a speedy liquidation of government assets for the peacetime economy. These assets included some $15 billion of industrial plants, equal to fully one fifth of the national industrial capacity.[35]

Although Roosevelt was not alive to see it happen, reconversion proceeded in a way that allayed the fears of business leaders wary of postwar government encroachment. Many business leaders feared publicly owned factories might become part of Roosevelt's program of full employment. Quite the opposite, reconversion was the largest privatization of public property in American history. Among these assets were ten government ordnance plants that were readily useful for nitrogen fertilizer production. These included a number of state-of-the-art facilities that relied on natural gas and petroleum byproducts for their feedstock. Indeed, many of these facilities would end up in the hands of private corporations, but they came with many more strings attached than the other properties in the postwar selloff. [36]

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[35] "Wickard Sees Need for More Fertilizer Use," *The Christian Science Monitor*, Feb. 23, 1945; Franklin Delano Roosevelt to Harold D. Smith, 18 September 1944, Box 1, Whitehouse correspondence Part 2 folder, entry 173, RG 234, NARA II; Wilson, *Destructive Creation*, 241.
[36] David M. Wishart, "Agricultural Chemicals, 28.7," in *Manufacturing: A Historical and Bibliographical Guide*, eds. Bessie Emrick Whitten and David O. Whitten (Westport, CT: Greenwood Press, 1990), 163.

The agricultural activist Vandana Shiva has quipped that because of the wartime expansion of nitrogen production, the world has been "eating the leftovers of World War II" ever since. While this is an evocative phrase, it is not strictly true. After the war, the government did sell off or lease some of the wartime plants, but they also reserved many for government operation because of simmering fears of another hot war. Those plants that the government did offer for sale carried the stipulation that any purchaser would agree to reconvert to munitions production in any coming war. To prevent monopoly, they came with the added caveat that the plants could not be sold to any of the largest fertilizer or chemical companies, and veteran entrepreneurs and local companies were given priority in the bidding process. With so many restrictions, many of the plants were retained as federal property, and two of them were shut down and sold for their land to Iowa State and Texas A&M. What really helped unleash the tide of postwar nitrogen production was not the wartime facilities, but generous tax amortization schemes and low-interest loans from federal agencies that allowed companies to build entirely new facilities. In other words, we are not eating the leftovers of World War II; we are reaping the harvest of generous federal subsidies for farms and arms production—and that practice had its roots in the 1920s.[37]

In contrast to the reconversion of wartime plants, in 1944 Alabama Senator Lister Hill introduced a bill that would have expanded TVA's fertilizer program through a new, and even larger government plant in Mobile and two

[37] Vandana Shiva uses this phrase often in her speeches and it is also quoted in Michael Pollan, *The Omnivore's Dilemma: A Natural History of Four Meals* (New York: Penguin Books, 2006), 146; Mark R. Wilson, 260, 268; Charles Brannan to Lister Hill, 21 March 1951, Box 1981, Fertilizer Jan. 1-Apr. 5, 1951, entry 17, RG 16, NARA II.

other western states. The "National Fertilizer and Policy Program" was the final round in a drawn out battle between the farm lobby and the fertilizer industry that had started at the end of WWI. The law would have subsidized farmers with government fertilizer nationwide for the foreseeable future. Lister Hill was resolutely motivated by driving federal investments in his state, but his bill would have had very consequential effects on the postwar agricultural outlook. The so-called "Hill Bill" set the fertilizer industry into a state of panic. At the NFA's 1945 convention in Atlanta the one speaker argued that the bill was "an entering wedge for state socialism" after the Soviet model that portended the end of the fertilizer industry altogether. So great was the panic over the bill that it led a group of manufacturers to splinter off from NFA and create a new organization with the specific goal of undermining the bill. As the volume of chemical and mineral fertilizers continued to grow and the industries faced new regulatory challenges, new lobbyists opened offices on K Street. The American Potash Institute and the Agricultural Ammonia Institute began to follow the lead of the their predecessor, with their own executives moving in and out of the revolving door of land-grant universities, the USDA, and private industry. The longtime president of the American Potash Institute was none other than J.W. Turrentine, USDA's man on the beach during the abortive World War I seaweed-to-potash program.[38]

During World War II, three of the top fertilizer and chemical companies in the nation cut their ties with the National Fertilizer Association without warning.

