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Blasting the Farm: Chemical High Explosives and the Rise of Industrial Agriculture, 1867-1930

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BLASTING THE FARM: CHEMICAL HIGH EXPLOSIVES AND THE RISE OF INDUSTRIAL AGRICULTURE, 1867-1930

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Blasting the Farm: Chemical High Explosives and the Rise of Industrial Agriculture, 1867-1930

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This thesis explores the golden age of chemical high explosives in American agriculture. It argues that the interactions of ordinary farmers, chemical manufacturers, and the agricultural state reinvented chemical high explosives as implements that farmers would use to restructure and manage agricultural ecosystems. By the second decade of the twentieth century dynamite had become a normal feature of the farm. While ordinary farmers used dynamite in everyday tasks to intensify crop production, chemical manufacturers and the agricultural state further promoted dynamite farming while simultaneously bolstering secondary industries such as irrigation and other land reclamation projects associated with extensive agricultural developments. As chemical high explosives helped Americans expand agriculture into new regions, new environmental barriers to crop production emerged. These barriers necessitated further inputs of capital and energy in agricultural production which catalyzed the movement towards intensive agriculture that is intimately linked to modern industrial agricultural practices. A mechanical implements and a new form of energy, chemical high explosives helped catalyze the development of industrial agriculture in this period of American history.

Contents

Introduction

In January 1913, H. O. Daniels of the Millbrook Farm in Middletown, Connecticut, marveled at the power of dynamite before the Vermont Draymen's Association's forty-third annual meeting in Burlington, Vermont. Daniels explained how he transformed a field of "chestnut and oak timbers" into "a splendid crop of corn" in just a single year.[1] In the fall of 1910, Daniels and three hired laborers had begun the arduous task of digging up by hand the tree stumps that spotted his Connecticut farm. After a single week of work and minimal progress, Daniels abandoned the project as "too expensive a proposition." Just a few months later, Daniels discovered a new and popular method of removing stumps—dynamite. With a small investment in "300 pounds of this powerful explosive," Daniels made quick work of the pesky hardwoods that stood between him and a bountiful harvest.[2]

Daniels addressed one of the biggest problems farmers in wooded areas faced, the tree stump. The cost of labor and time required to remove these barriers to agricultural progress were so great that many farmers of the late nineteenth and early twentieth century left them in place.[3] Stump-filled land not only limited the acreage available for planting; It also prevented farmers from employing such new forms of mechanization as ridding plows, manure spreaders and eventually tractors—all of which were much less effective in stump-plagued fields. While some invested in mechanical and horse powered stump twisters, neither matched dynamite's efficiency.[4] Mitigating costs, reducing the need for labor, and clearing the way for new

[1] F. H. Bickford, *Report of the Forty-Third Annual Meeting of the Vermont Dairymen's Association at Burlington, Vermont, January 8, 9, 1913* (St. Albans: St. Albans Messenger Co., 1913), 35-39.
[2] *Ibid., 37.*
[3] "Use of Dynamite on the Farm," *American Farmer,* (December 1876).
[4] University of Minnesota Agricultural Experiment Station, *Bulletin 163: Investigations in Costs and Methods of Clearing Land,* 1916; This experiment showed that dynamite proved exponentially more efficient in removing stumps than mechanical and horse powered devices. It showed that in a single day

technological advancements, dynamite fueled farm mechanization in this period of American agricultural history.

This thesis explores the golden age of chemical high explosives in American agriculture. Invented in 1867 by Swedish chemist Alfred Nobel, dynamite, one of the earliest and most common chemical high explosives, marked a distinct shift in the history of explosive power. Chemical high explosives' utility resulted from the fact that explosives straddle the line between energy and mechanization. Much like coal and oil, high explosives' value emanated from the potential energy stored in their chemical bonds. Unlike these other forms of energy, explosives did not require an external apparatus, such as steam or internal combustion engines, to harness their power. Instead, the mechanical forces of dynamite transferred directly, by way of rapidly expanding gasses, to whatever solid matter it encountered. In the second half of the nineteenth century, manufacturers of explosives primarily marketed dynamite, nitroglycerine and other high explosives to the mining and construction industries. But in this same period, farmers gradually began to harness its "concentrated power." By 1920, farmers regularly used chemical high explosives in agriculture.[5]

This thesis argues that the interactions of ordinary farmers, chemical manufacturers, and the agricultural state reinvented chemical high explosives as implements that farmers would use to restructure and manage agricultural ecosystems. By the second decade of the twentieth century, dynamite had become a normal feature of the farm. While ordinary farmers used dynamite in everyday tasks to intensify crop production, chemical manufacturers and the

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dynamite removed 70 stumps, the horse puller uprooted 61, and the "man-powered" stump puller completed only 24.

[5] Decomposition is the term used to describe the breaking of molecular bonds, which releases energy stored within those bonds. The slower rate of black powder's decomposition results in burning while nitroglycerine's molecules decompose simultaneously producing an explosive blast; The Buffalo, Rochester and Pittsburg Railway Company, *Intensive Farming and Use of Dynamite* (July, 1911).

agricultural state further promoted dynamite farming while simultaneously bolstering secondary industries such as irrigation and other land reclamation projects. These efforts expanded the nation's total acreage of farms. A mechanical implement and a new form of energy, dynamite catalyzed agricultural industrialization in the early twentieth century.

Media coverage and promotional literature aided chemical high explosive's transition to the farm. Farmers' organizations and popular media outlets broadcast stories of inventive farmers and land clearing businesses that experimented with dynamite while state-sponsored experiment stations and agricultural colleges tested and reported on the various uses of dynamite in food production in the late nineteenth century. By the twentieth century, this knowledge proliferated, and chemical manufacturers developed farm-specific high explosives, initiated advertisement campaigns, and published promotional literature that helped further democratize explosive agriculture. At once this process aided in the reapplication of chemical high explosives in agriculture and transferred knowledge of blasting techniques, held almost exclusively by blasting engineers in the nineteenth century, to ordinary farmers who consumed no less than 20,000,000 pounds of dynamite annually by the 1920s.[6]

The importance of chemical high explosives in the rise of industrial agriculture transcends their growing popularity among farmers. The engineers of early-twentieth-century land reclamation projects utilized new explosive technologies in their efforts to repurpose idol lands into productive and well-managed farmlands. This expansion of chemical high explosives in agriculture had major environmental and economic consequences. Americans used chemical

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[6] "New Markets For Implement Dealers," *Power Farming: The Magazine of Farming With Mechanical Power* Vol. 28, No. (April 1919), 34; Davis Dyer and David B. Sicilia, *Labors of a Modern Hercules: Evolution of a Chemical Company* (Boston: Harvard Business School Press, 1990), 34, 117; Arthur Pine Van Gelder and Hugo Schlatter, *History of the Explosives Industry in America* (New York: Arno Press, 1927), 1070.

high explosives to conform irrational landscapes and environments to their rationalized visions of industrial agriculture. The Reclamation Service, established through the National Reclamation Act of 1902, furnished funding and engineering expertise as contracted laborers blasted irrigation networks to water desert farms. State and local farmers' and land clearing associations dynamited cutover forest land for farming in wooded regions and drained swamps to grow crops in the nation's low lands. Ordinary farmers, blasting their own farms, followed suit. Dynamite agriculture sterilized existing ecosystems for the sole purpose of agricultural production. While these efforts created millions of new acres of farmland, environmental barriers such as climate and soil conditions created new dependencies on mechanical implements, often distant water sources, and increasingly, chemical fertilizers required to sustain agricultural production in these environments that were historically unsuitable for cultivation.[7] Dynamite then was a marvel and a miracle, but one that would push the need for further human innovation and reinvention.

Dynamite agriculture influenced economic conditions of the 1920s. Ecological transformations with explosives created new farms and made many existing ones more productive, but this fueled economic instability in agricultural markets. Used to put maximum acreage into cultivation and to intensify farming practices, dynamite agriculture fostered overproduction. Reacting to the global food shortages of World War I, the federal government bolstered land reclamation efforts, which utilized high explosives, to restructure ecosystems for agriculture and encouraged farmers to put every available acre into cultivation. As a result, prices for land and farm products skyrocketed. Heeding the call to action, farmers purchased land at exorbitant prices and intensified production by explosive means. But by the 1920s, the war had

[7] US Department of the Interior, U.S. Geological Survey, *First Annual Report of the Reclamation Service From June 17 to December 1, 1902* (Washington: Government Printing Office, 1903); *Minutes and Papers of the Third Annual Tri-State Development Congress of Wisconsin, Michigan and Minnesota* (March 2-3, 1922).

ended and increased acreage and efficiency in agriculture outpaced global demand for farm goods. Farm prices fell, reclaimed land often failed to meet productive expectations, and many farmers suffered greatly.[8]

The use of high explosives in the development of American agriculture at times did not meet the expectations of contemporaries. In stump removal, ditch digging, and tree planting, dynamite proved largely more efficient and effective than traditional hand and animal-powered labor, but it was not a panacea for all farm troubles. Though farmers tried, dynamite could not create rain and did not counteract the nearly limitless number of factors that determined quality crop yields.[9] Even with dynamite, environmental conditions fostered economic uncertainty on American farms. While the use of chemical high explosives in reclamation projects helped water deserts and cleared stumps from cutover land, crop yields in many of the transformed regions fell short of the Reclamation Service's and U.S. Department of Agriculture's estimations. The embrace of chemical high explosives also introduced a new degree of danger to the farm that was inherent to the product. The fruits of dynamite's versatility and efficiency were often at the cost of personal safety as farmers and workers literally risked life and limb in their efforts to industrialize American agriculture.[10]

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[8] "The World Faces Famine," *Vertical Farming* Vol. 1, No. 2 (March 1915), 3; Willard W. Cochrane, *The Development of American Agriculture: A Historical Analysis* (Minneapolis: University of Minnesota Press, 1993), 114-120.
[9] Robert G. Dyrenforth, "Can We Make it Rain?," *The North American Review,* (Oct. 1891), "Rain Making in Texas," *Scientific American,* (Nov. 21, 1891); "Dynamite Rain Making," *Scientific American,* (Sep. 23, 1893).
[10] *Powers v. Harlow,* 53 Michigan, 507, (1884).

Despite the rising ubiquity of dynamite in the late nineteenth-century industrial agricultural landscape, its history has yet to be critically analyzed.[11] While works of popular history have used dynamite as a framing tool to tell broad narratives about a modernizing world, this thesis is the first scholarly history of dynamite's applications in industrial agriculture and joins with scholars exploring the vast implications of changing sources of energy in the late nineteenth century.[12] Chemical high explosives supplanted black powder and supplemented human and animal power beginning in the second half of the nineteenth century, providing contemporaries with access to energy previously unattainable. Historians have traditionally emphasized the importance of coal, oil, and electricity as improvements over energy sources such as wind, water, and wood while also studying the role of the government in promoting new industries.[13] Bringing dynamite into these conversations elevates the importance of new forms of energy in America's burgeoning industrial economy and in turn expands traditional understandings of new energy to include explosives.

The rise of chemical high explosive agriculture also shows the importance of chemical innovation to the processes of farm mechanization. Traditionally, scholars of industrial agriculture argue that mechanical innovation preceded both chemical and biological

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[11] The one exception to this is Louis Adamic's, *Dynamite: The Story of Class Violence in America* (New York: The Viking Press, 1934). Adamic uses dynamite as a lens to the history of class violence and labor unrest in the late nineteenth and early twentieth century.
[12] Stephen R. Brown. *A Most Damnable Invention: Dynamite, Nitrates, and the Making of the Modern World* (New York: Thomas Dunne Books, 2005) positions dynamite and nitrates as central to a broad range of "modern developments." This is a global history that begins in 424 b.c. and concludes in 2005. Largely a historical narrative, this book does not access the direct application of dynamite or chemical high explosives in agriculture.
[13] Harold L. Platt, *The Electric City: Energy and the Growth of the Chicago Area, 1880-1930* (Chicago: University of Chicago Press, 1991); Paul Sabin, *Crude Politics: the California Oil Market, 1900-1940* (Berkeley: University of California Press, 2005); Thomas Andrews, *Killing for Coal: America's Deadliest Labor War* (Cambridge: Harvard University Press, 2008).

developments on the farm.[14] But farmers employed chemical high explosives to remove stumps and facilitate the implementation of new mechanical technologies as early as the 1870s. Studying explosives as chemical energy reveals the overlap between mechanical and chemical developments on the American farm and in turn uncovers the importance of chemical technology in both periods of farm development.

This thesis also places the rise of industrial agriculture in conversation with the expansion of the bureaucratic state. As in other industries, late-nineteenth- and early-twentieth-century Americans looked for ways to streamline, organize, and professionalize agricultural production. Generally, scholars contend that these trends gave rise to the bureaucratic state, which in agriculture manifested in the establishment of the Reclamation Service, the United States Department of Agriculture, experiment stations, and extension services.[15] Analyzing high explosives, this thesis shows how efforts to streamline agriculture went beyond the development of bureaucratic structures and translated in the reorganization or rationalization of nature as farmers used dynamite to create highly managed agroecosystems.[16]

Studying chemical high explosives as both energy and technology, this thesis problematizes the role of new energy in the history of technologies like irrigation and the railroads. Scholars have stressed the importance of railroads networks in shaping rural and

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[14] Willard W. Cochrane, *The Development of American Agriculture: A Historical Analysis* (Minneapolis: University of Minnesota Press, 1993); Yujiro Hayami and Vernon Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985).

[15] For examples see: Robert Wiebe, *The Search for Order, 1877-1920* (New York: Hill and Wang, 1967); Gary Gerstle, *Liberty and Coercion: The Paradox of American Government from the Founding to the Present* (Princeton: Princeton University Press, 2015); Willard W. Cochrane, *The Development of American Agriculture: A Historical Analysis* (Minneapolis: University of Minnesota Press, 1993)

[16] While modern scientists use the term agroecology in many different ways, a general summation of the term is "the science of the relationships of organisms in an environment purposefully transformed by man for crop or livestock production." For more on agroecology and agroecosystems see Konrad Martin and Joachim Sauerborn, *Agroecology* (Dordrechts: Springer Science and Business Media, 2013).

western development, highlighted the role of irrigations systems in creating socioeconomic dependencies on engineering expertise, and detailed the environmental consequences of such projects.[17] The importance of these developments is undeniable, but scholars have all but ignored the significance of new forms of chemical energy in the construction of these works. Historians have also argued that railroads contributed to the opening up of new lands, promoted western settlement, supported scientific agriculture, and introduced a capitalist logic to a North American hinterland.[18] This emphasis has overshadowed the importance of other technological advances, specifically within the realm of agricultural history. Chemical high explosives provide a window into the ways in which burgeoning chemical companies such as E. I. du Pont de Nemours and Company and Hercules Powder Company also contributed to these developments directly through booster campaigns, collaboration with government experiment stations and agricultural colleges, publication of informational literature, and indirectly through the creation of a product that aided countless industrial developments upon which industrial agriculture depended.

Chemical high explosives provide an ideal lens to explore American agriculture in this period of significant change. The nature of agricultural work, varying from region to region, state to state, and even farm to farm, makes writing a national narrative difficult. But dynamite's versatility in application made it popular with farmers across the country. Further, the history of explosive agriculture reflects themes of nineteenth-century optimism as it related to burgeoning scientific discoveries and Joseph Schumpeter's idea of "creative destruction." Creative

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[17] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985); Donald J. Pisani, *From the Family Farm to Agribusiness: The Irrigation Crusade in California and the West, 1850-1931* (Berkeley: University of California Press, 1984); Orsi, *Sunset Limited* (Berkley: University of California Press, 2005).
[18] William Cronon, *Natures Metropolis: Chicago and the Great West* (New York, W.W. Norton and Company, 1991); Richard White, *Railroaded: The Transcontinentals and the Making of Modern America* (New York: W.W. Norton and Company, 2011); Richard J. Orsi, *Sunset Limited: The Southern Pacific Railroad and the Development of the American West* (Berkley: University of California Press, 2005).

destruction is traditionally understood as "the necessity of capitalism always to uproot the old in order to institute the new."[19] This thesis employs a more literal usage of the phrase "creative destruction" to describe the literal destruction, wrought by chemical high explosives, which cleared the way for industrial capitalist expansion. As farmers, chemical manufacturers, and the state creatively reinvented dynamite as a farm implement, they redefined the nature of farm labor and eroded landscapes in their economically motivated efforts to industrialize American agriculture.

Chapter One explores the history of dynamite on the American farm from its early and sporadic applications starting in the 1870s through its much more extensive use in the age of agricultural extension up to 1920. It argues that the interactions of ordinary farmers, chemical manufacturers, and the agricultural state gradually reinvented dynamite as a farm tool. It investigates the ways in which farmers, across the ecologically and geographically diverse regions of North America, employed chemical high explosives in conjunction with other forms of mechanization and how, as a new form of energy, it aided American farmers' ability to overcome environmental barriers to productivity that were inherent to their specific regions. It also reveals the importance of the agricultural state and chemical manufacturers in further propagating dynamite's agricultural uses. By World War I, these actors elevated dynamite agriculture from its experimental stage into a common practice as they regularly used dynamite to meet wartime demands for food.