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[38] Farmers' Union, "America Needs More Fertilizer...But It's Not in This Bag!," Box 27, Farmers' Union folder, Agricultural Development and Agricultural Relations, 1933-1948, RG 142, NARA ATL; Katherine Barnwell, "Fertilizer Association Head Hits 2 'Paternalistic' Bills,'" *Atlanta Constitution*, Nov. 13, 1945; Charles Bradfield, "Should Fertilizer Production Be Subsidized?" (New York: The Academy Press, 1947): 13.

The NFA's official records have little to say about why the companies left, and only show that the association tried unsuccessfully to win them back. With an eye towards moving forward from its period of difficulty, in 1945 the NFA asked Charles Brand to tender his resignation. After having mounted a fierce opposition to government intervention and even government handouts, Brand's was not the face that the industry wanted to put forward. His loyalty to smaller fertilizer manufacturers and opposition to the structural changes within the industry also must have played a part. With Brand gone, the NFA appointed a new spokesman who obtained the management consulting services of the Booz Allen Hamilton firm to modernize their operation. The agency hired Public Relations consultants to polish its image, and it eventually changed its name to distance itself from its turbulent past. Realizing it was no longer a threat, in the early 1950s, the NFA began extensive cooperation with TVA's National Fertilizer Development Center in Muscle Shoals. The collaboration between the successors to these two organizations remains unshaken today.

War had also shifted the TVA's priorities. In the beginning, the fertilizer program was rooted in the philosophy of "permanent agriculture," based on conservation principles with one foot in nineteenth century husbandry and the other in high modernist planning. It was a hybrid of two impulses, first, a desire to create self-sufficient farms, and second, the belief that modern public enterprise could provide the technical assistance needed to keep these farmers secure. In practice, the delicate balance between these two ideologies was top heavy, and one toppled the other. TVA's leadership decided to prioritize the technical side of fertilizer development. In the tradition of the FNRL, it limited its

direct assistance to farmers and expanded its activities as a pilot research facility and consultant for corporations, and later, developing countries. When TVA began to roll back the test-demonstration program in the 1950s, it was busy establishing relationships with private firms and international aid organizations. The focus on humanitarian aims painted their work with a vaguely altruistic gloss that at least contained glimmers of the TVA's former utopian zeal. But in the end, H.A. Morgan's dream of making the Tennessee Valley into a showcase of smallholders on self-sustaining farms was overshadowed by a state-run chemical research and consulting agency that underwrote some of the world's most powerful corporations. So much for alfalfa.

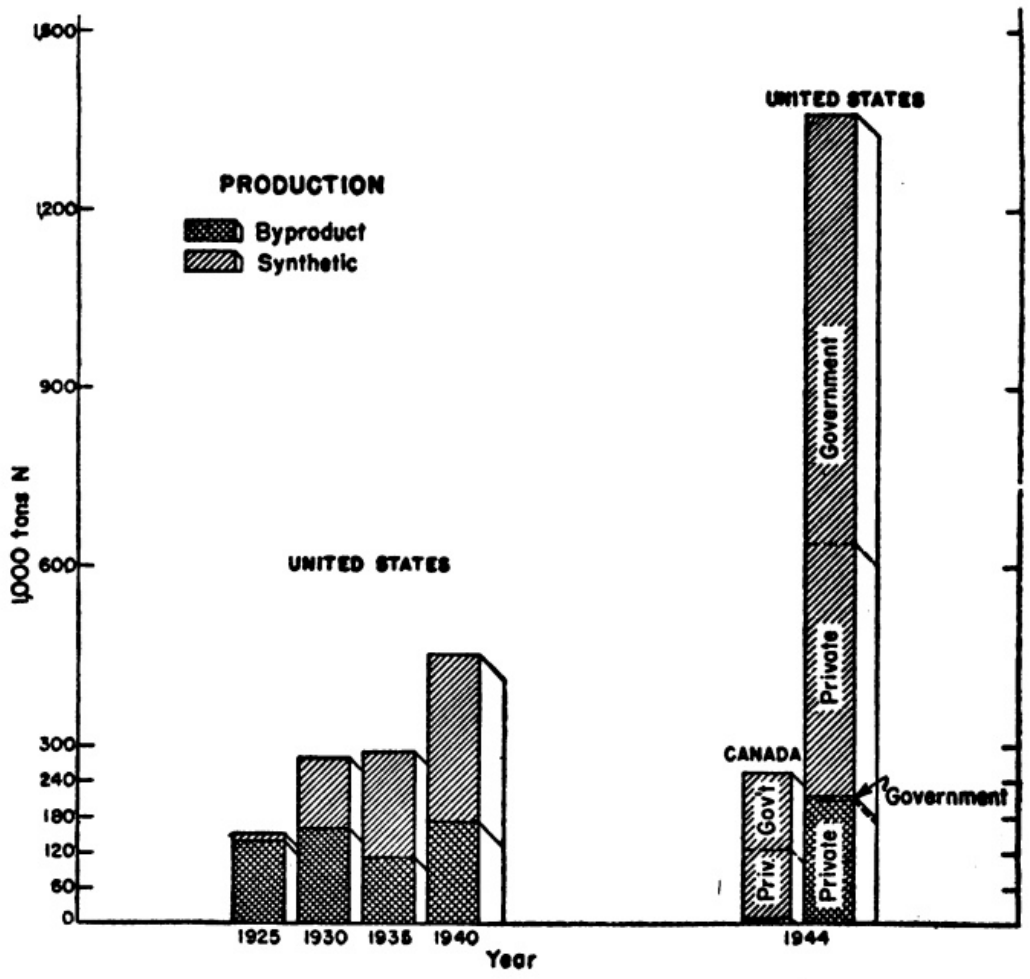

Figure 5.4. Wartime nitrogen synthesis output, 1946. Nitrogen plant construction by a combination of federal and private enterprise helped expand the nation's capacity to feed weapons and plants on an a much larger scale, but many of the plants lay dormant or closed after the war. The expansion of nitrogen synthesis in the postwar period was largely funded by generous federal subsidies used to build new plants. This chart also shows the diminishing importance nitrogen extracted as a byproduct of coking natural gas. (*Fertilizers and Lime in the United States*, 56)

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Through depression and war, the frenzied activities of the agricultural state during the New Deal led to major changes in the way that Americans fed their plants and themselves. Building upon the research practices of the Fixed Nitrogen Research Laboratory, the Tennessee Valley Authority launched an ambitious program to remake the economy and landscape of the Upper South. This program was intended to draw the region into the national economy, but it also included a major agricultural conservation program that provided government subsidized fertilizers to many areas of the country that had not used fertilizer before. Although the agency faced internal strife and scrutiny from the fertilizer industry, the TVA's fertilizer program eventually expanded to serve other regions of the country, and to supply other agricultural initiatives of the New Deal. In many ways, the TVA fell short of its ambitious goals, but its fertilizer research program eventually became a hub of advanced research that played an active role in postwar international development programs.

The technological advances that emerged with assistance from federal research programs revealed fissures that led to a major period of restructuring for the American fertilizer industry. Since turn of the century, the National Fertilizer Association had protected fertilizer manufacturers from government encroachment and sought opportunities that the growing agricultural state presented. Despite efforts to pursue the common interests of manufacturers during the New Deal, by the 1930s, it was becoming evident that the fertilizer industry was breaking into factions. Led by Charles Brand, the NFA continued to

lobby on behalf of the smaller fertilizer concerns that had supplied the southern cotton and tobacco belts and represented the largest branch of the industry since the Civil War. For these small, risk-averse operations, the new agro-chemical technologies developed at government facilities posed a significant threat. Under Brand's leadership, the NFA attempted to undermine federal fertilizer research. By contrast, large chemical corporations such as DuPont and General Chemical welcomed federal research, and used their financial clout to take advantage of new publicly funded technologies. As hybrid seed helped open new fertilizer markets across the country, these corporations seized the opportunity and sold their products directly to farm cooperatives, upending the longtime opposition to these purchasing arrangements customary in the southern fertilizer market. Just as the chemical nutrient regime had provided new opportunities for well-capitalized companies, it also did the same for the wealthiest farmers. Guano notes were a disappearing phenomenon by the 1950s, as were the poor farmers who had been held in the thrall of fertilizer debt.