Chapter Two focuses on the importance of chemical high explosives in land reclamation projects that directed the course of agricultural development. It argues that new high explosives aided the construction of irrigation works, cutover land reclamation, and small-scale

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[19] White, *Railroaded,* xxv.

improvements on individual farms. These actions created highly managed ecosystems intended for crop production. At times, these changes facilitated mechanization, created new dependencies of chemical fertilizers, and fueled the overproduction of farm products that plagued agricultural markets throughout the 1920s. The development of these lands in turn revealed the limitations of explosive energy in land reclamation, highlighting the uncalculated labors of the agricultural state and ordinary farmers who overestimated the potential productivity of lands reclassified as suitable for farming.

Due to the limitations of a master's thesis, a lack of sources, and restrictions on time, this project gives only limited attention to the importance of chemical high explosives in other industrial development such as mining, construction, and infrastructural projects beyond irrigation. While this project investigates the broad consequences of World War I on agricultural production and the reception of explosive farm techniques, it does not examine the military history of these products and the role they played in the changing nature of warfare in this period. Instead, the goal of this thesis is to illuminate the processes through which chemical high explosive shaped modern agricultural practices and to raise new questions about the sustainability and ecological viability of these developments.

Chapter 1:

Breaking New Ground: The Democratization of Chemical High explosives in American Agriculture

"Yesterday irrigation was the big word in agricultural development; today the biggest term in the farming vocabulary is dynamite." In 1911, almost half a century after Alfred Nobel invented dynamite, Samuel Wesley Long, contributor to *National Magazine,* praised the valuable offerings of dynamite in the development of American agriculture. Admiring dynamite's ability to pacify common farmland nuisances such as "stumps, boulders, hardpan, worked-out top-soil" and "swamp land," Long explained that "this land can be made to laugh into harvest when awakened from its sleep by the dynamite blast."[20] In using chemical high explosives as farming implements, farmers of the late nineteenth and early twentieth century addressed these barriers to agrarian expansion in new and profound ways, and by the 1920s, farming with dynamite helped create the productive farmlands that spanned North America's diverse geography.

Before Americans imagined dynamite as a farm tool, the nation's mining and construction industries used chemical high explosives to extract resources, erect cities, and establish the country's infrastructural networks. These developments were largely made possible through chemical high explosives' versatility in commercial applications. As William S. Dutton, historian of the E. I. Du Pont de Nemours and Company, explained in 1942, "Dynamite is distinctly an industrial tool. It may be used incidentally in war as a demolition agent, but it cannot be fired successfully in guns."[21] As such, the history of dynamite closely follows that of the major industrial developments in the postbellum United States.

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[20] "Greater than Irrigation," *National Magazine* (May 1911), 319.
[21] William S. Dutton, *Du Pont: One Hundred and Forty Du Pont: One Hundred and Forty Years* (New York: Charles Scribner's Sons, 1942), 152.

Not initially intended for agricultural work, dynamite underwent a series of reinventions before it came to impress twentieth-century commentators like Samuel Wesley Long. The interplay and exchange between ordinary farmers, chemical manufactures, and critical arms of the agricultural state that occurred over the half century from the invention of dynamite to the end of World War I reinvented dynamite as a tool for the farm. Publicity of the media, farmers' organizations and cooperatives, government publications, and business advertisement campaigns aided this process, and by the 1920s, these developments normalized dynamite agriculture.

Facing economic hardships throughout the nineteenth century, many farmers used dynamite to address the demands of changing economic, social and cultural life.[22] This tumult released creative energies across rural America, which in some cases manifested as the reimagination of dynamite as a farm implement that aided farmers' broader efforts to save time, labor, and money in the movement towards farm mechanization in this period.

By the late 1880s, state and federal governments established agricultural colleges and experiment stations to generate knowledge of the agricultural sciences and disseminate information about best practice. While colleges researched and published literature, federal county agents demonstrated the new techniques for American farmers.[23] Where at once the innovation of individual farmers inspired new publicly funded experiments, so too did extension work further inspire farmers to employ these new techniques. Chemical manufacturers engaged in this process of knowledge production as well. Advertisement campaigns portrayed dynamite and other blasting elements as universally effective farm tools, which stirred interest among farmers and inspired new testing at agricultural experiment. Manufacturers emphasized the

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[22] Willard W. Cochrane, *The Development of American Agriculture: A Historical Analysis* (Minneapolis: University of Minnesota Press, 1993), 93-94.
[23] Jeffery W. Moss and Cynthia B. Lass, "A History of Farmers' Institutes," *Agricultural History* Vol. 62, No. 2 (Spring 1988), 150-151.

safety of their products and even developed farm-specific high explosives. [24] These efforts helped transfer knowledge, exclusively held by highly experienced explosives engineers in the nineteenth century, to farm laborers who were hesitant to embrace explosive because of safety concerns and dynamite's reputation as a tool for political radicalism.[25]

In 1914, the outbreak of World War I further exacerbated interest in dynamite agriculture as global food shortages catalyzed efforts to put maximum acreage under cultivation.[26] Expanding experiment station activity, new advertisement campaigns, and increased demonstration work exposed a large number of American farmers to the fruits of dynamite's labors. Dynamite became the explosive of the Homefront portrayed as both essential to national prosperity and useful in addressing farmers' desires to modernize their farms.

At once, chemical high explosives reshaped farming practices, facilitated farm mechanization, and recast Americans' perception of dynamite. This was a vital component of

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[24] Nearly all of the E.I. du Pont de Nemours and Company's promotions of agricultural explosives addressed the safety of their products. For examples see, E.I. du Pont de Nemours and Company, *Farming with Dynamite: An Improvement in Farming that is Proving Greater than Irrigation* (Wilmington: 1911); E.I. du Pont de Nemours and Company, *The history of the E.I. du Pont de Nemours Powder Company: A Century of Progress* (New York: Business America, 1912); "Improved Red Cross Dynamite," *Du Pont Magazine* Vol. 2, No. 2 (February 1914), 3; "Safe Handling of Dynamite," *New Farms for Old Through Deep Plowing, with Du Pont Red Cross Low Freezing Dynamite* (Wilmington, 1911), 31; "Safe Handling of Dynamite," *Du Pont Farmer's Handbook: Instruction in the Use of Dynamite for Clearing Planting and Cultivating Trees, Drainage, Ditching and Subsoiling* (Wilmington, 1912), 108.

[25] For examples see: For examples, see Louis Adamic, *Dynamite: The Story of Class Violence in America* (New York: The Viking Press, 1934); James Green, *Death in the Haymarket: A Story of Chicago, the First Labor Movement and the Bombing that Divided Gilded Age America* (New York: Anchor Books, 2006).

[26] Cochrane, *The Development of American Agriculture,* 99. For examples of how explosives manufactures engaged the agricultural markets see E.I. du Pont de Nemours and Company, *Farming with Dynamite: An Improvement in Farming that is Proving Greater than Irrigation* (Wilmington: 1911), 21, 23; Davis Dyer and David B. Sicilia, "Demobilization and Diversification, 1918-1920," *Labors of a Modern Hercules: Evolution of a Chemical Company* (Boston: Harvard Business School Press, 1990), 111-141; E.I. du Pont de Nemours and Company, *The history of the E.I. du Pont de Nemours Powder Company: A Century of Progress* (New York: Business America, 1912); *Du Pont Magazine* Vol. 2, No. 2 (February 1914); Du Pont, *New Farms for Old* (Wilmington, 1911), and Du Pont, *Du Pont Farmer's Handbook* (Wilmington, 1912).

agricultural industrialization as chemical high explosives helped to reshape both the nature of farm labor and the physical appearances of the farms upon which this labor was conducted. Employed as a time and laborsaving devise, dynamite facilitated farm mechanization. In application, dynamite increased inputs of capital and energy to expand production. The very nature of chemical high explosives as a physically destructive device was also important. Associations with violence, embodied in the early days of dynamite's existence, were never removed from American consciousness, but dynamite was no longer exclusively associated with radical foreigners pursuing social and political gains by the 1920s. At least for the farmers, it became a means of achieving economic security facilitated by the violent expansion of chemical gases that crumbled barriers to nature's commodifiable goods.

An Industrial Explosive, 1867-1877

On September 24, 1876, the explosive powers of dynamite calmed Hell Gate, a tidal straight that terrorized vessels in New York's East River. On the downstream side of Long Island Sounds, Hallett's point and the waters of Hell Gate "formed the principle obstruction to New York Harbor" until 1876.[27] As early as 1665, sailors dreaded this perilous passage, and in 1872, it was estimated that nearly 1000 ships a year "were wrecked or seriously damaged" while navigating its waters. That same year, a contributor to the *Science Record* lamented, "More harm is suffered and more risks incurred here in a space of 2000 yards, than in all the rest of the navigable waters this side of New-York to the farthest extremity of the Sound."[28]

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[27] "How Gen. Newton Raised Hell-Gate," *Indiana School Journal: Organ of the State Teachers' Association and of the Superintendent of Public Instruction* Vol. 21 (Indianapolis, 1876), 515, 516;
[28] Alfred Ely Beach, ed., "The Government Work at Helgate," *Science Record For 1872: A Compendium of Scientific Progress and Discovery During the Past Year* (New York: Munn and Company, Office of the "Scientific American," 1872), 10-12.

Contemporaries saw Hell Gate and Hallett's Point as a danger to their ships and as a major barrier to economic development. While the erratic currents of Hell Gate proved hazardous to ships of all sizes, it was the shallow depths as low as eight feet that stood as the primary barrier for large vessels. The exclusion of larger ships from entering New York Harbor proved "hurtful to commerce." In 1851, Mons. Maillefert made the first attempt to tame Hell Gate. Granted $15,000 by the New York City Chamber of Commerce, Maillefert embarked on a three-year effort to remove Pot Rock, Frying Pan, and Way's Reef—three aquatic features that barred entry to the port. Detonating submerged charges of black powder, Maillefert crumbled the reefs and calmed Hell Gate's currents. But the shallow depths of the passage continued to bar entry.[29] It was clear the powers of black powder were not enough to overcome the natural barriers to the development of New York Harbor.

After the Civil War, discussion of Hell Gate's conversion "into a safe highway for commerce" emerged once again. In 1868, the War Department assigned Brevet Major-General Newton to the project and granted him $85,000 from a congressional fund established for the purposes of public works in rivers and harbors. Armed with recently invented chemical high explosives, Newton engaged in a seven-year improvement project that finally overcame the environmental barriers to New York Harbor. At completion, Newton and his workers used 28,901 pounds of dynamite and 9,061 and a half cartridges of rendrock, another nitroglycerin-based explosive, to erode the river bottom to new depths. According to the project's final report, the high explosives successfully altered the passage allowing vessels that drew "12 feet of water" to pass within 70 yards of the shore and ships drawing 19 feet to "pass within 100 yards."[30]

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[29] *Ibid.,* 12.
[30] "The Great Blast," *The Sailor's Magazine and Seamen's Friend* Vol. 28, No. 11 (November 1876), 336-337.

The conversion of the Hell Gate tidal straight into a navigable waterway is emblematic of dynamite's increasingly common role in late-nineteenth-century industrial development. Constructing New York's Catskill aqueduct, workers used over 17 million pounds of dynamite, and California's Los Angeles aqueduct depended on the use of gelatin dynamite's to excavate the irrigation project's 26,870-foot Elizabethan Tunnel with record breaking speed.[31] These new and powerful explosives were also imperative to the construction of the nation's railways where between 1870 and 1890, workers laid 114,955 miles of new tracks with the help of dynamite and other high explosives. In 1898, Henry de Mosenthal, contributor to *Eclectic Magazine of Foreign Literature,* professed, "The invention of dynamite marks an epoch in the history of civilization."[32] By 1900, it was clear that the chemical energies of high explosive laid the foundation for many of the United States' major industrial works.

Following its invention in 1867, dynamite was primary used in mining and construction ventures. Less than a year after Alfred Nobel patented his new explosive, he licensed Julius Bandmann and the Giant Powder Company of San Francisco, California, to manufacture and sell his dynamite, and small powder firms across the country began to produce their own unique formulations of the high explosive. Dynamite soon gained popularity among construction workers and mining engineers who marveled at dynamite's superiority to black blasting powder, and by the late 1870s, dynamite disrupted the explosives market enough to catch the attention of major black powder producers such as E. I du Pont de Nemours and Company and Laflin and Rand Powder Company. Du Pont and Laflin & Rand joined forces to create the Repauno

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[31] *Los Angeles Aqueduct-Final Report, 1916,* 22, 145; Dyer and Sicilia, *Labors of a Modern Hercules,* 34.
[32] "The Inventor of Dynamite," *Eclectic Magazine of Foreign Literature* (November 1898), 694; For information on the use of dynamite in the construction of the Catskill and Los Angeles aqueducts see: Dutton, *Du Pont,* 115; By the 1920s, minerals amounted to 53.4 percent of the total carload tonnage of railroads. For more see Arthur Pine Van Gelder and Hugo Schlatter, *History of the Explosives Industry in America* (New York: Arno Press, 1927), 1041.

Chemical Company in 1879. Through Repauno, the companies brought dynamite into the well-organized explosives market they had established through the Gunpowder Trade Association, which fashioned regional markets and minimum price controls to ensure stability and restrict unwanted competition.[33] Because early demand originated primarily from construction and mining operation, these became the target markets for nineteenth-century chemical manufacturers. As chemical high explosives flourished in these industries, it caught the attention of farmers and land reclamation companies that explored the potential the benefits of dynamite in their own professions.

Dynamite Reimagined, 1877-1887

"Now that Hell Gate is blown up, some ingenious individual has set to work to see what can be done in the same line with that universal farm nuisance" reported the *Independent Stateman* in 1877. Inspired by dynamite's ability to bring economic opportunity to New York Harbor, this inventive farmer explored the explosive's merits against his own barriers to economic success—the stump. Blasting out his stumps with dynamite, this individual completed what "would have been a hard days work for two or more good men" in half a day. He "proved not only the thorough effectiveness of the new method, but its economy in cost and in time." [34] Ordinary farmers were one of the first groups to explore the merits of dynamite agriculture. Between 1865 and 1896, the prices of farm products in large part declined as wheat prices fell

[33] E.I. du Pont De Nemours & Company, *The History of the E.I. du Pont de Nemours Powder Company: A Century of Progress* (New York, Business America, 1912), 131-134; Donald Andrew Grinde, Jr., "The Gunpowder Trade Association: A Search for Stability, 1872-1912" (PhD diss., University of Delaware, 1974), 106-107; Van Gelder and Schlatter, *History of the Explosives Industry* (New York: Arno Press, 1927), 408-409; Dyer and Sicilia, *Labors of a Modern Hercules,* 38-39.
[34] "Stump Blasting," *Independent Statesman* (February 15, 1887), 155.

over 75 percent and corn prices drop nearly 66 percent.[35] Plagued with extended economic depression, ordinary farmers reimagined dynamite as a farm implement to save time and labor.

By the 1920s, dynamite shaped the face of agriculture as an industry in the United States, but before this transformation happened, dynamite underwent a series of reinventions. Individuals like the unnamed farmer and farmers' organizations creatively employed dynamite in their own economic pursuits reapplying it as a tool for the farm. These applications inspired others to reimagine dynamite's potential and fueled further reinventions creating the process through which dynamite came to be widely accepted as an agricultural implement.

For most of the mid to late-nineteenth century, local and regional farmers' institutes informed farmers about the latest methods of farming with informational lectures and literature. As early as the 1850s, state boards of agriculture took an interest in establishing and promoting farmers institutes with the explicit purpose of delivering lectures on best practice and the science of agriculture. Federally, the government supported American farmers in the early 1860s through the transfer of public lands to the states for the establishment of agricultural colleges as well as through the establishment of the United States Department of Agriculture, which for most of the 1860s, 70s, and 80s distributed seeds to farmers across the country.[36] The media also spread information through trade journals and newspapers. In sharing information about creative reinventions of dynamite, the media, along with farmers' institutes were crucial to dynamite's reapplication. Though the state and media played an active role in prompting new methods of agriculture in the second half of the nineteenth century, it was ordinary farmers who first reimagined dynamite in their efforts to cleanse their farms of tree stumps and boulders.

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[35] Cochrane, *Development of American Agriculture,* 93, 96, 240-242.
[36] Alfred Charles True, *A History of Agricultural Extension Work in the United States, 1785-1923* (Washington: U.S. Government Printing Office, 1928), 5; Gerstle, *Liberty and Coercion,* 191.

In the nineteenth and early twentieth century, tree stumps and boulders were one of the most common challenges that farmers faced in their pursuits of bountiful harvests. According to the agricultural census of 1870s, unimproved woodland comprised 159,310,177 of the nation's 407, 735,041 total acres of farmland.[37] With nearly forty percent of the United States' farms being unimproved woodlands, it was a commonly held belief that there was "no greater obstacle to farm operations" than stump and rocks.[38] Stumps and boulders posed a variety of challenges for farmers. They occupied valuable real estate that could otherwise be put under the plow, and the removal of these woodland obstructions was costly and labor intensive. Some farmers attempted to remove the stumps and rocks with shovels and axes, but many farmers could not afford to invest the time and labor. For farmers with working livestock or a mechanical stump puller that twisted their stumps and dislodged their boulders, the issue of chopping up the stump and crushing the rocks into manageable pieces for removal still remained. When faced with large stumps and stones, these methods often proved fruitless. It was not uncommon for removal to take well over half a day to complete. In many cases, the task proved so labor intensive and expensive that farmers let the stumps rot before investing in their removal and simply left the boulders in place.[39] But as popular praise for dynamite's utility in other industries flourished in the 1870s, farmers began to reimagine the ways in which this high explosive could be used to rationalize the rocky woodlands landscapes that were their farms.