The war and postwar agricultural transformation saw a larger, more successful program of farms and arms production than the First World War through the construction of dozens of new facilities to support the war effort, forming a key part of FDR's Arsenal of Democracy. Drawing on the nation's new chemical production capacity, USDA officials urged farmers to apply more fertilizer and grow more crops to supply America's military needs. The proliferation of hybrid corn and nitrogen helped increase meat production to feed soldiers during the war and the postwar American diet. The transition of wartime munitions plants to fertilizer plants played a less significant role in expanding

America's agro-chemical production capacity than major, low-interest federal loans that allowed corporations to build state-of-the-art plants in the postwar years. Through the process, America's chemical and nutritional circuitry was effectively "rewired" through a combination of public investment and private sector expansion. In time, the fertilizer-fueled agriculture first developed to grow inedible staples become common across the United States and much of the world. Markets created economic incentives that channel nutrients towards the most valuable products, but the language of "free markets" obscures the countless ways the agricultural state has fostered these conditions by subsidizing private industry. These patterns came of age during World War II, but they started in the shadow of slavery.

EPILOGUE

TEXAS CITY, 1947

The full extent of the explosion is still unknowable. It started on the morning of April 16, 1947, when a small fire erupted without any apparent cause in the hull of a ship in Texas City, a port outside of Houston. The flames were impervious to water, and the captain ordered the crew to seal off burning section of the ship to try to starve the fire of oxygen. Within hours, the *Grandcamp* exploded in blaze so powerful that it shot a plume of smoke 2,000 feet in the air and demolished a harbor-side Monsanto Chemical plant built during the war. Debris from the explosion ignited a blaze in the nearby *Highflyer*, which a boatman had valiantly steered away from the flames to limit onshore damage from the second boat's inevitable fate. In the melee of destruction, jagged pieces of shrapnel and flaming bails of sisal twine rained down over the area for minutes after each of the two blasts. The first explosion was so forceful it carried victims more than a mile through the air, and people some 250 miles distant in Louisiana could feel the impact. It leveled factories and oil refineries, setting off a string of interminable blazes that lasted for days. It was the largest industrial accident in American history, claiming the lives of 568 people and injuring 3,500 more. The ships were laden with tons of nitrogen-rich fertilizer, which has long since

become a well-known accelerant in the hands of terrorists as well as in more recent industrial accidents like the 2013 explosion in West, Texas.[1]

The blast offers a grim metaphor for the explosive growth of America's postwar agricultural production that was fueled in large measure by an exponential rise of fertilizer production. But rather than using the blast as a symbol of things to come, understanding the historical forces that had converged to "light the wick" uncovers that the postwar agricultural transformation was deeply rooted in the events detailed in the proceeding chapters. Sifting through the wreckage of the disaster offers a chance to take stock of how and why a product that had once been so dilute that it was likened to a useless patent medicine evolved into something so powerful that it was capable of spontaneously combusting.

During the decades preceding the Texas City Disaster, the agricultural state had helped research, develop, and distribute new fertilizer technologies. Over time, highly capitalized segments of the fertilizer industry eagerly adapted new technologies and relied on federal programs to help get their products to new customers that had hitherto been most densely concentrated in the South. Ammonium nitrate, the accelerant in the Texas City Disaster, was first developed in Germany by the firm BASF. As chapters two and three examined, American production was expedited after the First World War through the seizure of

[1] "Blasts and Fires Wreck Texas City of 15,000; 300 to 1,200 Dead; Thousands Hurt, Homeless; Wide Coast Area Rocked, Damage in Millions." *New York Times*, Apr. 17, 1947. On the history of the blast and the postwar settlement proceedings, see Hugh D. Stephens, *The Texas City Disaster, 1947* (Austin: University of Texas Press, 1997). Victims of the blast filed hundreds of suits against the federal government for negligent acts, their combined suit went to the Supreme Court, which ruled in their favor. The government paid the plaintiffs more than $17 million for failing to properly label and store the fertilizer.

German patents and by improvement and distribution by the Fixed Nitrogen Research Laboratory. The circuits of scientific knowledge and capital that benefitted agro-chemical companies became even more robust in the postwar era, but the pattern of public research and subsidies for private industry went back to the early twentieth century, expediting the chemicalization of agriculture in the United States.