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[37] Bureau of the Census, *The Statistics of the Wealth and Industry of the United States*: *Embracing the Tables of Wealth, Taxation, and Public Indebtedness; of Agriculture; Manufactures; Mining; and the Fisheries* (Washington: Government Printing Office, 1872), 81.
[38] "Stump Blasting," *Independent Statesman* (February 15, 1887), 155; "Use of Dynamite on the Farm," *American Farmer* (December 1876), 5.
[39] "Use of Dynamite on the Farm," *American Farmer* (Dec 1876), 5; "The Use of Dynamite for Removing Stumps," *Southern Planter,* (January 1899).

In addition to domestic industrial progress, land clearing operations in Great Britain also prompted the reapplication of dynamite. In 1874, the Glasgow Canadian Land and Trust Company conducted experiments on the property of Sir W. S. Maxwell in Glasgow, Scotland, exploring dynamite's merits in land reclamation. Mr. John Scott, manager of the company, tested "the utility of the material [dynamite] for land reclamation in Canada" pitting dynamite against entrenched stumps and whinstone boulders. Dynamite emerged victorious, prompting new optimism for Scott who felt confident that "he could use the new blasting agent with great effect and economy in land-clearing operation."[40] Though the arbiters of this experiment had their eyes set on the Canadian wilderness, their study reached American newspapers such as the *New York Times, Scientific American,* and *Galaxy.*

In October 1875, a contributor to the popular religious publication the *Christian Union,* reported on successful land clearing efforts in Ireland explaining, "We have seen dynamite used with perfect success in blowing stumps to pieces preparatory to the final clearing of forest-land."[41] A New York based publication known as *The Friend* also discussed these early European experiments in August 1876, highlighting the demonstrations of Robert McArthur and J. C. Aitken of the British Dynamite Company. Like John Scott, they were interested in dynamite's land clearing capabilities. McArthur and Aitken showed the "rapidity with which tree stumps and stones could be cleared from land."[42] Dynamite furnished fruitful results. As one contributor to the *American Agriculturalist* broadcast in 1876, "Dynamite or giant powder has been extensively used in clearing land of stumps and stones in England and Scotland, and it is

[40] "Dynamite for Land Reclamation," *Country Gentleman's Magazine,* Vol. 2 (1874), 366-367; "Dynamite as a Stump Puller for Land Reclamation," *Scientific American* (May 1874), 341; "Land Clearing With Dynamite," *Galaxy,* Vol. 18 (June 1874), 128; "Experiments with Dynamite," *New York Times* (July 18, 1876), 3. .
[41] "The Uses of Dynamite in Clearing Land," *Christian Union* (Oct. 1875), 336.
[42] "Experiments with Dynamite," *The Friend* (Aug. 1876), 38.

more effective than common powder. It will doubtless be found useful here for the same purpose."[43]

These events inspired American farmers to try it for themselves. The following year the *American Agriculturalist* received a "large number of quarries" from farmers interested in further information about dynamite's land clearing capabilities. Eager to oblige, officials at the publication cooperated with the Atlantic Giant Powder Company to further explore dynamites uses as a stump and rock remover on American farms.[44] Though the manufacturer of the explosives and media officials conducted this early experiment, the requests of farmers, intrigued by dynamites potential, fueled this reinvention of dynamite as a tool for agricultural land improvement.

With the aid of the media, these isolated incidents of reinvention translated into the wide reception of dynamite as a stump and rock remover in the late nineteenth century. Ex-sheriff and farmer John T. Pressly, used dynamite to remove "40 huge stumps" from 40 acres of his Indiana farm in 1881. According to the media reports, dynamite was "entirely satisfactory, and every stump was blown to atoms." In 1887, John Hill of Logansport, Indiana hired 23-year-old Henry Pletecher to blast the stumps on his farm. Unfortunately for Henry, an accidental explosion cost him his life. In 1899, A. M. Goodman of Rochester, New York secured dynamite for the removal of stumps on his farm, but before he completed the task, an accidental explosion, allegedly caused by "mice endeavoring to eat the explosive," leveled his new farmhouse. These accidents fostered new fear and anxiety that hampered dynamite's agricultural proliferation. As farmers gradually engaged in the practice, the perils of handing explosives became evidently clear.

Despite the danger, many farmers continued to utilize the explosive farm tool.

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[43] "The Use of Dynamite for Removing Stumps and Stones," *American Agriculturalist* (Jul. 1876), 275.
[44] "Clearing Land By Blasting," *American Agriculturalist* Vol. 36, No. 360 (January 1887), 19.

In 1899, Albert Bellwood recounted his experiences removing stumps for the *Southern Planter.* Bellwood explained that "dynamite can be employed to great advantage in disposing of large stumps." He detailed the steps necessary to place a charge of dynamite under a stump and to properly set the blasting cap and fuse. Bellwood exclaimed, "there is no good reason why a farmer should lose the land [the stump] occupies and plow and run his machinery around it for twenty or thirty years."[45] Albert Bellwood conveyed dynamite's utility in the broader processes of farm mechanization explaining the limits that stumped land placed on farmers' mechanical implements such as the plow. Dynamite allowed ordinary farmers to further mechanize their farms, and the widespread media coverage of their actions further promoted dynamite agriculture.

By the late 1880s, farmers' institutes began taking a more active role in spreading information of dynamite's new applications as well. In a lecture titled "Origins of the Pine Stump Farm," presented February 8, 1889 in Big Rapids, Michigan, W.M. Ladner discussed the reality of farming in cutover regions of the north. Following the lecture, rigorous debate ensued as Ladner and lecture attendees argued the merits and limitations of dynamite as an affordable and effective stump remover. These discussions were not limited to the northern states. On a rainy Missouri Monday in 1891, Otho McCrackin, Will Sims, and T. W. Herring of the Callaway Country Farmers' Institute organized a demonstration of dynamite's capabilities as a stump and rock remover in wet conditions. According to the Institute's report, "The test was highly gratifying" with 13 of the 16 charges of dynamite exploded being "entirely satisfactory."[46] In the

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[45] "A Field Cleared With Dynamite," *New York Times* (February 7, 1881), 2; "His Last Dynamite Blast," *New York Times* (September 2, 1887), 3; "The Use of Dynamite for Removing Stumps," *Southern Planter* (January 1899), 60; "Mice Nibbled Dynamite," *New York Times* (November 24, 1899), 3.

[46] *Twenty-Eight Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan From July 1, 1888 to June 30, 1889* (Lansing: Darius D. Throp, State Printer and Binder, 1889), 402-404;

early decades of dynamite agricultural, institutes primarily reported the efforts of outside individuals, but by the late 1880s, institutes became actively involved in generating new experiments and information about the advantages of using dynamite on the farm as well.

To a limited extent, state boards of agriculture also aided in the dissemination of information. In 1878, the Connecticut State Board of Agriculture's reported on dynamite stump and rock removal in Litchfield, Connecticut where local farmer, Mr. Starr, welcomed Mr. Parmelee, an independent blaster, onto his farm to remove boulders. Having no prior experiences with the explosive, Starr invited Parmelee to demonstrate his craft on a field he intended to clear. Mesmerized by the results, he hired Parmelee to continue his work for two and a half days. Mr. Starr explained that "the same number of men…could not have accomplished in a month what he accomplished in two days and a half."[47] Parmelee demonstrated dynamite agriculture's economy in cost and time, impressing the Connecticut agricultural board. As early as 1867 the Connecticut State Board of Agriculture actively promoted extension work, organized lectures, and distributed informational literature with stories like Starr's.[48] These materials catalyzed new progressive farming techniques like dynamite land clearing. Though these organizations were not yet engaged in experimentation, they indirectly served as a conduit through which information reached farmers across the country.

For most of the nineteenth century, ordinary farmers were responsible for the reinvention of dynamite as a viable farm tool in America. Primarily applied in stump and rock removal, dynamite was a means through which many rural individuals actively addressed and creatively

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Twenty-Fourth Annual Report of the State Board of Agriculture of the State of Missouri For the Year 1891 (Jefferson City: Tribune Printing Company, 1892), 115.

[47] *Eleventh Annual Report of the Secretary of the Connecticut Board of Agriculture* (Harford: Case, Lockwood, and Brainard Co., 1878), 90-93; "Clearing Out Rocks," *New York Observer and Chronicle* (August 1876), 280.

[48] True, *A History of Agricultural Extension,* 8-9, 14.

sought solutions the many problems they faced in the agricultural spheres of the postbellum United States. The ways in which farmers used dynamite to rationalize landscapes in their attempts to decreased inputs of time, labor, and money reveals the degree to which financial troubles motivated many rural Americans to redefine farm labor. In many ways, the efforts of these individuals catalyzed the further development of explosive agriculture as state and federal governments became increasingly interested in the professionalization of scientific agriculture in the closing decades of the century.

Developing the Agricultural Sciences, 1887-1900

The passage of the Hatch Act in 1887 marked a distinct shift in the establishment of the agricultural sciences. By 1886, private entrepreneurs and land grant colleges had furnished experiment stations in twelve states. In the nation's capital, members of Congress discussed efforts to secure federal funding for these experiment stations as early as 1883, but it was not until March 2, 1887, when President Cleveland signed the Hatch Act into law that the federal government allotted funds for the purposes of scientific experimentation in agriculture. This act "provided $15,000 a year from the sales of public lands, to be given to each state and territory for experiment station work."[49] Connected to the land grant colleges, these experiment stations were the primary testing ground for the agricultural sciences, and despite institutional turmoil, explored dynamite's agricultural applications beyond stump and rock removal.

The Hatch Act of 1887 was the result of seventy years of agitation within the agricultural community for the establishment of formal institutions of education. The impetus for agricultural education in the nineteenth century began in the 1820s with the organization of local agricultural societies. These local organization eventually associated to form state-level orders

[49] Fred A. Shannon, *The Farmer's Last Frontier: Agriculture, 1860-1897* (New York: Farrar and Rinehart, 1945), 280-281.

that joined forces in 1852 to establish the United States Agricultural Society. These organizations lobbied the federal and state governments to create institutions of agricultural learning. Amidst the chaos of the Civil War, Congress answered with the Morrill Act, which established agricultural colleges across the country. While the act successfully created new institutions, efforts to educative rural Americans in best farming practices were dismal. The state of agriculture was so poor that in 1875 Congress formally authorized the United States Military to distribute 2,000,000 rations to over 100,000 farmers in Minnesota, the Dakota territory, Nebraska, Kansas, Iowa, and Colorado.[50] The primary reason for the bleak performance was the lack of foundational knowledge. Prior to 1862, agricultural science had not existed as a discipline in the U.S., and as a result, there was neither the structured curriculum or qualified instructors required to address the needs of farmers. Between 1862 and 1887, the agricultural colleges had little effect on the state of agriculture.[51]

The Hatch Act was of vital importance to the establishment of the agricultural sciences, but internal struggles in the early years of the experiment stations' existence hindered research efforts. Classical chemists, the old guard of agricultural education, argued for curriculum grounded in the principles of agricultural chemistry based on the studies of German scientist Justus Liebig. But by the time Congress passed the Hatch Act in 1887, new progressive minded agriculturalists were pushing for scientific research and exploration in practical agricultural practices. This included proper plowing techniques, mechanization, and even genetics. These differing visions of agricultural education gridlocked research efforts at the colleges and experiment stations for nearly a decade. Despite the conflict, forty-six experiment stations had

[50] Cochrane*, Development of American Agriculture,* 93, 97.
[51] Cochrane, *Development of American Agriculture,* 96, 240-242; Gerstle, *Liberty and Coercion,* 191

issued a total of "45 reports and 237 bulletins" containing information on best practices in agriculture by 1893.[52]

Through the end of the nineteenth century, work at the experiment stations, especially when it came to exploration of chemical high explosives, was to a large degree reactionary. As experiment station researchers worked to establish a knowledge base for the agricultural sciences, a select few stations overcame the internal conflicts to address the troubles of their constituents. The 1894 report of the Agricultural Experiment Station of the University of California explained that the organization was "designed for the benefit of the agricultural public," which was reflected in the organization's soil examination programs that inspected soil samples sent in by ordinary farmers and published the results of the finding in annual reports.[53] The ingenuity of individuals inspired further experimentation in the agricultural sciences, but to a large degree, the stations minimally studied dynamite in the nineteenth century. Instead, the experiment stations developed the base of scientific research required for the broader development of the agricultural sciences. In the limited extent it was studied, dynamite, as a tool for the farm, took on new meaning as station employees tested chemical high explosive's capabilities in new scientific studies beyond land clearing.

In 1897, the agricultural experiment station in Oregon explored the merits of subsoiling and its relationship to drainage in one of the first instances where an experiment station directly studied the uses of chemical high explosives. "Subsoiling" the annual report explained, was "intimately connected with drainage" because the purpose of subsoiling was to loosen

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[52] Cochrane, *Development of American Agriculture,* 281, 288; Jeffrey W. Moss and Cynthia B. Lass, "A History of Farmers' institutes," *Agricultural History,* Vol. 62, No. 2 (Spring, 1988), 150; Cochrane, *Development of American Agriculture,* 106, 244.
[53] University of California College of Agriculture, Agricultural Experiment Station, *Report of the Work of the Agricultural Experiment Stations of the University of California For the Years 1892-93 and part of 1894* (Sacramento: State Office, 1894), 1.

undesirable compact subsoils that would otherwise be impervious to water. This was important because soil composition determines moisture content, and moisture content was one of the most important factors in determining crop yield. The experiment station researchers discovered that some farmers in the eastern part of the state had used dynamite "as a means of breaking the hard-pan so that water can drain through" their soil. The scientists found the practice to be fruitful in areas with compact soils but explained that "open porous subsoil cannot be benefitted by having the soil made more open."[54] Addressing the variability of soil types that existed across the state, the Oregon scientists acknowledged that individual farms often have a variety of different soils. They found that what might be considered best practice in agriculture on one person's farm could be detrimental to another individual's work. They engaged both in the development of foundational agricultural knowledge and showed how individual reinventions of dynamite became interwoven in this process.

In this period, the agricultural experiment stations also further explored dynamite's application in stump and rock removal. While this method received much praise in the 1870s and 1880s, a lack of scientific experimentation in the practice prompted many farmers to question the virtues of this practice. Into the twentieth century this lack of scientific understanding still prompted inquiries. In 1902, K. B. Fort wrote to the *Southern Cultivator* asking about the cost of removing pine stumps with dynamite. Two years later, J. M. Herring of Calvary, Georgia further inquired about the price of dynamite and the best means of employing it in the removal of tree

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[54] Oregon Agricultural Experiment Station, *Bulletin No. 45* (June 1897), 13; United States Department of Agriculture, Bureau of Soils, *Soil Moisture: A Record of the Amount of Water Contained in Soils During the Month of July, 1895* (Washington: Government Printing Office, 1895), 2.

stumps. Even as late as 1906, the publication received queries about the merits of dynamite and stump pullers with a particular interest in cost-efficient applications.[55]

As a result, experiment stations across the country blasted stumps with a scientific rigor not seen among the applications of decades past. The Washington State Agricultural College Experiment Station's exploration of stump blasting in the state's upland soils showed this new scientific meticulousness. Where instructions on stump blasting lacked specific direction in most of the nineteenth-century accounts, the 1897 report from Washington explained, "the manner in which a blast is placed determines its efficiency" going into great detail about the proper placement of dynamite in stump blasting operations. Blasting 221 stumps across four and a quarter acres, the work of the Washington scientists also utilized a sample size far greater than most of the independent experiments reported before 1887. The experiment showed that on average, it cost 77 cents to remove a stump. Though no comparative analysis between blasting and other methods was conducted, the arbiters of the experiment proclaimed dynamite "the most practicable means of getting out sound stumps."[56]

While the experiment stations developed the agricultural sciences, the information generated there inspired individuals and private farmers' associations to further reinvent dynamite. In 1889, a Pennsylvania farmer named J. H. Hale planted a home orchard on the "rocky timbered lot" that was his property. Employing the "best grade of dynamite," Hale found that it would cost him $200 an acre to clear his poor land, a proposition he initially thought was far too expensive. But "on account of the stones or stumps where trees ought to go," Hale

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[55] "Dynamiting Stumps," *Ohio Farmer* (December 7, 1889); "Dynamite and Renting Poor Land," *Southern Cultivator* (April 15, 1902), 28; "Dynamite and Stump-Pullers," *Southern Cultivator* (February 1, 1903), 23; "Dynamiting Stumps," *Southern Cultivator* (May 15, 1904), 5; "Shall I Blow Up Stumps or Pull Them?," *Southern Cultivator* (July 15, 1906), 13.
[56]Washington State Agricultural College and School of Science Experiment Station, *Bulletin 28* (January 1897) 6-17.

decided to employ dynamite when it came to planting one section of his property. On the other section, Hale plowed the ground with a traditional spring tooth harrow and explained that he drove "a little in one direction, and then in another way, and every way that [he] could get between the stumps and the stones." As he stated, "It takes about two years to do any plowing equal to one plowing on ordinary farm land."[57] Hale engaged in new explosive farming techniques to tackle the issues of time and labor. In using the blasted holes to plant a new orchard, Hale was also engaged in the process of reinvention as he creatively employed dynamite both as a stump remover and a means of planting his orchard.