The particular lots of ammonium nitrate responsible for the disaster came from wartime plants operated by the Commodity Credit Corporation, a New Deal-era government loan program that would play an important role in financing new agribusiness developments and underwriting foreign market development for American agricultural surpluses. Other New Deal and wartime public lending agencies were repurposed in the postwar era to underwrite new chemical fertilizer plants across the country. In 1950, for example, the Reconstruction Finance Corporation provided the Mississippi Chemical Company with a low-interest loan to build new high-capacity ammonia and ammonium nitrate plants. These public investments in advanced chemical production helped transform the southern fertilizer industry and raised the technological bar of entry for farming in the South. In fact, the same year of the Texas City Disaster, as public funding for private fertilizer production began to grow, legislation designed to fund public factories and expand direct fertilizer subsidies to farmers fell flat. Alabama senator Lister Hill failed to achieve

legislative support for his plan to expand the TVA's fertilizer program in the business-friendly postwar climate.[2]

The fertilizer in the ships was destined for France as part of America's postwar aid program. Food, as well as plant food, became major elements of America's cold war era foreign policy program, including the "Food for Peace" program and the U.S. led "Green Revolution" in the global South. Fertilizer provided a critical material and technological basis for these programs. The presence of a Monsanto Plant and refineries provides evidence of the tightening connection between petrochemicals and agrochemicals that would help similar companies become powerful actors in the postwar economy. Indeed, even the geography of the Gulf Coast itself helped facilitate this interdependence between oil, sulfur, chemicals, and nitrogen production. Most of the postwar nitrogen production capacity was clustered along the gulf coast in Texas and Louisiana where oil refineries provided a cheap feedstock for fertilizer production and access to water transportation.[3]

Both at home and abroad, the postwar agricultural explosion was a boon for some and a bust for others. The collapse of small fertilizer manufacturers in the South did not result in social justice for poor, and especially, African American farmers. As historians of the Civil Rights era have noted, as the agricultural state became more powerful than ever in the lives of farmers during

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[2] After a devastating fertilizer plant blast at BASF in Oppau, FNRL head Richard Tolman provided safety guidelines to the National Research Council. Richard Tolman to Charles E. Munroe, 29 June 1922, Box 2, Letters sent 1919-1927, entry 206, RG 54, NARA; *Making Things Grow: The Story of the Mississippi Chemical Company* (Jackson: University of Mississippi Press), 43.
[3] McGlade, Jacqueline. "More a Plowshare Than a Sword: The Legacy of Us Cold War Agricultural Diplomacy." *Agricultural History* 83, no. 1 (2009): 79-102; Harriet Friedmann, "The Political Economy of Food: The Rise and Fall of the Postwar International Food Order," *The American Journal of Sociology* 88 (1982): 248-286; Nelson, History of the Fertilizer Industry, 332.

the period, but it was still just as unlikely to withhold assistance from black farmers. In contrast to the relative decorum shown by the TVA by foreswearing racial discrimination in its charter, the dispossession of black farmers was the "intended consequences" of high-level USDA officials. The capital outlays needed to finance the modern farm included costly new fertilizer apparatus like liquid applicators, high-pressure gas tanks, and tractors. Missing out on USDA programs took a severe toll on black farmers, and the rate of African American farm ownership declined disastrously.[4]

The new world of fertilizer-fueled agriculture was not limited to the United States. In the cold war era, agricultural programs intended to bring political stability through food security and open new markets for American agribusiness coalesced around new international development initiatives. Fertilizer became a central component in all of these schemes. TVA's National Fertilizer Development Center became a key actor in this process, working closely with the USAID and Green Revolution visionary Norman Borlaug to provide developing nations with technical assistance. Doing so, the TVA built upon its earlier model of research and development work, but this time it was deployed to assist aid projects that advanced America's foreign policy objectives. In 1974, the organization ended its role within TVA and became the International Fertilizer Development Center (IFDC), a public-private hybrid that remains in the shadow of WWI-era buildings in Muscle Shoals. Today this outgrowth of TVA's fertilizer department has offices in Togo and Bangladesh and oversees research initiatives in 40 countries around the world. Their mission continues the tradition of

[4] Pete Daniel, *Dispossession*, passim.

balancing the project of altruism with the pursuit of new markets in the developing world. This approach has drawn no small amount of criticism from scholars and activists who see these activities as subtle forms of American imperialism clothed in the language of food security. Whether one sees this work as altruistic, opportunistic, or some combination of the two, today the IFDC estimates that the majority of fertilizers in use worldwide—as much as 75 percent of them—owe their existence to research performed in Muscle Shoals by TVA staff.[5]