Discussion of individual successes with dynamite agriculture prompted individuals, private organizations, and college experiment stations to further adopt the practice. Both *Our Horticultural Visitor,* an Illinois based publication targeting the orchard growers and cultivators of ornamental plants, and the Missouri State Horticultural Society discussed a resourceful Illinois farmer's successful application of dynamite in planting his apple orchard. In his existing orchard, which contained "several varieties [of apples] that would not pay for the use of the ground they occupied," the farmer employed dynamite in the removal of the unproductive trees. This proved useful not only in the clearing of land but because the dynamite "made a hole that it took a half load of fresh dirt to fill up," the property owner planted the new trees in the blasted holes. Impressed by the results, *Our Horticultural Visitor* advocated, "there need be no fear of replanting an old orchard with young trees, if they used dynamite to removal the old stumps; provided that they fed and cultivated the young trees as they ought to be." [58] With dynamite, the farmer revitalized his orchard.

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[57] State Horticultural Association of Pennsylvania, *A list of Apples, Pears, Peaches, Plums and Cherries* (Harrisburg: Meyers Printing and Publishing House, 1889), 93.
[58] "Some Experience in the Cultivation and Care of a Bearing Orchard," *Our Horticultural Visitor* Vol. 4, No. 4 (April 1898), 4; State Horticultural Society of Missouri, *Forty-First Annual Report* (Jefferson City:

Between 1887 and 1900 experiment stations and the agricultural sciences took root and flourished. While exploration of dynamite's merits in applications new and old occurred, it was the not the primary concern for the majority of the experiment stations that worked through internal disagreements and established the foundational agricultural sciences and curriculums. The unorthodox practice that was explosive farming only occasionally meshed with these efforts. But at the turn of the twentieth century this changed dramatically as the United States further invested in agricultural research and education, and as the explosives industry experienced a major restructuring that significantly affected the agricultural explosives market.

Experimentation, 1900-1914

By 1900, a new order of leaders took control of the experiment stations. Taking a keen interest in the needs of their constituents, these individuals restructured their respective experiment station's research agendas. While William H. Henry of Wisconsin, Eugene Davenport of Illinois, and Eugene W. Hilgard of California spearheaded this movement, they were not alone in their efforts. The 1903 annual report of the North Dakota experiment station highlighted its extensive support and cooperation with farmers' institutes. Cooperation with institutes, which were privately organized, shows the level of concern that experiment stations took in the plight of their constituent farmers. They also focused on more specific concerns that emanated from the state's newly settled regions. In the "immense area of the state lying west of the Red River Valley" the report explained, "the soil and agricultural conditions of this vast territory, now occupied by small farm holdings, differs so radically from the soil and agricultural condition of the Red River Valley…that a line of experiments should be begun at the earliest

Tribune Printing Company, 1898), 185-190; For more information on the rise of horticultural and orcharding see Cheryl Lyon-Jenness, "Planting a Seed: The Nineteenth-Century Horticultural Boom in America," *Business History Review,* Vol. 78, No. 3 (Autumn, 2004).

moment to meet these concerns."[59] Overcoming the tumult of internal conflict, the experiment stations of the twentieth century greatly expanded practical research efforts.

By 1906, the federal government further directed the efforts of the experiment stations toward the needs of local farmers. On March 16, 1906, Congress passed the Adams Act which "increased annual appropriations for agricultural experiment stations and regulating the expenditure thereof." According to the United States Office of Experiment Stations:

> The policy of the Office as heretofore, is to endeavor to formulate and hold to such general principles in the administration of the Adams Act as seen most likely to secure the efficient use of the Adams fund for research work of a high and substantial character and at the same time to safeguard the autonomy of the stations and raise their work and its results in the estimation of their farmer constituents.

Further, federal officials called for "much additional correspondence and personal conference" between farmers and their respective experiment stations to guide the experiment station researchers' work.[60] This focus allowed for a collaborative relationship between the government and individuals to flourish, a relationship that fostered further reapplication of dynamite.

As early-twentieth-century experiment station workers addressed the concerns of farmers across the country, ordinary farmers' interest in chemical high explosives as farm implements soon prompted new scientific experimentation of dynamite agriculture. By 1911, the Kentucky Agricultural Experiment Station explored further the use of dynamite in stump removal operations. George Roberts, head of the Kentucky Agricultural Experiment Station's Division of Agronomy, encapsulated the struggle of many Southern and Midwestern farmers who toiled on previously wooded lands in the station's 154th bulletin. In his telling, cost-benefit analysis of

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[59] Cochrane, *Development of American Agriculture,* 245; North Dakota Agricultural Experiment Station, *Thirteenth Annual Report* (Bismarck: Tribune, 1903), 10; The Pennsylvania State College, *Annual Report of the Pennsylvania State College for the Year 1906-1907* (Harrisburg: Harrisburg Publishing, 1908), 12.

[60] US Department of Agriculture, Office of Experiment Stations, *Annual Report of the Office of Experiment Stations For the Year Ended June 30, 1906* (Washington: Government Printing Office, 1907), 16-17.

stump removal with dynamite had not been calculated as of June 1911, but the long-term benefits of this practice made stump removal a worthwhile venture. The biggest limitation of farming stumped fields was that it prevented “a proper rotation of crops.”[61] Roberts explained that it was common practice for “a field in the stumps” to be planted with a “cultivated crop, generally corn, until the stumps have rotted down” making removal much easier; for stumps that were 10 inches or smaller this was understood to take about eight years.[62] This practice, effective in the short run, hampered the field’s ability to produce steady and profitable harvest. In the extended period of time in which the stumps were left to rot, the field remained un-rotated, which depleted the soil of the essential nutrients required for continued production.[63] In some instances, farmers attempted to rotate stumped fields planting either straw or grain crops. Still the stumps proved to be a significant barrier to production because the efficacy of seeding machines and harvesters commonly used in grain and straw farming was severely diminished, as there was often a “large loss of space around the stumps.”[64] The most effective way to overcome these woodland obstacles was dynamite.

Researchers at the Kentucky Agricultural Experiment Station examined dynamite’s effectiveness as a stump remover in two separate experiments in the spring of 1911. In both instances it proved an effective and affordable mechanical implementation and labor-saving device. In the first experiment carried out on a farm in London, Kentucky, dynamite removed a total of 102 trees stumps with an average diameter of 16 inches. Stumps removed were primarily dead oak, but a small percentage of green oak, dead pine, green black gum, green sugar maple,

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[61] Kentucky Agricultural Experiment Station. *Bulletin No. 154: Blowing* Stumps with Dynamite (June 1911), 19.
[62] *Ibid.,* 24.
[63] *Ibid.,* 19.
[64] *Ibid.,* 20.

and green gum stumps were also removed in the test. The researchers used a total of 265 sticks of dynamite, or 2.6 per stump. The average cost of material per stump was 25.7 cents or a total of $26.20 for the entire field. A single worker completed the task in five days averaging 30 minutes per stump. At a cost of $1.50 per day for labor, it cost a total of $33.70 or 33 cents per stump to remove the 102 specimens.[65]

The second experiment conducted under the authority of the experiment station on its farm in Lexington, Kentucky, tested dynamite against a much smaller sample size of 16 trees. Nine of the stumps were green, and the tree varieties were hackberry, elm, walnut, cherry, maple, osage orange, and oak. Three of the green oak stumps included in the test were of exceptional size measuring 43, 45, and 48 inches in diameter. Compared to other tests reported in experiment station records, these stumps appear to be an anomaly. While unique, this experiment yielded interesting results. Researchers discovered that the removal of green stumps required a significantly larger quantity of dynamite than dead stumps. For the nine tested, workers recorded an average diameter of 22 inches, and it required a total of 93 sticks of dynamite to remove them. The cost of supplies and labor was $14.06. The three large oaks accounted for $10.55 of the total costs. Researchers concluded that the largest factor in determining the amount of dynamite required to remove a stump was the square of the "area of the cross section of a stump." Despite the increased cost, those who conducted the experiment also concluded that there was "no other method by which they could be removed so cheaply," and in assessment of the two tests stated, "One point seems clear, and that is, that when stumps are to be removed, the cheapest methods is by the use of dynamite."[66]

[65] *Ibid.,* 27-28.
[66] *Ibid.,* 28-30.

Figure 1: Kansas experiment station worker using an auger to create a hole under a stump to be removed with dynamite, circa 1911.

Figure 2: Stump to be blown out with dynamite, circa 1911.

Figure 3: Picture of dynamite explosion used to remove a tree stump, circa 1911.

Superintendent of the Minnesota experiment station, A. J. McGuire, was arguably the most devout supporter of dynamite agriculture in this period of experiment station work. McGuire had a vision of transforming the vast cutover regions of Northern Minnesota, an area encompassing nearly a quarter of the state's landmass, into "clover fields and cow pastures."

Explaining that "the possibilities of its agriculture are no longer experimental," McGuire stated, "The only practicable means of getting rid of the stumps is by the horse powered stump puller and explosives…the machine is used for the smaller stumps while explosives are used on the larger ones." According to the station report, dynamite is "best for blasting" and cost including labor would not exceed $25 per acre. This was according to the results of a recent experiment station study that cleared 8.7 acres of land at a cost of $205.68.[67]

Among the ranks of the experiment station, the early years of the twentieth century brought a newfound focus on the development of agricultural science with an emphasis on addressing the needs of farmers across the country. In some instances, this brought the developments of dynamite agriculture to the attention of the researchers who further explored dynamite's merits in stump and rock removal and to a limited degree, tree planting, plowing, and subsoiling. But a third player, chemical manufacturers, took notice of these explosive developments as well, and became a new and powerful force that shaped the ways in which Americans used and understood dynamite as a progressive farm implement.

A series of developments in the first two decades of the twentieth century diverted part of the chemical manufacturers' focus from the construction and mining industries. In addition to having a myopic marketing strategy in the nineteenth century, producers of explosives began consolidating the high explosives industry as early as 1881 when the Du Pont and Laflin Rand owned Repauno Chemical Company started purchasing stock in smaller dynamite firms. This included California Powder Works that Repauno renamed Hercules Powder Company in 1881. By 1902, Du Pont president Coleman Du Pont purchased Laflin & Rand giving his company a minority interest in a majority of the nation's dynamite firms as part of a larger effort to unite the

[67] "To Reclaim Cut-Over Land: Minnesota Plans to Bring Great Area Under Agriculture" *New York Times* (May 11, 1913), 7.

dynamite and explosives industry under the sole name of Du Pont Powder Company. As a result, Du Pont was the primary supplier of dynamite and other chemical high explosives until 1912.[68]

Being the primary producer of dynamite for the first 12 years of the twentieth century, Du Pont directly targeted the agricultural market with informational pamphlets about dynamite's utility in agriculture as early as 1909. A decline in black powder sales prompted the shift, but by 1913, a 10 percent drop in dynamite sales to the construction and mining industries further inspired the move. In 1911, farmers were introduced to *New Farms For Old Through Deep Plowing With Du Pont Red Cross Low Freezing Dynamite.* This book was the first of many Du Pont mailers that specifically highlighted the uses of dynamite in agriculture. Additionally, this was the first publication that marketed Du Pont's new Red Cross brand dynamite. In a section titled "Why We Recommend Red Cross Dynamite For Farm-work" the pamphlet explained:

> Red Cross Dynamite is better suited for most of the blasting necessary about the farm, than any other explosive. Our many years of experience in the manufacture and use of explosive, has taught us that if an explosive is to do its work at the lowest possible cost and produce the best results, it must be made with qualities especially suited to the work in which it is to be used. Red Cross Dynamite is particularly strong in those qualities necessary in agricultural blasting.[69]

This was the first time that a manufacturer of explosives produced and marketed a formulation of dynamite specifically for agricultural needs.

By 1912, Du Pont had manufactured a whole line of agricultural explosives. Informing readers that "there are many different kinds of high explosives manufactured for the various blasting operations," the 1912 *Du Pont Farmers' Handbook* showed the merits of their entire

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[68] Grinde, *Gunpowder Trade Association,* 106-107; Van Gelder and Schlatter, *Explosives Industry in America, 428-429.*

[69] Dyer and Sicilia, *Labors of A Modern Hercules,* 80; Du Pont, *New Farms For Old Through Deep Plowing With Du Pont Re Cross Low Freezing Dynamite*, 30.

line of agricultural implements.[70] This included Du Pont standard Red Cross Dynamite, which was touted for its "sensitiveness, stability, or power of keeping, and resistance to cold and water" and its virtues of "strength, or disruptive power, and quickness, or shattering power."[71] Other high explosives advertised included Red Cross Farm Powder, Red Cross Extra 20 to 60 Per Cent dynamite, Pacific Stumping Powder, and Du Pont Gelatin among others. All of these explosives were specifically designed to overcome environmental limitations to agricultural development. The Pacific Stumping powder, for example, was "especially adapted to stump blasting in the Pacific Northwest and sold only in that district." Red Cross Farm Powder, "a slow acting, low freezing powder" was specific designed for "subsoil blasting, tree planting, gully filling, loosening soils for road grading, and stump and boulder blasting on heavy soils" where the more rapid explosion of standard Red Cross Dynamite was not needed. When faced with particularly cold and wet conditions, *Farmers' Handbook* recommended Du Pont Gelatin for its "plastic" nature that allowed a greater degree of cold tolerance and water resistance when compared to other Du Pont brand high explosives.[72] By creating farm specific formulations of dynamite, Du Pont engaged in the literal reinvention of high explosives as a tool for the farm that redirected marketing efforts, catalyzed new experimentation, and increased the use of dynamite among the population.

Addressing the concerns of farmers across the country, Du Pont's informational literature engaged in the reinvention of dynamite and cultivated new consumers of agricultural explosives. *New Farms For Old* placed dynamite in conversation with subsoiling explaining, "The value of

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[70] E. I. du Pont de Nemours and Company, *Du Pont Farmer's Handbook: Instruction in the use of Dynamite for Clearing Land, Planting and Cultivating Trees, Drainage, Ditching and Subsoiling* (1912), 5.
[71] *Ibid.,* 9.
[72] *Ibid.,* 10-11.

dynamite in the orchard has been proved beyond question," the booklet portrayed dynamite as universally effective in these efforts.[73] Emphasizing the destructive elements of the Red-Cross Dynamite, the booklet showed how dynamite effectively "breaks up the hardpan and permits the roots to take their downward course into the lower strata of the soil in which plenty of plant food elements are available. Under these conditions one tree is not interfered with by another; each one receives the benefits of all of the soil allotted to it at the time the surface was measured and aid out at planting time."[74]

Reacting to experiment station researchers' interest in subsoiling, this publication offered numerous anecdotal examples to show dynamite's efficacy in the pratice. The Commissioner of the New York State Fair wrote to Du Pont to say, "Sub-Soiling work [with dynamite] has proven a great success" in the fairground's oat fields (See figures 4 and 5). W. C. Maxwell, a farmer and landowner from Derrick City, Pennsylvania, use dynamite to subsoil for buckwheat on previously worthless ground. After blasting his ground and witnessing a superb harvest, Maxwell valued an acre of his land at "fifty dollars, which was formerly worthless." The claim being made was simple. Subsoiling with dynamite transformed poor ground into productive farmland.[75] W. R. Cobb of the Steward Oconee County Poor Farm in Walhalla, South Carolina reportedly doubled his normal harvest of cotton when he decided to subsoil a field with dynamite before sowing cottonseeds.[76] This pamphlet not only showed evidence of dynamite's use beyond the boundaries of the experiment stations, but also addressed other concerns that many farmers had.

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73 E. I. du Pont de Nemours and Company, *New Farms for Old Through Deep Plowing with Du Pont Red Cross Low Freezing Dynamite* (1911), 3, 6-7.
74 *Ibid.*, 7.
75 *Ibid.*, 13.
76 *Ibid.*, 15.

OATS GROWN ON N. Y. STATE FAIR GROUNDS AT SYRACUSE ON GROUND NOT PLOWED WITH DYNAMITE. NOTE THIN ROWS, SHORT STALKS AND POOR HEADS

Figure 4

OATS GROWN ALONGSIDE OF CROP IN UPPER PICTURE BUT ON GROUND DEEP-PLOWED WITH DYNAMITE. NOTE HEIGHT, VIGOROUS GROWTH AND WELL DEVELOPED HEADS

Figure 5

Even though experiment stations and chemical manufacturers keenly addressed the problems facing farmers in the early twentieth century, the state of American agriculture had never been better. Farm prices grew steadily between 1897 and 1910, which ushered in the high and stable prices of the "Golden age of American Agriculture" that lasted from 1910 to 1914. With farm prices high and stable, chemical manufacturers began to capitalize on the cash rich agricultural market.[77] While farmers still faced many challenges to productive harvests, times were good, which prompted farmers to explore new techniques like dynamite agriculture as they hoped to take full advanced of the favorable economic forecast.