As an environmental hazard, fertilizer has never received the same level of scrutiny that Rachel Carson helped bring to pesticide, but the great postwar flood of fertilizer has had many detractors. In the United States, the organic food movement appealed to suburban gardeners who wanted healthy food grown without the use of agricultural chemicals. J.I. Rodale, the American prophet of the movement, often insisted that food grown with fertilizer was less nutritious and even toxic. These claims drew the ire of the NFA who saw in Rodale the specter of Cyril Hopkins. They never missing an opportunity to discredit and challenge his ideas in their public relations work. Although fertilizer-fed food is not harmful to the eater, with each year scientists are discovering new ways that fertilizer disrupts the health of the environment in unintended ways. As early as 1949, the leadership of the NFA became aware that children in farming regions

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[5] Nick Cullather, *The Hungry World: America's Cold War Battle against Poverty in Asia* (Cambridge: Harvard University Press, 2010); Tore Olsson, *Agrarian Crossings: Remaking the U.S. And Mexican Countryside in the Twentieth Century*. Princeton: Princeton University Press, 2017); Timothy Mitchell, *Rule of Experts: Egypt, Techno-Politics, Modernity* (Berkley: University of California Press, 2002), 41; "IFDC History"; International Fertilizer Research Development Center, "TVA fertilizer technology used worldwide -- but few new products since 1970s," http://www.eurekalert.org/pub_releases/2008-08/i-tft082508.php

heavily saturated in nitrogen fertilizer were succumbing to nitrate caused infant cyanosis, or "blue baby syndrome." After aggregating medical opinions that were mostly dismissive of the correlation, they quietly commissioned a private scientific investigation to test the effects of heavy nitrate ingestion on a variety of lab animals. The effects of blue baby syndrome are the most extreme example of fertilizer pollution on the human body, but it also acts as a major pollutant on ecosystems.[6]

The upstream and downstream effects of industrial fertilizer production are now pervasive around the globe. The ecosystems surrounding Florida's phosphate beds have become so heavily impacted by mining and the storage of toxic, nutrient-laden tailings and agricultural runoff that the region's land and waterways have undergone a staggering succession of transformative ecological events. Fertilizer was notably absent from the wave of environmental regulations that helped curb the use of toxic pesticide in the 1970s. In developed countries the liberal application of fertilizer has transformed the problem of soil nutrition from one of dearth to an embarrassment of riches. Each year flows of unabsorbed fertilizer enter waterways as runoff that gathers in warm waters feeding algae blooms that remove oxygen and kill plant and animal life. These "dead zones" are common occurrences in the Gulf of Mexico as well as Lake Erie, where a 2014 algae bloom rendered the water supply of many Ohio cities poisonous. With rising global temperatures, these annual events threaten to seriously disrupt marine ecosystems and the humans that depend on them in new ways and on

[6] Rachel Carson, *Silent Spring* (New York: Houghton Mifflin, 1962); NFA, Meetings of the Board of Directors, Public Relations Report, 1949, NFA.

greater scales. Seeking ways to limit the upstream and downstream costs of the modern fertilizer regime is one of the great challenges facing everyone—and every thing—on the planet.

Today, the global nutrient economy has become so vast and interdependent that maps that chart the flow of nutrients between nations appear like an image of the globe wrapped in multicolored rubber bands. The preceding chapters have shown that this dizzying, multidirectional flow of commodities and capital was far from an inevitable outcome of economic pressures or the natural result of technological development. Rather, it was the consequence of negotiations between business, state actors, and farmers over time. As the preceding chapters have shown, the monocultures of southern agriculture became the early proving ground of the American fertilizer market. As the region became entangled in international fertilizer commodity webs, the fertilizer industry consolidated power by enlisting the support of the agricultural state. As publicly funded fertilizer research and development grew, it proved advantageous to chemical corporations that used government subsidies to produce powerful new agro-chemicals. This new infrastructure of production has become so potent and pervasive that it is difficult to imagine the world that preceded it, but farmers in the global South still face the troubling prospect of fertilizer debt to feed their crops. It is worth bearing in mind that the proliferation of productive technologies can still fall far short of their basic promise after more than a century and a half.

APPENDIX

FERTILIZER TONNAGE CONSUMED BY REGION AND STATE

	1880	1890	1900	1910	1920
South Atlantic					
Virginia	55000	100000	220000	344900	465200
North Carolina	65000	140000	276200	630900	1170400
South Carolina	86500	126000	292200	975000	1098500
Georgia	152500	288000	412800	1022000	1003050
Florida	1200	31000	33200	172600	262000
Total	360,200	685,000	1,234,400	3,145,400	3,999,150
Middle Atlantic					
New York	39000	85000	247000	229600	250000
New Jersey	30000	39500	66000	125000	164800
Pennsylvania	90000	110000	213000	287000	319700
Delaware	6000	8000	12000	23000	36200
Maryland	84000	100000	151000	148000	172400
Washington, D.C.	500	700	1000	1000	1000
West Virginia	5000	15000	25000	27300	35400
Total	254,500	358,200	715,000	840,900	979,500
New England					
Maine	5000	17000	40000	95700	168000
New Hampshire	3,000	7,500	12,270	12,800	17,000
Vermont	4000	8500	15500	18000	20000
Massachusetts	22000	40000	75100	41600	61400
Rhode Island	2000	5000	6000	6500	10000
Connecticut	5000	15000	35000	42000	65000
Total	41,000	93,000	183,870	216,600	341,400

	1880	1890	1900	1910	1920
East South Central					
Kentucky	4500	7300	24000	58000	88000
Tennessee	4000	8600	36400	58600	98500
Alabama	35000	99900	150000	425000	374900
Mississippi	6000	28000	98000	132800	131100
Total	49500	143800	308400	674400	692500
East North Central					
Ohio	15000	40000	89000	130000	280000
Indiana	7000	29000	58000	151900	231800
Illinois	4000	8000	11000	15000	45000
Michigan	5000	6000	15000	38400	112600
Wisconsin	4000	3000	2500	2000	12000
Total	35000	86000	175500	337300	681400
West South Central					
Arkansas	50	300	3000	30000	77500
Louisiana	5000	11120	31813	88396	110765
Oklahoma	0	0	0	1000	4000
Texas	1000	2000	10000	34000	55405
Total	6050	13420	44813	153396	247670
West North Central					
Minnesota	1000	1000	1000	2000	5000
Iowa	1000	1000	1000	1200	3500
Missouri	1000	1500	3300	31585	92737
North Dakota	0	0	0	0	200
South Dakota	0	0	0	0	200
Nebraska	0	0	0	100	500
Kansas	1000	700	700	1200	12700
Total	4000	4200	6000	36085	114837

	1880	1890	1900	1910	1920
Mountain					
Montana	0	0	0	0	0
Idaho	0	0	0	0	300
Wyoming	0	0	0	0	0
Colorado	100	300	500	500	250
New Mexico	100	100	200	300	700
Arizona	0	0	0	0	500
Utah	100	200	200	200	200
Nevada	0	0	0	0	30
Total	300	500	900	1000	1980
Pacific					
Washington	0	100	400	1000	6000
Oregon	100	200	500	2500	6000
California	2000	2500	8000	44900	66400
Total	2100	2800	8900	48400	78400
Territories					
Hawaii	0	3000	50000	70000	70000
Puerto Rico	0	0	2000	23000	50000
Alaska	0	0	0	10	10
Total	0	3000	52000	93010	120010

Source: A.L Mehring, J.R. Adams, K.D. Jacob, *Statistics of Fertilizer and Liming Materials in the United States* U.S. Department of Agriculture Statistical Bulletin 191 (Washington, D.C.: Government Printing Office, 1957).

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- Camak Family Papers
- Harry Hodgson Family Papers

International Fertilizer Development Center, Muscle Shoals, Alabama (IFDC)
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Rubenstein Rare Book and Manuscript Library, Duke University (Duke)
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- Clyde Roark Hoey Papers
- Ephemera Collection
- John N. Robson Papers

Smithsonian National Museum of American History, Washington, D.C. (NMAH)
- Warshaw Collection of Business Americana

Southern Historical Collection, University of North Carolina, Chapel Hill (SHC)
- Stephen D. Heard Papers

The Fertilizer Institute, Washington, D.C. (TFI)
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Record Group 16 – Office of the Secretary of Agriculture
Record Group 33 – Extension Service
Record Group 54 – Plant Industry, Soils, and Agricultural Engineering
Record Group 83 – Bureau of Agricultural Economics
Record Group 145 – Agricultural Stabilization and Conservation Service
Record Group 234 – Reconstruction Finance Corporation

National Archives at Atlanta, Morrow, Georgia

Record Group 142 – Tennessee Valley Authority (RG 142)

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