Du Pont's tendency to portray dynamite as a universally effective farm implement prompted additional reactions from experiment stations. From 1911 to 1916, the agricultural

[77] Cochrane, *The Development of American Agriculture,* 99-100.

experiment station in Manhattan, Kansas studied the effects of dynamite on soil composition and plant growth. *Bulletin 209* of the Kansas State Agricultural College reported,

> Within the last four or five years several firms manufacturing dynamite have advocated its use for the purpose of loosening the subsoils of cultivated fields to a greater depth than it is possible to loosen them by means of the common subsoil plow or other deep tillage implements. It has been asserted that almost any type of soil can be improved in physical condition…It was for the purpose of obtaining definite information as to the value of dynamite for soil improvement that experimental work was started at this station.

On the farm of J. E. Thompson in Fredonia, Kansas, researchers tested the effects of dynamite on sorghum growth in Oswego Silt Loam soil. This was characterized as "mellow, dark gray silt loam to a depth of twelve inches" with a thirty-inch subsoil comprised of "dark-brown to drab silty clay which is very tough and plastic when wet." Noting that the blasting was conducted while the soil was "very wet," the scientist reported that "the effect of the charge was to form a cavity about eight inches in diameter, the walls of which were puddled and compacted very hard. Despite the unintended soil compaction, the harvest of sorghums from the dynamited field was empirically the same as the harvest from an undynamited control field.[78]

A similar experiment in Agra, Kansas fostered different results. Conducted in similar soil conditions, the wheat harvest from a field treated with dynamite was 2.1 bushels per acre less than the first control field and 5.2 bushels per acre below the yield of a second control plot. Nearly every test of blasting in heavy clay soils showed that it had a tendency to create a hallow cavity referred to as a "dynamite jug" (see figure 6).[79] These results served as a check against the ostentatious advertisement of chemical manufacturers, but they also reveal the ways in which discussion of dynamite agriculture prompted research and furthered the development of agricultural science.

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[78] Kansas State Agricultural College Agricultural Experiment Station. *Bulletin No. 209: The Use of Dynamite in the Improvement of Heavy Clay Soils* (December 1915), 10.
[79] *Ibid.,* 11.

Figure 6

Describing the versatility of Red Cross Dynamite in cold weather, its safety and stability, its affordability, and the availability of various concentrations, Du Pont's advertisements straddled a line between marketing and education. The primary educational component was safety. While information on applications appeared exaggerated, Du Pont's safety materials were not. Du Pont and other manufacturers addressed safety because consumers in the budding agricultural market expressed reservations about the dangers of handling dynamite.

Even if an individual farmer had not experienced first-hand the risks of handling chemical high explosives, extensive media reports of dynamite related accidents on the farm uncovered the potential perils of dynamite's explosive energies to farmers across the country. In 1878, the *Chicago Tribune* described in graphic detail an accidental explosion that killed four men, Andy P. Higgins, J. P. Burkholder, N. B. Pulver, and Charles S. Page who were present on the Curtis Farm in Oil City, Pennsylvania when "twenty pounds of glycerine [sic] and seventy-five pounds of dynamite" exploded. "Fragments of flesh and shreds of clothing were strewn over the ground" between 50 and 100 feet from the explosion. This was not a singular event. In September of 1882, the *Tribune* reported that a dynamite explosion killed an Indiana farmer named William Henry and badly injured his son while they were on their way to blast stumps. A spark from a torch had ignited the explosives. Those doing the blasting were not the only ones whose lives were in danger. A Minnesota farmer named James Hunter attempted to thaw dynamite intended for stump blasting in his oven. Forgetting about the dynamite, Hunter went into town and the dynamite exploded killing his wife and two children.[80]

While safety concerns threatened dynamite's proliferation on the farm, other developments also fostered reluctance. The second most important barrier was political radicalism. In a sense, political radicals' use of chemical high explosives was not dissimilar to that of farmers. Irish nationalist, anarchists, and radical labor groups also channeled their dissatisfactions into creative reinventions of dynamite. Leveraging dynamite as a tool for political independence, agitation, and as a means of achieving social and economic reform, these groups attacked their opposition with dynamite and other improvised explosives.[81] But these applications did much more than damage property and dismember those they understood as oppressors. Dynamite outrages, as they were often referred to, had much broader cultural ramifications that shaped popular conceptions. For many, dynamite became inextricably linked to radicalism and entangled in anti-immigrant sentiments that circulated the streets of nineteenth- and early twentieth-century America often prompting new and restrictive regulations of explosives in cities and states across the country.[82] While it is impossible to measure the degree

[80] "Terrible Explosion," *Chicago Tribune* (September 17, 1878), 2; "Fatally Injured by an Explosion of Dynamite," *Chicago Tribune* (September 5, 1882), 2; "Left Dynamite in Oven," *New York Times* (May 5, 1905), 1.
[81] For examples see: For examples, see Louis Adamic, *Dynamite: The Story of Class Violence in America* (New York: The Viking Press, 1934); James Green, *Death in the Haymarket: A Story of Chicago, the First Labor Movement and the Bombing that Divided Gilded Age America* (New York: Anchor Books, 2006).
[82] "The Anti-Dynamite Law," *The Independent* (April 19, 1883), 17; "The Legislature: Proceedings in Senate and House—Several Important Measures Introduced," *Chicago Tribune* (January 13, 1887), 2; "Easy To Purchase Dynamite: No Law Requiring Would-be Purchasers to Show that Explosives is to be

to which this played into farmers' purchasing habits, the wide spread hysteria recorded in newspapers suggests that political radicalism may not have informed farmers' opinions on dynamite as a legitimate farm tool. Additionally, these outrages prompted local and state level regulations that measurably barred farmers' access to explosives.[83]

While radicalism and accidents fostered a culture of fear and anxiety that hampered dynamite's agricultural applications, it also formed the basis upon which Du Pont engaged in educational work. Du Pont literature tended to segment discussion of safety concerns into the categories of hauling, handling, storing, unpacking, and thawing dynamite giving special attention to directions on thawing. "The best way to thaw dynamite…is in a thawing kettle made for the purpose" explained the authors of the 1912 *Du Pont Farmers' Handbook,* who were addressing the fact that "a large majority of the accidents which happen when dynamite is used, occur in thawing." Further, the authors of the Du Pont literature addressed "bomb throwing by anarchists." Events like the 1886 Chicago Haymarket Affair in which anarchists allegedly hurled a dynamite bomb into a crowd of police officers crystalized the association between dynamite and political radicalism that was detrimental to Du Pont's business. Attempting to cast dynamite in a new light, they argued that newspapers "incorrectly report[ed]" such events. In addressing "popular misconceptions of dynamite in the public mind," the marketing directors at Du Pont

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Used for Legitimate Purpose, but Smallest Amount Sold Costs $10," *New York Times* (May 31, 1903), 35; "Deadly Dynamite," *Chicago Tribune* (November 8, 1884), 5; "Murdered with Dynamite: A Pennsylvania Contractor Blown Up by Robbers," *New York Times* (September 26, 1903), 1; "News of Old World Investigating the Irish Dynamite Plots," *New York Times* (April 9, 1883), 1; "Night Riders Plant Dynamite in Wheat: Ku Klux Klan Methods Revived in Kentucky Tobacco Planters' War," *New York Times* (July 19, 1907), 2.

[83] Of the Powers of the Common Council, *Laws of Michigan,* Ch. 5 (1873); An Act Concerning the Transportation of Nitro Glycerine and other Combustible and Explosive Articles, *Colorado Compiled Statutes* (1876).

were at once reinventing dynamite as a tool for the farm and engaging in an education campaign that challenged popular perceptions of dynamite.[84]

Just as Du Pont was breaking into the agricultural market, the federal government fundamentally restructured the explosive industry. Du Pont's consolidation of the high explosive industry in 1902 essentially created a monopoly on explosives, but shortly after, the federal government sued Du Pont for violating the Sherman Anti-Trust Act in 1907. The suit divided the company into the E. I. DuPont de Nemours Powder Company, Hercules Powder Company, and Atlas Powder Company in 1912 with Du Pont retaining "58 percent of its capacity to make dynamite." As for the other two companies, it was ordered that the larger, which would become Hercules, be twice as big as the smaller, which would become Atlas. These three new companies subsequently diversified their interests in the broader explosives market, but because the majority of the assets went to both Du Pont and Hercules, they became the two major players in the budding agricultural explosives market.[85]

An Explosive for the Homefront, 1914-1920

Just two years after the explosives industry found itself at odds with the federal government, the outbreak of World War I created a climate in which the two adversaries found common ground. This alliance took shape in pursuit of productive farmland. The increased pressure placed on farmers to intensify crop production in response to the global demand for

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[84] E. I. du Pont de Nemours and Company, *Du Pont Farmer's Handbook: Instruction in the use of Dynamite for Clearing Land, Planting and Cultivating Trees, Drainage, Ditching and Subsoiling* (Wilmington: 1912), 106-111; For examples of accidents when thawing dynamite see: "Left Dynamite in Oven," *New York Times* (May 5, 1905), 1; "Dynamite, In Stove To Thaw, Wipes Out Family Of Five," *Chicago Daily Tribune* (March 1, 1907), 4; James Green, *Death in the Haymarket: A Story of Chicago, the First Labor Movement and the Bombing that Divided Gilded Age America* (New York: Anchor Books, 2006), 5.
[85] Grinde, *Gunpowder Trade Association,* 106-107; Van Gelder and Schlatter, *Explosives Industry in America, 428-429; Dyer and Sicilia,* Labors of Modern Hercules, 42.

food prompted manufacturers of explosives to further invest in agriculture-specific explosives while the federal government was interested in studying and promoting best practices for farming and encouraging farmers to put every acre of tillable land into production.

World War I drastically affected the degree to which experiment station employees researched, and chemical high explosive manufactures promoted dynamite agriculture. The U.S. Office of Experiment Stations expressed in its July 1918 report that one result of extended global combat was "to demonstrate anew the value of generous and systematic provisions for the encouragement of agricultural research." This opinion was more than just blind speculations as the funds allotted for experiment station work amounted to $5,642,149.16 in 1917 where in 1910, the total funding amounted to $3,537,700.25. This increased funding translated into additional research and outreach efforts. In 1910 the experiment stations collectively published "583 annual reports, bulletins and circulars, which were supplied to over 952,000 addresses. By 1917 the amount of published literature expanded threefold to "1,624 annual reports, bulletins, and circulars, aggregating 28,109 pages, and these were distributed to 1,130,219 addresses." In the private sector, Du Pont continued its advertisement efforts while the newly organized Hercules Powder Company distributed literature of its own and sent company sales representatives to cooperate with agricultural colleges giving lectures and demonstrations.[86]

World War I also ushered in a new set of conditions that greatly affected the role dynamite played on the American farm. Increased export demand, the subsequent rise in farm prices that accompanied it, and the increased demand for farmland prompted farmers to intensify

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[86] US Department of Agriculture, Office of Experiment Stations, *Experiment Station Record* Vol. 39, No. 1 (July-December 1918), 1; US Department of Agriculture, Office of Experiment Stations, *Work and Expenditures of the Agricultural Experiment Stations 1917* (Washington: Government Printing Office, 1918), 285; US Department of Agriculture, Office of Experiment Stations, *Annual Report of the Office of Experiment Stations For the Year Ended June 30, 1910* (Washington: Government Printing Office, 1911), 273-274; Dyer and Sicilia, *Labors of A Modern Hercules,* 117.

production and further mechanize their farms. By the time World War I erupted in Europe, American farmers had placed the majority of the nation's easily adaptable farmland into production. Wartime demand for foodstuffs caused farm prices to more than double between 1916 and 1920 and this led to bidding wars for farmland as prices rose by "70 percent between 1913 and 1920."[87] Also, at least by the time the U.S. entered combat, the war drew on the nation's labor supply, which when combined with the effects of urbanization, left many farmers shorthanded.

For manufacturers of explosives this meant a new opportunity to further promote the agricultural benefits of blasting. Hercules, for example, mailed out free pamphlets such as *Progressive Cultivation and Farm Dynamite,* which described new methods of explosive farming. In fact, the agricultural market was the only area that Hercules saw continually growth in immediately following the war's end.[88]

For the federal government, this meant a heightened urgency to boost agricultural production. This manifested in the increased funding for agricultural research and education through the passage of the 1914 Smith-Lever Act. The passage of the Smith-Lever Act in 1914 greatly expanded the Agricultural Experiment Stations' spheres of influence by bringing into cooperation the federally funded county extension programs, operating in 928 counties at this time and the work of state level experiment stations. The Act furnished $10,000 for states that cooperated with the terms of the law and offered additional funds based on the rural populations of the state, provided that the state matched the funding. As a result, subsidies for agricultural extension nearly doubled between 1915 and 1917 to a total of $6.1 million with 4100 agricultural agents working across 1434 counties. This transformed the county agents into federally funded

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[87] Cochrane, *The Development of American Agriculture,* 99-100.
[88] Dyer and Sicilia, *Labors of a Modern Hercules,* 34, 117.

"off-campus instructors of the colleges of agriculture," and they served as the "principle conduit through which scientific knowledge and technological advances were transmitted to farmers from the state colleges of agriculture."[89] This included information on how to most effectively deploy chemical high explosives to meet growing demands for food. The Smith-Lever Act streamlined the flow of information as experiment stations researched new application for dynamite on the Homefront.

World War I created new opportunities for business and government cooperation. In 1916, the agricultural experiment station in Wisconsin organized a 13-week series of farm demonstration in collaboration with Du Pont and number of railroads including the Chicago, Milwaukee and St. Paul and the Chicago and North Western railroads. Making 15 stops in 14 counties, "three experienced operators" from the E. I. du Pont de Nemours Company demonstrated the efficacy of various concentrations of Du Pont brand dynamite and other blasting accessories used in stump removal. In 1917, the Wisconsin experiment station made "a special appropriation of $37,500" for demonstration work in clearing cutover land with stump pullers and dynamite. Collaborating with a local railroad, the station's demonstration workers conducted 30 demonstrations, 16 of which lasted a week long, for more than 8000 residents of the state's northern region. These demonstrations successfully prompted the cooperative buying of stump pullers, and "in many instances…whole communities united in the purchase of dynamite in car lots." [90] Educating farmers how to handle explosives, these demonstrations transferred the expertise of Du Pont's blasting agents to ordinary farmers. The collaborative

[89] Cochrane, *The Development of American Agriculture,* 106, 249-250.
[90] Agricultural Experiment Station of The University of Wisconsin, *The Work of the Experiment Station and Agricultural Extension Service for 1916* (Madison: 1917), 25; US Department of Agriculture, Office of Experiment Stations, *Work and Expenditures of the Agricultural Experiment Stations 1917* (Washington: Government Printing Office, 1918), 277, 368.

efforts of business and government increased access to information and translated into reception of the practice.

Beyond collaborating with experiment station and extension services, manufacturers of explosives also capitalized on wartime conditions. In 1915, Du Pont introduced *Vertical Farming,* a monthly magazine "to acquaint farm owners with the uses of dynamite in farming." While du Pont had already published *Du Pont Magazine,* which focused on a wide variety of du Pont's chemical products, *Vertical Farming* was primarily dedicated to agriculture. The second issue of *Vertical Farming,* released in March of 1915, featured President Woodrow Wilson's address on the global food shortage and the war. Highlighting the president' s call to agricultural action, Du Pont's marketers urged their readers to "force every acre of cultivated land to maximum food production and put under cultivation the millions of acres of cut-over and swampland that now occupy parts of our country just as truly as a hostile force." The advertisement also highlighted specific applications urging farmers to "buy cut-over land and clear it right now. With Red Cross Dynamite, which is low-freezing, you can get stumps out before the snow is off the ground, and raise a big food crop in 1915 on acres now in stump." Furthermore, Du Pont pressured farmers to regain swamplands and irrigate arid ground. By urging farmers to "blast ditches and drain reclaimable swamp land" and to "eliminate the waste parts of [their] farm" Du Pont motivated farmers to improve existing farmlands and reclaim those previously unable to be cultivated.[91]

In 1918, Du Pont ran a series of advertisements exploiting rural labor shortages. Featured in a December issue of *Progressive Farmer,* an ad titled "Does Labor Shortage Worry You?" engaged the fears and anxieties that plagued many farmers in 1918. The ad touted Du Pont's line

[91] "Wanted: Names of Farm Owners," *Du Pont Magazine* Vol. 6, No. 3(March 1916), 9; "The World Faces Famine," *Vertical Farming* Vol. 1, No. 2 (March 1915), 3.

of agricultural explosives for their ability to "do the work of many men," and in an effort to personify the product, it explained, "Red Cross Farm Powder is a modern miracle worker that saves time, money, and work."[92] This example is one of many that highlighted chemical high explosives potential to save farmers' time, money, and labor. Featured in the March 23, 1918 issue of *Literary Digest,* was another advertisement titled "Is Your Problem Lack of Labor?" This promotion positioned Du Pont brand dynamite in conversation with the global food shortages and labor troubles of the time. "Red Cross Farm Explosives will do more real work for you in a few hours than ten men could do in a week" the advertisement boasted, and "just now the whole world needs food…It is very farmers golden opportunity."[93] Advertisements like these reshaped popular understanding of explosives by casting the product as a tool for increased farm productivity, and in the contest of the war, many farmers answered their patriotic duty to blast their farms.

Though Hercules Powder Company did not outwardly address the wartime demands on agriculture in the same fashion as Du Pont, the same issues appear in its advertisements in a subtler manner. In 1917, Hercules ran an ad in the *Farm, Stock, and Home* journal titled "There are Dollars In Your Subsoil. Get Them Out!" Claiming that subsoiling with dynamite could increase crop yields from 10 to 200 percent, the advertisement not only addressed the wartime demand for food, but also revealed the economic motivations that drove many ordinary farmers to rationalize their farms through mechanization and intensified production. Playing into "high prices and increased land value" that demanded "the use of every acre" after the conclusion of the war, another Hercules ad asked, "are you taking advantage of every opportunity to improve

[92] E. I. Du Pont de Nemours and Company, Advertisement, *Progressive Farmer,* December 7, 1918, 5.
[93] E. I. Du Pont de Nemours and Company, Advertisement, *Literary Digest,* March 23, 1918, 54.

your farm and make your idle acres pay?" The advertisement stated that "$72.65 for dynamite and caps" reclaimed "$1000 worth of land" for one progressively minded farmer.[94]

Experiment stations operated independently as well. In 1917, the experiment station in Kansas explored the effects of dynamite upon soil conditions and its effects on crop yields, "moisture content, nitrate development, bacterial flora, and physical conditions of the soil." Of all these tests, the only experiment to show a marked improvement over soils not treated with dynamite was in reference to the number of bacteria in the "surface foot" of soil blasted with dynamite. Though it was not all negative either, as the only experiment to yield an explicitly negative effect was the one dealing with dynamiting heavy clay soils for the planting of fruit trees.[95] Regardless of the outcomes, the complexity of exploration illuminated the effect of wartime demand on the intricacy of scientific research and showed the ways that dynamite's newfound place in agriculture aided in this process.

World War I was the ultimate realization of dynamite agriculture that resulted from fifty years of creative reimagination of dynamite as a tool for the farm. Wartime demands for food prompted the collaborative efforts of business and government to at once research chemical high explosive agriculture, educate ordinary farmers on its merits, help dispel popular fears of dynamite, and further promote its reception. Additionally, food shortages resulted in skyrocketing farm prices that lined the pockets of newly optimistic farmers. This led to increased value for farmland, which with the help of business and government, prompted farmers to actively reclaim every acre of tillable farmland with the help of dynamite. By 1920, there was

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[94] *Farm, Stock, and Home* Vol. 33, No. 8 (April 15, 1917), 366; "Farmers Who Are Leaders Know the Use of Dynamite," *The Cornell Countryman* Vol. 17, No. 1 (October 1919), 29.
[95] US Department of Agriculture, Office of Experiment Stations, *Report on the Agricultural Experiment Stations, 1916* (Washington, DC, 1918), 38-39.

total of 503,073,007 acres of improved farmland in the United States where in 1870, there was only 188,921,099.[96]

Conclusion

By the end of World War I, dynamite had become a tool for the farm. From 1867 to 1920, the interplay and exchange between ordinary farmers, chemical manufacturers, and critical arms of the agricultural state developed and distributed knowledge of dynamite's utility and varied applications on American farms. Aided by publicity from the media, farmers' organizations, government publications, and business advertisement campaigns, this process transformed dynamite agriculture from a series of isolated reinventions to a significant subset of the explosives industry. By the first decade of the twentieth century, the practice supported large-scale advertisement campaigns, the production of farm specific explosives, and the publication of application specific periodicals such as Du Pont's *Vertical Farming.* By 1919, Du Pont reported average sales of "15,000,000 pounds of dynamite yearly for farm uses," between 1914 and 1919, agriculture was the only market for explosives in which Hercules saw sustained growth in sales, and by 1924, dynamite sold for agricultural purposes amounted to no less than 20,000,000 pounds annually.[97] While it is impossible to track the exact percentage of farmers who adopted explosive farming practices, the scale of the industry reflects its importance.

Of all the applications explored in this period, the most successful and widely received use for dynamite on the farm was stump removal. Writing for the *Manufacturers Record* in

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[96] US Department of Commerce, *Fourteenth Census of the United States Taken in the Year 1920* Vol. 5 (Washington: Government Printing Office, 1922), 24; Bureau of the Census, *The Statistics of the Wealth and Industry of the United States, Embracing The Tables of Wealth, Taxation, and Public Indebtedness; of Agriculture; Manufactures; Mining; and the Fisheries* (Washington: Government Printing Office, 1872), 81.

[97] "New Markets For Implement Dealers," *Power Farming: The Magazine of Farming With Mechanical Power* Vol. 28, No. (April 1919), 34; Dyer and Sicilia, *Labors of a Modern Hercules,* 34, 117; Van Gelder and Schlatter, *History of the Explosives Industry in America,* 1070.

September 1919, Geo D. Lowe reported that "75 percent of the Wisconsin cutover land that [went] into cultivation [was] cleared with Dynamite." A. J. McAdams of the *Michigan Farmer* described the practice as "becoming more universal" by 1922. While this was the most common application, other uses such as tree planting, ditching, and subsoiling prevailed in this period as well even in spite of experiment station reports that questioned the efficiency of such uses.[98] By 1920, dynamite had found its place in American agriculture.

[98] Deo D. Lowe, "Making Prairies and Multiplying Manpower by Clearing Cutover Lands in Coastal Plain Section," *Manufacturers Record* Vol. 73, No. 13 (September 24, 1919), 102; A. J. McAdams, "Land-Clearing Robbed of Its Drudgery," *Michigan Farmer* Vol. 159, No. 17 (October 21, 1922), 411; "How To Blast Drainage Ditches," *Farm Mechanics* (March 1924), 34.

Chapter II:

Restructuring Landscapes: Explosive Energy and the Rise of Agroecosystems, 1902-1929

"Agriculture never carried so broad a meaning as at this present time" exclaimed Alvah Hayward Pulver, special contributor to *Vertical Farming* in 1917. "It now means the energizing of Nature to profitable crop production in land areas once deemed of no commercial value." While farmers of centuries past put the most accessible and productive lands under the plow, the geographic landscapes of twentieth-century North America posed new barriers to the expansion of agriculture. Tasked with converting deserts, cutover forest lands, and swamps into productive farms, American farmers of the twentieth century "met the situation with determination and high explosive."[99]

The turn of the twentieth century demarcates a new stage of American agriculture. The further development and expansion of farmlands, to meet the demands of a growing population that settled new and geographically diverse regions, depended on large scale reclamation projects. The proliferation and repurposing of chemical high explosive in agriculture in the late nineteenth and early twentieth century aided this process and had vast environmental consequences. By the turn of the twentieth century, farmers used explosive farm implements to restructure waterways for irrigation, clear cutover land to cultivate woodlands, and drain swamps to access the nutrient rich souls that rested below the murky waters. Chemical high explosive straddled the line between technology and energy. Contemporaries leverage this technology against environmental limitations to agrarian progress. But unlike other new farm technologies, chemical high explosives provided Americans with a new and accessible form of energy. This

[99] Alvah Hayward Pulver, "Muck Land Development," *Vertical Farming* Vol. 2, No. 12 (February 1917), 10.

energy allowed farmers to overcome the environmentally dictated limitations to agrarian development that plagued agriculturalists of previous generations.[100]

Employing chemical high explosive in the development of new and productive farmlands, early-twentieth-century farmers reordered human relationships to the natural world. Col. George G. King, president of the Institute of Makers of Explosives, declared, "Modern high explosives can force a way through any obstacle nature has erected."[101] Straightening crooked streams, subsoiling, and stump blasting, farmers, the agricultural state, and chemical manufactures conformed nature to human visions of agricultural development. In other words, industrial agriculture, as it developed in this period, restructured existing ecosystems to create agroecosystems.[102]

Though agriculture was not the only industry dependent on the restructuring of landscapes, the overwhelming demand for acreage required to support the industry translated into an elevated dependence on environmental rationalization. The legal pathways required for these developments emerged as reclamation legislation like the National Reclamation Act of 1902, which furnished the capital and engineering expertise necessary to reclaim lands on such a large scale and the organization of the Tri-State Land Development Congress that prompted cutover land reclamation in Minnesota, Michigan, and Wisconsin. But these efforts did not solely emanate from the imagination of federal and state government. Individual settlers, albeit inspired

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[100] US Department of the Interior, US Geological Survey, *First Annual Report of the Reclamation Service From June 17 to December 1, 1902* (Washington: Government Printing Office, 1903), 22; Alvah Hayward Pulver, "Muck Land Development," *Vertical Farming* Vol. 2, No. 12 (February 1917), 10.
[101] "Blasts that Saved a City," *Popular Science Monthly* (September 1927), 21.
[102] While modern scientists use the terms agroecology in a variety of different ways, a general summation of the term is "the science of the relationships of organisms in an environment purposefully transformed by man for crop or livestock production." For more information on agroecology and agroecosystems see Konrad Martin and Joachim Sauerborn, *Agroecology* (Dordrechts: Springer Science and Business Media, 2013).

to move west by federally sponsored boosterism, lobbied for federal reclamation projects while private companies capitalized on the demands for improved farmland. The interplay between these actors transformed this agrarian vision into a reality.[103]

This chapter explores the rise of agroecosystems in the United States' arid regions and vast cutover lands. In the arid regions of the country, the federal government funded the construction of complex irrigation networks and led movements for farm development. While these projects fundamentally restructured broad swaths of desert in the West, the unforeseen circumstances of speculative land buying, and excessive cost of land improvement set in motion the process through which small farms would be consolidated into industrial agribusinesses. In the nation's cutover regions, agricultural colleges, state extension services, experiment stations, chemical manufacturers, and railroad companies organized the efforts of individual farmers who helped economically revitalize and ecologically reorder vast acres of stump land.

Ordinary farmers participated in both of these environmental transformations, but in localized efforts to improve their farms, these individuals also used chemical high explosives to fashion agroecosystems. In large part, chemical manufacturers made these alterations possible. Du Pont and Hercules promoted the environmentally transformative nature of their products, which idealized rationalized farms. Motivated by economic factors, individuals consumed explosives to secure financial stability, but in the aggregate, these actions transformed the face of North America. Swamplands grew fruit and nut trees, deserts produced wheat and citrus, and cutover lands produced alfalfa and corn. But as agroecosystems began to dominate the continent

[103] US Department of the Interior, U.S. Geological Survey, *First Annual Report of the Reclamation Service From June 17 to December 1, 1902* (Washington: Government Printing Office, 1903); *Minutes and Papers of the Third Annual Tri-State Development Congress of Wisconsin, Michigan and Minnesota* (March 2-3, 1922).

of North America, farmers developed new dependencies on the chemical products and mechanical implements required to sustain production.

Making the Desert Bloom

In reclaiming arid lands, early-twentieth-century Americans used chemical high explosives in extensive ecological restructurings. From the passage of the Reclamation Act in 1902 until 1925 major irrigation projects furnished a full water supply for approximately 1.5 million acres of arid land. An additional 1,000,000 acres had received a partial supply of water. Government projects alone supplied more than 35,000 farmers with the opportunity to cultivate these arid regions. By 1921, federally irrigated farm projects produced more than $64,000,000 in crops annually. Because this was area largely considered unsuitable for agriculture before the twentieth century, there is no record of economic production in the arid regions prior to 1902. But in 1927, historians Arthur Pin Van Gelder and Hugo Schlatter estimated that before 1902, farmers of the region never produced more than $1,000,000 worth of farm products for any given year.[104]

While efforts to irrigate the West began as early as the 1840s, large scale hydration of the West was primarily a twentieth-century venture. The National Reclamation Act of 1902 appropriated "the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands," and catalyzed this change. In 1906, federal projects irrigated 22,300 acres of arid land producing a total crop value of $244,900. By 1930, the irrigated acreage totaled 1,504,810 and the total crop value from those acres amounted to $64,418,940. The cumulative total of generated wealth for

[104] Van Gelder and Schlatter, *History of the Explosives Industry,* 1068-1070.

that same year was $1,100,859,341.[105] Legislating the Reclamation Service into existence, the National Reclamation Act set in motion the fundamental transformation of arid lands into a factory of industrial food production.

In large part, these major economic developments and ecological restructurings rested on the explosive energies of chemical high explosives that aided the construction of intricate irrigation networks and reservoirs. This is evident in the nature of reclamation work. From 1902 to 1925, workers excavated approximately 250,000,000 cubic yards of dirt and rock; built more than 15,700 miles of canals, ditches, and drains; and carved 29 miles of tunnels. Chemical high explosives aided all of these tasks. Dynamite was also central to the production of the "2,400,000 cubic yards of rip rap, 3,760,000 cubic yards of concrete, and…3,530,000 barrels of cement" used in reclamation projects in the same period of time.[106] Reclamation projects depended on the outputs of the quarrying industry, and with the exception of mining, quarrying operations consumed more high explosive than any other twentieth-century industry.[107]

The history of Colorado's Uncompahgre Valley illustrates the transformative effects of reclamation projects and reveals the importance of chemical high explosives in the rise of industrial agriculture. By 1919, 5,471 settlers resided in the Uncompahgre Valley and owned 1526 farms encompassing and area of 60,906 acres of irrigated land. Collectively, these farms produced $3,391,456 worth of crops from the soils of the arid Colorado Valley that only two

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[105] Donald Worster, *Rivers of Empire: Water, Aridity, and the growth of the American West* (New York: Oxford University Press, 1985), 64; US Department of the Interior, Reclamation Service, *First Annual Report of the Reclamation Service From June 17 to December 1, 1902* (Washington: Government Printing Office, 1903), 15; US Department of the Interior, Reclamation Service, *Annual Report From the Commissioner of Reclamation to the Secretary of the Interior* (Washington: Government Printing Office, 1946), 66.
[106] Van Gelder and Schlatter, *History of the Explosives Industry,* 1069-1070.
[107] *Ibid.,* 989; Dyer and Sicilia, *Labors of a Modern Hercules,* 34.

decades before struggled to support a meager 10,000 acres of irrigated farms.[108] Historically, members of the Ute tribe, a large group of indigenous peoples that occupied the Great Basin region of Colorado, called the Uncompahgre Valley home. But in 1881, the U.S. government forcibly removed the Ute to Utah to make room for white settlers. Thousands of settlers entered to stake their claims in the valley with the hopes of creating productive farms. [109]

The arid Uncompahgre Valley was historically unsuitable for intensive agriculture. To address this, early settlers excavated "ditches for the purpose of irrigation," diverting the waters of the Uncompahgre River so that crops could be grown. With irrigation, the farmers "discovered that the soil possessed remarkable productive power" explained Barton Walter Marsh, a resident of the valley who recorded the region's history in 1905. "But along with this pleasing fact it soon became apparent that the water supply afforded by the Uncompahgre River was insufficient to properly water the lands already occupied."[110] To realize the vision of white agrarian settlement, residents of Uncompahgre needed to address the valley's limited supply of water.

The lack of water in the Uncompahgre Valley served as a natural barrier to economic development. In many ways, the environmental factors that characterized the region largely defined the nature of settlement and economic development. In the 1880s and 1890s, settlers placed so many demands on the Uncompahgre River that many aspiring homesteaders were forced to abandon their plots, "Which were by that act allowed to relapse into a wilderness." As the flows the river decreed that settlers could exploit no more than 10,000 acres of the valley's

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[108] US Department of the Interior, Reclamation Service, *Nineteenth Annual Report of the Reclamation Service, 1919-1920* (Washington, Government Printing Office, 1920), 123, 127.

[109] Barton W. Marsh, *The Uncompahgre Valley and the Gunnison Tunnel: A Description of Scenery, Natural Resources, Products, Industries, Exploration, Adventure, Etc.* (Montrose: Marsh and Torrence, 1905), 32.

[110] "Uncle Sam's Greatest Engineering Feat is Finished," *Chicago Tribune* (August 1, 1909), 4; Marsh, *The Uncompahgre Valley,* 35-36.

nutrient rich soils, a certain equilibrium existed between humans and nature that would soon be challenged.[111]

Motived by economic desires, settlers of the region and critical arms of the agricultural state reimaged the ecological make-up of the arid Colorado valley. Describing the region in 1905, Barton Marsh declared that the Uncompahgre Valley was "destine to become, within a short time, one of the most beautiful and fruitful garden spots on the face of the earth." Four years later, the *Chicago Tribune* reported "110,000 acres of land now seemingly an arid desert and covered chiefly with sage brush, will through the agency of the United States, be transformed into a garden spot." To achieve this vision of a landscape transformed, settlers needed to renegotiate the established relationship between humans and nature. The answer was simple. To properly irrigate the valley, settlers needed to divert water from the Gunnison River, which flowed just sixteen miles away, into the Uncompahgre Valley. But sixteen miles of granite known as the Squaw Mountains stood between the farmers and their transformative dreams.[112] Financially and technologically, the vision appeared unattainable until the twentieth century.

Responding to local agitation, the federal government made the ecological transformations a reality. Early residents of the valley credited a French immigrant named Lauzon as the first person to imagine the diversion of the Gunnison River. Organizing lectures in "school houses" and pontificating on "street corners," Lauzon drummed up support for the project by August 1904. The three Colorado counties of Ouray, Montrose, and Delta appointed civil engineers, Walter Fleming and Richard Whinerah to conduct preliminary surveys. Fleming and Whinerah concluded that the only practicable means of diversion would be to tunnel through

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[111] Marsh, *The Uncompahgre Valley,* 36.
[112] Marsh, *The Uncompahgre Valley,* 36; "Uncle Sam's Greatest Engineering Feat is Finished," *Chicago Tribune* (August 1, 1909), 4

the mountains. With sufficient support from the community, district representative, the Hon. John C. Bell, lobbied the Reclamation Service to appropriate the funds and engineering expertise necessary to complete the task. By October 18, 1904, under the authority of the National Reclamation Act of 1902, the Reclamation Service approved a contract for the construction of the six-mile Gunnison Tunnel and 11-mile canal to command the waters of the Gunnison River into the fields of the Uncompahgre Valley at a total cost of $3,006,465.30.[113] But ecological transformations of this scale required more than just monetary backing and engineers.

Tunneling through the continental divide required massive amounts of energy, and by the twentieth century, chemical high explosives made this energy attainable and affordable. The team of engineers in charge of blasting operations decided on the use of both 40 and 60 percent standard dynamite, with workers using 60 percent charges for the bulk of the blasting. According to a 1914 report of the Bureau of Mines, "nearly 30 pounds of 40 per cent and 60 pounds of 60 per cent gelatin dynamite was employed per round" in the construction of the Gunnison Tunnel. This was "equivalent to approximately 5.5 pounds per cubic yard excavated."[114]

While workers used dynamite's explosive energies to reshape the contours of a river and excavate a tunnel through a mountain, the energy stored in dynamite's chemical bonds also eroded nature's leverage against the exploitative developments of people eager to commodify the nutrients rich soils in the Uncompahgre Valley. Settlers utilized the waters of the Gunnison River to raise wheat, oats, potato's, barley, alfalfa, and 17 types of vegetables from the arid ground. But fruit cultivation was the primary industry in this period as Uncompahgre Valley farmers had

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[113] Marsh, *The Uncompahgre Valley,* 76-79; Uncle Sam's Greatest Engineering Feat is Finished" *Chicago Tribune* (August 1, 1909), 4; US Department of the Interior, Reclamation Service, *Twelfth Annual report of the Reclamation Service, 1912-1913* (Washington: Government Printing Office, 1914), 77, 83.

[114] Uncle Sam's Greatest Engineering Feat is Finished," *Chicago Tribune* (August 1, 1909), 4; US Department of the Interior, Bureau of Mines, *Safety and Efficiency in Mine Tunneling* (Washington: Government Printing Office, 1914), 155-156.

their eyes set on national markets. By 1920, the region produced 7,143,600 pounds of apples, which far exceeded all other crops.[115] The vested interest of the federal government in peopling the West to establish national control and the economic desires and agitations of individuals and communities of settlers who sought to improve their financial conditions transformed the Uncompahgre Valley into a well-managed agroecosystem. Both visions rested on changes of established ecological orders. While the forceful removal of indigenous peoples and legally authorized sale of public lands encouraged expansion, the agitations of settlers prompted further infrastructural development. By 1920, their collective efforts irrigated 50,000 additional acres of arid land that generated close to $3.5 million worth of crops annually.[116]

The Uncompahgre Valley Project and the creation of the Gunnison tunnel were not anomalies in the history of land reclamation. The construction of many irrigation projects depended on chemical high explosives. The irrigation of Utah's Strawberry Valley required the construction of the Strawberry tunnel—a 19,200-foot passage through the Wasatch Mountains that helped supply 47,560 acres of previously arid land with water by 1924. Workers used 40 percent dynamite to hallow out the "hard blue limestone and hard, course-grained sandstone" mountain.[117]

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[115] Marsh, *The Uncompahgre Valley,* 38-41, 46, 47; US Department of the Interior, Reclamation Service, *Nineteenth Annual Report of the Reclamation Service, 1919-1920* (Washington, Government Printing Office, 1920), 127.

[116] US Department of the Interior, Reclamation Service, *Nineteenth Annual Report of the Reclamation Service, 1919-1920* (Washington, Government Printing Office, 1920), 123, 127.

[117] US Department of the Interior, Bureau of Mines, *Safety and Efficiency in Mine Tunneling* (Washington: Government Printing Office, 1914), 155; B. A. Etcheverry, *Irrigation Practice and Engineering: Conveyance of Water* (New York: McGraw-Hill Book Company, 1915), 175; US Department of the Interior, Bureau of Reclamation, *Tenety-Fourth Annual Report of Bureau of Reclamation For the Fiscal Year Ended June 30, 1925* (Washington: Government Printing Office, 1925), 95.

Beyond the works of the federal government, private enterprises engaged in ecological transformations as well. The Laramie-Poudre Reservoirs and Irrigation Company constructed the Laramie Poudre Tunnel, an 11,306-foot irrigation passage near Greeley, Colorado. Working to supply 125,000 acres of arid land with the water supply necessary to grow crops, workers used 60 percent and 100 percent dynamite to excavate the passage. Depending on the type of rock being removed, blasting technicians used between 3.9 and 4.9 pounds of dynamite per cubic yard of material removed to create a tunnel with a carrying capacity of "800 cubic feet [of water] per second." Completed in 1911, the tunnel never fully achieved its environmentally transformative potential because of an 11-year lawsuit over water rights to the Laramie River between Colorado and Wyoming that eventually went to the Supreme Court of the United States. Throughout the litigation process water continued to flow through tunnel. Concluded in 1922, the High Court appropriated approximately half of the water supply that investors in the tunnel had originally anticipated. This spelled financial ruin for the Laramie-Poudre Reservoirs and Irrigation Company and the speculative investors in the region, but still, the tunnel increased the water supply in and around Greeley, Colorado allowing settlers to exploit its nutrient rich soils despite limits nature had previously imposed. In 1910, one year before the tunnel's completion, the Greeley Valley supported a total of 3981 farms. The restricting of waterways permitted an additional 1,784 farms—5765 in total. By 1925, due to court ordered water restrictions, that number fell to 5610, still a significant increase from 1910, when natural limitations still largely dictated the development of agriculture in the valley.[118]

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[118] US Department of the Interior, Bureau of Mines, *Safety and Efficiency in Mine Tunneling* (Washington: Government Printing Office, 1914), 155-156; B. A. Etcheverry, *Irrigation Practice and Engineering: Conveyance of Water* (New York: McGraw-Hill Book Company, 1915), 175-176; William R. Kelly, *Laramie-Poudre Irrigation Co. Poudre Valley Canal, Greeley-Poudre Irrigation District* (Greeley: July 15, 1964), 14, 26-27; US Department of Commerce, Bureau of the Census, *United*

Reclamation works consumed chemical high explosives in more than just tunneling operations. In the construction of reservoirs that stored the waters destine for irrigation, dynamite aided workers as well. Laborers in Idaho's Boise Project harnessed the powers of dynamite in other foundational operations. The success of the Boise Project rested on the ability of engineers to effectively store enough water for continuous irrigation during southern Idaho's dry season, which lasted from April to October. The answer to this problem was the creation of Arrowrock Dam, 22 miles above Boise, Idaho, to store the water necessary for the irrigation of 255,000 acres of land. With a massive radius of 672.5 feet for its upstream face, the Arrowrock Dam required a solid bedrock foundation to be structurally sound. Workers excavated 330,000 cubic yards of granite to expose an acre of bedrock approximately 80 feet below the existing riverbed. To complete this monstrous task, project engineers employed dynamite. Du Pont representative E. F. King explained, "Du Pont 40 per cent. Straight Nitroglycerin dynamite and Du Pont Black Blasting Powder were used in this part of the work during the early stages." But because of its versatility in cold weather, "the Du Pont Company's Red Cross Low Freezing Straight Nitroglycerin dynamite was introduced on the work." Additionally, in the excavation of 350,000 cubic yards of granite in the creation of the dam's spillway, Du Pont brand "Monobel No. 6" a low freezing permissible explosive, "was largely used in this part of the work."[119]

With the Arrowcreek Dam completed in 1915, the Boise Project helped to rationalize Idaho's landscapes. Prior to the completion of this project, environmental determinates such as the region's average annual rainfall of 12.71 inches and the natural pathways of the Boise River

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States Census of Agriculture, 1925: Reports for States, With Statistics For Counties and a Summary For the United States Part 3 The Western States (Washington: Government Printing Office, 1927), 213.

[119] US Department of the Interior, Reclamation Service, *Fifteenth Annual report of the Reclamation Service, 1915-1916* (Washington: Government Printing Office, 1916), 129, 134-136; "The Arrowrock Dam," *Du Pont Magazine* Vol. 4, No. 7 (July 1915), 5-7.

determined the extent of agricultural production in the region. Environmental condition defined the ecological order. But government officials and settlers harnessed the energy of chemical high explosives to realize their shared vision of agriculturally viable farmland in southern Idaho. The government underwrote complex irrigation networks with money and engineering expertise while chemical high explosives eroded the foundations upon which laborers built these new infrastructural marvels. By 1923, 112,000 acres of the initial 143,000 acres imagined as irrigable farmland had access to the water necessary to raise $3,992,600 worth of crops.[120] Thanks to the energies of chemical high explosives, Idaho farmers overcame nature's barriers to economic development.

The construction of the Tieton Dam in Washington showed similar results. Part of the larger Yakima Project of 1906, the Reclamation Service completed the Tieton Reservoir in 1925. "Situated on the Tieton River, at Rimrock, Washington," the Tieton Dam was an earth and rock filled structure that measured "900 feet long and 25 feet wide" with a height of 321 feet. According to reports from the Du Pont Chemical Company, from 1921 to its completion, workers detonated "approximately 460,000 pounds of explosives." In building the spillway alone, workers, under the direction of construction engineer F. T. Crowe of the U.S. Reclamation Service, used 16.4 tons of T.N.T. to remove approximately 41,100 cubic yards of rock. Upon completion, the reservoir had a carrying capacity of "202,500 acre feet of water, sufficient to irrigate 70,000 acres." This far exceeded the 32,000 acres deemed irrigable in the Bureau of

[120] US Department of the Interior, Reclamation Service, *Fifteenth Annual report of the Reclamation Service, 1915-1916* (Washington: Government Printing Office, 1916), 129; US Department of the Interior, Reclamation Service, *Twenty-Second Annual Report of the Bureau of Reclamation, 1922-1923* (Washington: Government Printing Office, 1923), 10.

Reclamation's surveys of the region. In its first year of operation, the reservoir's water irrigated 27,650 acres of arid lands.[121]

While the federal government controlled major waterways and erected dams and canals, ordinary farmers reimagined dynamite in their efforts to rationalize the landscapes of their individual plots. In the Storm Lake Drainage District near Greeley, Colorado, "a considerable portion" of the 800-acre area "was inundated as a result of seepage from the irrigation ditches" in 1920. The uncontrolled water flooded the productive farmland. Constructing a "drainage ditch 9,500 feet long," local agricultural blaster Ben Marsh used dynamite to corral the flow of water across the flooded arid landscape. As the *Du Pont Magazine* eagerly broadcast, "The undertaking was completely successful. Next year this land, which unfortunately received too much of the life-giving element that makes the desert bloom, will be producing bumper crops of hay and sugar-beets…and there will be more money in it for the owner."[122] Dynamite drainage was not unique to the West. In 1923, the Commissioner of the Drury Drainage District in Illinois hired a Du Pont representative to clear "three and one-half miles" of a clogged drainage ditch that threatened to flood farmland in the northern part of the Mississippi River Valley drainage. Using 8000 pounds of Du Pont nitroglycerine dynamite, the representative successfully cleared the ditch of obstructions.[123] As ditches required continual maintenance, farmers in irrigated districts developed a new dependency on chemical high explosives. Harnessing dynamite's explosive

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[121] "To Irrigate 70,000 Acres," *Du Pont Magazine* Vol. 19, No. 8 (August 1925), 7, 14; "T.N.T. Moves Rock on Tieton Dam Project," *Engineering News-Record* Vol. 90, N0. 13 (March 29, 1923), 594; US Department of the Interior, Bureau of Reclamation, *Twenty-Fifth Annual Report of Bureau of Reclamation for the Fiscal Year Ended June 30, 1926* (Washington: Government Printing Office, 1926), 81.
[122] "Draining Irrigated Acres," *Du Pont Magazine* Vol. 12, No. 4 (April 1920), 8, 16.
[123] "Missis-Seepage," *Du Pont Magazine* Vol. 17, No. 8 (August 1923), 8.

energy to effectively manage water supplies, ordinary farmers played a critical role in the ecological transformations of arid lands as well.

As irrigation works helped bring deserts under cultivation, less obvious environmental transformations were underway. As early as 1901, F. H. King, the professor of agricultural physics at the University of Wisconsin observed the association between irrigation and diminished concentrations of nitrogen in soils. King explained that "the application of too much water to these lands might lead to the loss of so much plant food by leaching as to overcome any advantage which might be derived from the irrigation." Conducting a series of experiments, King discovered "the amount of nitrates in the soil under irrigation" to be "less than that in the soil not irrigated." King witnessed a problem that still faces farmers of today. Like water, nitrates are essential for plant growth. But because nitrates are water soluble, excessive water absorbs, or leaches nitrates out of the soil preventing plants from extracting it with their roots. The proliferation of agricultural irrigation projects at once provided farmers sufficient water supplies and depleted the nitrate levels of their soils.[124]

Nitrate leaching created a number of problems for the American farmers. As irrigation depleted nutrient rich soils, farms became depended on chemical fertilizers to replenish their farms. In 1911, Irrigation Engineer C. E. Tait explored the relationship of irrigation and fertilizers in the cultivation of citrus trees in Pomona, California. Tait explained that "both are necessary for success," and if a farmer fertilized during irrigation, the nutrients were "washed into the subsoil requiring additional fertilizer to revitalize the orchard."[125] Irrigating over 1.5

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[124] US Department of Agriculture, Office of Experiment Stations, *Bulletin No. 119*: *Report of Irrigation Investigations for 1901* (Washington: Government Printing Office, 1902), 342, 344; For more information on nitrate leaching see R. F. Follett and J. A. Delgado, "Nitrogen Fate and Transport in Agricultural Systems," *Journal of Soil and Water Conservation* Vol. 56, No. 6 (November/December 2002), 402-407.
[125] US Department of Agriculture, Office of Experiment Stations, *Bulletin 236: The Use of Underground Water for Irrigation at Pomona, California* (Washington: Government Printing Office, 1911), 79.

million acres of farmland between 1902 and 1930, American farmers consumed commercial fertilizers to counteract leeching. Where in 1900 farmers used 2,730,000 tons of fertilizers to aid production, they used 8,208,000 tons by 1929.[126] The increased acreage of total farmland and efforts to intensify crop production influenced fertilizer consumption as well, but the practice of artificial irrigation contributed to the process. As such, the use of chemical high explosives in irrigation works catalyzed new chemical dependencies in American agriculture as farmers in irrigated fields relied on the use of chemical fertilizers.

From its inception, the Reclamation Service spearheaded the establishment of complex irrigation networks. But as these examples show, the economic desires of settlers and businesses also fueled these developments. For federal and state governments, these projects proved financially successful with the total income of the Bureau of Reclamation far outweighing total expensive of irrigation operations. By 1926 net income totaled $11,573,157.21 with total expenses amounting to $2,402,316.91.[127]

American farmers experienced these developments differently. Congress passed the National Reclamation Act of 1902 under the assumption that the transformation of arid lands into small irrigable farms would be an inexpensive enterprise because "settlers would have virtually free land, and that water would be cheap because the irrigation works would be constructed by the Government without profit, and with interest free money." In practice, speculation resulted in inflated land prices, and the cost to develop 40 to 80-acre plots of unimproved land into farms "was not only much greater than was anticipated," but in many cases exceeded "the cost of

[126] US Department of Agriculture, Statistical Reporting Service, *Commercial Fertilizers: Consumption of Commercial Fertilizers, Primary Plant Nutrients, and Micronutrients* (Washington: Government Printing Officer, 1971), 2.
[127] US Department of the Interior, Bureau of Reclamation, *Tenety-Fifth Annual Report of Bureau of Reclamation for the Fiscal Year Ended June 30, 1926* (Washington: Government Printing Office, 1926), 1.

canals and reservoirs." While net production of farm goods in arid regions rose and contributed to the nation's GDP, the idea of small irrigated farms in the arid West began to give way to the consolidation that took place over the next two decades to furnish the large-scale farms characteristic of industrial agriculture by the end of World War II.[128]

Revitalizing Cutover Lands

In terms of ecologically transformative effects, the reclamation of cutover lands for farming purposes differed from its counterpart in the arid regions of the country. While efforts to irrigate the desert targeted the largely unmanaged ecologies of the West, stump land reclamation was concentrated in regions where humans had already drastically restructured the existing ecological order. Stump land reclamation also differed in the degree of government involvement. Federal arms of the agricultural state promoted the reclamation of these cutover lands but with limited financial and engineering support. Instead, ordinary farmers cooperating with chemical manufacturers and state and local governments mobilized to restructure the nation's broad swaths of cutover land.

The United States' lumbering industry flourished in the nineteenth century supplying the nation with building materials and fuel. But by the twentieth century the economic effects of mass deforestation stirred concern among government officials and business executives. In 1925, W. B. Greeley, Chief of the U.S. Forest Service, explained "The progress of civilization has been called a struggle between human wants and natural resources. And no part of this age-long contest has been more clear cut than the effort of mankind to supply its need for wood." By 1925, the United States consumed "22 ½ billion cubic feet [of lumber], or about two-fifths of the

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[128] US Department of the Interior, Bureau of Reclamation, *Twenty-Third Annual Report of Bureau of Reclamation for the Fiscal Year Ended June 30, 1924* (Washington: Government Printing Office, 1924), 1-2.

yearly consumption in the entire world." Where in 1620 the total acreage of virgin forest in the contagious United States was approximately 820,000,000, roughly 138,000,000 acres remained by 1920 (see figures 1, 2, and 3).[129] The eradication of nearly 700,000,000 acres of virgin forest, the bulk of which was removed in the second half of the nineteenth century, in turn left broad swaths cutover land that laid both devoid of forest resources and economic productivity. But enterprising individuals reimagined these wastelands as productive farmlands.

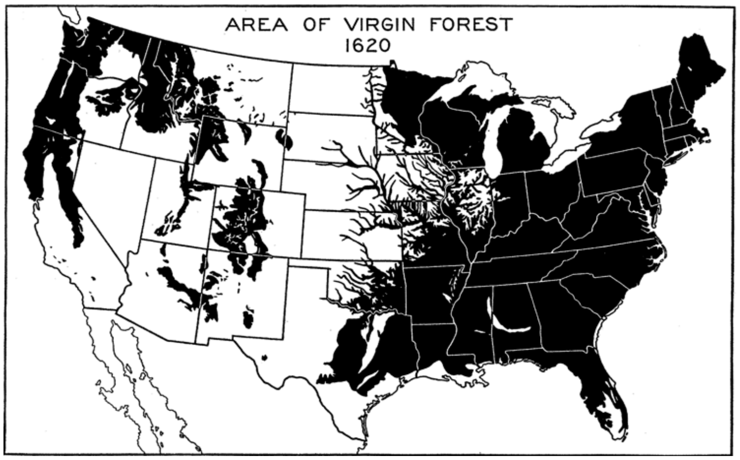

Figure 1—U.S. Forest Service map of the area of virgin forest in 1620

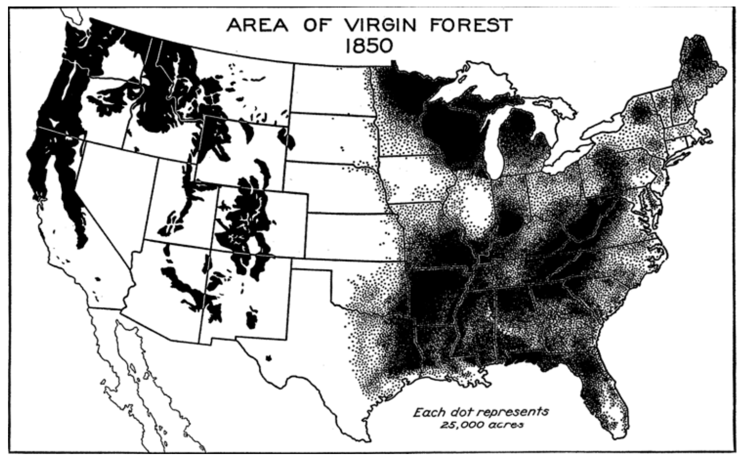

Figure 2—U.S. Forest Service map of the area of virgin forest in 1850

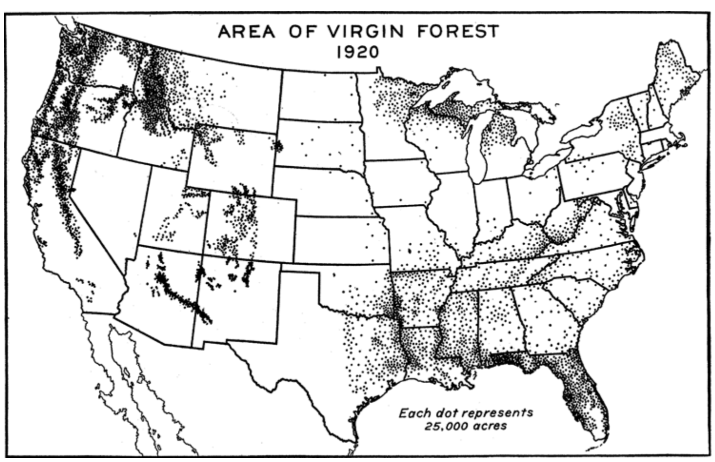

Figure 3—U.S. Forest Service map of the area of virgin forest in 1920

[129] W. B. Greeley, "The Relation of Geography to Timber Supply," *Economic Geography* Vol. 1, No. 1 (March 1925), 1-2, 4-5.

As the first chapter illustrated, ordinary farmers used chemical high explosives to address the issues that came with farming stumped land. Blasting their farms, these progressive agriculturalists engaged in small scale environmental restructurings to achieve greater economic output as early as the 1870s. By the twentieth century, critical arms of the agricultural state at both the state and federal level, chemical manufacturers, and in many cases railroad executives promoted the reclamation of cutover lands on a much larger scale than what was seen in the nineteenth century.

During World War I, the federal government supported land reclamation through the USDA. In the south, the USDA actively worked with chemical manufacturers to find solutions to the problems facing southern farmers. By 1918, the sales department at Hercules, headed by W. R. James, sought out ways in which the company could contribute to the war effort, and asked government agencies, including the USDA, to endorse Hercules' advertisements. USDA director, Bradford Knapp, offered to cooperate if Hercules could find a solution to the issues of deforestation and excessive cutover land, which troubled both southern agriculture and the timber industry. Looking to diversify their markets, Hercules began to explore ways in which an entry into the naval stores industry—the production of terpene and rosin products from pine trees—could prove both lucrative for their business and as an effective means of addressing the problems of southern industry.[130]

The southern naval stores industry suffered greatly in this period as a result of forest depletion. This gave rise to new methods of resource extraction, mainly of tar oils and pitch, which workers could effectively extract from fallen trees and stumps through a process called

[130] Dyer and Sicilia, *Labors of a Modern Hercules,* 131-133. According to Dyer and Sicilia, the naval stores industry is characterized by its production of "terpene and rosin products obtained from living pines, pine wood extraction, and paper production."

destructive distillation. This was opposed to extraction from living trees, which was the traditional means of acquisition. The Hercules' Industrial Research Department (IRD) and Marketing Department increased marketing efforts to promote stump removal with Hercules brand dynamite while simultaneously investing in the naval stores industry. They intended to boost dynamite sales and reduce farmers' experienced cost of land clearing by purchasing their blasted stumps for destructive distillation. On May 3, 1920, Hercules secured a contract with Newman Lumber Company in Hattiesburg, Mississippi, to clear 75,000 acres of longleaf pine stumps with dynamite. This in turn provided Hercules with the raw materials needed to enter the naval stores industry while simultaneously transforming the Newman Lumber Company's cutover land into property that could be sold as farmlands.[131] The transformation of cutover lands appeared economically lucrative for all the players involved. Hercules would be able to diversify in naval stores, Newman Lumber Company could profit on the sale of cutover lands, and the USDA and federal government would theoretically benefit from increased agricultural output in the region. In turn, the forest ecology of the region was fundamentally restructured.

After the war, Americans expanded their efforts to clear cutover lands. As early as 1920, the United States Department of Agriculture's Division of Agricultural Engineering cooperated with agricultural colleges and state officials to distribute surplus war explosives for the expressed purposes of reclaiming cutover lands. S. H. McCrory, chief of the USDA Division of Agricultural Engineering, reported that between July 1, 1922 and July 1, 1923 "a total of 4,179,550 pounds" of picric acid, a chemical high explosive similar to dynamite, "was distributed to twenty different states" (see figure 3). The USDA directed the majority for the surplus explosives to Minnesota, Michigan, and Wisconsin where the lumbering industry had

[131] *Ibid.,* 134-141.

most drastically effected landscapes, but distribution also included southern states such as the Carolinas, Georgia, and Tennessee as well as such western states as Arizona and California. In addition to picric acid, government extension workers helped distribute sodatol, a mixture of surplus sodium nitrate and TNT, to farmers across the country. The Division of Agricultural Engineering, the University of Wisconsin, and the U.S. Bureau of Mines spearheaded the efforts. Distributed in the same general manner as picric acid, sodatol offered farmers an explosive that was "15 to 20 per cent stronger than ordinary dynamite" at a price "less than one-third of the retail cost of dynamite."[132] Farmers used these cheap and readily available new explosives to transform forests into farmland.

Picric Acid Distributed for Agricultural Purposes by States During the Year, July 1, 1922 to June 30, 1923, by the Division of Agricultural Engineering, Department of Agriculture

States	Pounds	States	Pounds
Alabama	100	Mississippi	18,000
Arizona	1,100	Missouri	25,100
California	18,000	Nebraska	67,000
Connecticut	17,000	North Carolina	107,950
Georgia	40,000	Ohio	20,000
Iowa	82,000	Oklahoma	400
Kentucky	33,000	South Carolina	16,700
Maryland	500	Tennessee	36,200
Michigan	451,300	Vermont	3,200
Minnesota	627,900	Wisconsin	2,614,000
TOTAL	4,179,550 pounds		

Figure 3—Table showing the distribution of military surplus picric acid in 1922 and 1923.

While state officials from Wisconsin, Minnesota, and Michigan independently organized reclamation efforts in their respective states before the war, they cooperated in the post war years to create the Tri-State Land Development Congress in 1921 with a goal of clearing the regions 35,000,000 acres of cutover land. Receding glaciers of the last ice age, approximately 10,000

[132] John Swenehart, "The Utilization of Salvaged War Explosives in Cut Over Land Reclamation," *Transaction of the American Society of Agricultural Engineers* Vol. 17, (Clemens: American Society of Agricultural Engineers, 1925), 39-40, 46.

years ago, shaped the topography of the Great Lakes region, left rich mineral deposits, and cleared the way for broad swaths of boreal forests. Before the time of white settlers, a large number of native tribes called this region home. But the forest resources and mineral deposits of the region attracted settlement after European contact, which supported the mining and lumber industries that defined the region by the mid nineteenth century. In 1830, Wisconsin alone held 129,000,000,000 board feet of lumber, but by 1920, only 1,000,000,000 board feet remained because of logging operations.[133] After a century of clear cutting, the three states looked to economically revitalize the millions of acres of decimated forest lands.[134]

The agricultural college of Wisconsin's close connection with surplus war explosives allowed the state to be a leader in these reclamation efforts. In 1921, Wisconsin farmers effectively cleared 150,000 acres of previously stumped land, which translated into approximately 4.5 acres per settler. Just five years earlier, residents of Wisconsin cleared no fewer than 30,000 acres a year. Chemical high explosives were central to this accelerated transformation of the landscape. In the first six months of 1921, Wisconsin farmers "shot over 2,000,000 pounds of explosives in their battle against the stumps." Describing the achievement, George H. Dacy, contributor to *Farm Mechanics,* stated, "as practically all of the cutover land is virgin, fertile soil, its reclamation and utilization for farming purposes is one of the greatest agricultural achievements which could be consummated in the states which have been leaders in lumbering."[135]

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[133] James Willard Hurst, *Law and Economic Growth: The Legal History of the Lumber Industry in Wisconsin, 1836-1915* (Washington: Belknap Press, 1964), 2-3.
[134] Aaron Alex Shapiro, "'One Crop Worth Cultivating': Tourism in the Upper Great Lakes, 1910-1965," PhD diss., University of Chicago, 2005, 1; William Whipple Warren, "Emigration of the Ojibways from the Shores of the Atlantic Ocean to Their Occupation of the Area of Lake Superior" *History of the Ojibway People* (1885), 42.
[135] George H. Dacy, "Land Clearing in the Northern States with T.N.T.," *Farm Mechanics* (October 1921), 42.

Similar events transpired in Minnesota. Minnesota's white pine forests attracted non-native settlers to Beltrami County and the town of Bemidji in the nineteenth century, and the new settlers created a "railroad and lumber center." After depleting much of the forest's resources, these new citizens expressed great concern over the fate of their community. In 1921, the Bemidji Commercial Club hosted a special meeting with "representatives of the State University, the railroads, the press, the banks, and farmers and business men" to devise a plan for the revitalization of Bemidji's "neighboring villages and the surrounding agricultural territory." The attendees concluded that if Bemidji was to remain as a center of trade then "agricultural interests" were of the utmost importance. Plagued by stumped fields, local farmers present at the meeting lobbied to "clear more land." According to an article published in *Du Pont Magazine,* "That was the forward to a unanimous vote to begin upbuilding Bemidji with dynamite: for these men realized that every acre of stump cleared, developed and put into crops was a potential source of profit to the farmers as well as to every business interest in the city." Organizing the Beltrami Country Land Clearing Association, the community set funding goals and a land clearing quota of 15,000 acres for the first year. A. W. Stone, business manager and representative board member of the Association, organized demonstrations in corroboration with the Du Pont Company to convey the most economical blasting methods to be used in stump removal. Following the demonstrations, "farmers pooled their orders for explosives." By May 27, the railroad had delivered "ten cars of dynamite" and "operations were started in all sections of the county." By the end of summer, workers added more than 15,000 acres "to the producing area." With fall work underway, the cooperative efforts of the Beltrami County community members far exceeded the annual quota of 15,000 acres.[136]

[136] "Building Up Bemidji with Dynamite," *Du Pont Magazine* Vol. 15, No. 5 (November-December 1921), 6-7; "Governor Preus Will Do Some Dynamiting," *Brainerd Daily Dispatch* Vol. 20, No. 289

Residents of Beltrami County successfully cleared cutover lands with chemical high explosives, but natural limitations continued to bar economic development. Where in 1910 Bemidji and broader Beltrami County supported 1577 farms, there was 3065 by the end of 1920. But in 1925, only 2534 remained. Farmers uncalculated reclamation efforts contributed to the failing of farms. When they began blasting in 1920, the residents of Bemidji did not investigate the agricultural viability of the land they cleared. As such, a portion of the cleared land failed to produce bountiful harvest.[137] While new chemical energies drastically altered landscapes and facilitated the rise of agroecology, certain environmental barriers remained. Farmers in Bemidji showed that even when cleared of stumps, some lands failed preform as farm land.

In addition to environmental limitations, the postwar agricultural depression of the 1920s created economic barriers to success as well. Bemidji like the rest of the nation's agricultural regions suffered from a nearly fifty percent decrease in farm prices that followed the conclusion of World War I. Addressing these issues, farmers worked to create national agricultural cooperatives and gain legislative support from sympathetic congressional representatives known as the Farm Bloc as early as 1920. Organizers like Aaron Shapiro, a California lawyer who represented several agricultural cooperatives, worked to establish a national grain cooperative in the early 1920s, but due to organizational difficulties, the project collapsed. Additionally, farm legislation that passed in the 1920s supported cooperative efforts and expanded credit but lacked the capacity to address the underlying problem—insufficient demand, both foreign and domestic,

(May 10, 1921), 1; *Brainerd Daily Dispatch* Vol. 20, No. 304 (May 27, 1921), 4; US Department of Commerce, Bureau of the Census, *United States Census of Agriculture, 1925: Reports for States, With Statistics For Counties and a Summary For the United States Part 1 The Northern States* (Washington: Government Printing Office, 1927), 733.

137 US Department of Commerce, Bureau of the Census, *United States Census of Agriculture, 1925: Reports for States, With Statistics For Counties and a Summary For the United States Part 1 The Northern States* (Washington: Government Printing Office, 1927), 733.

for farm products. While prices recovered slightly in 1925, agricultural markets remained dismal into the 1930s.[138]

Nevertheless, easy credit and cooperation bolstered efforts to clear cutover land in the northern region of the United States. It Aitken County, Minnesota, local banker E. O. Buhler helped furnish the credit necessary for local residents to purchase land clearing dynamite. "The settlers had done nobly in blowing up the stumps" explained Buhler, which left many acres ready to be turned. But the "cradle knolls, stones and tangled web of roots that [was] the heritage of the stump field" exposed "a lack of sufficient horse power" in the region. Farmers found that horse and mule teams often times did not possess enough power to turn the blasted fields. The solution was the tractor. Buhler explained that tractors gave "a new stimulus to the clearing game" as the increased horsepower turned the soils in preparation for cultivation.[139] Between 1920 and 1930 tractor owner ship increased from approximately 250,000 to nearly 900,000 on American farms. This transformation manifested most drastically in the northern region of the country where farmers concentrated their efforts to blast stumped lands. Northern farmers owned about two thirds of the nation's tractors by 1930.[140] As chemical high explosives cleared new farmland, farmers adopted and at times depended on mechanical implements to fashion agroecosystems in the once forested northern United States.

In prompting mechanization and the proliferation of tractor ownership, chemical high explosive indirectly liberated many farmers from their dependencies on working livestock that required grazing land and the cultivation of feed crops. By 1930, farmers owned nearly

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[138] Cochrane, *Development of American Agriculture,* 114-120.
[139] E. O. Buhler, "New Facts and Figures," *Minutes and Papers of the Third Annual Tri-State Development Congress of Wisconsin, Michigan and Minnesota* (January 1923), 76-77
[140] US Department of Commerce, Bureau of the Census, and US Department of Agriculture, Bureau of Agricultural Economics, *1950 Census of Agriculture Special Reports: Agriculture 1950: A Graphic Summary* (Washington: Government Printing Office, 1952), 78.

7,500,000 fewer mules and horses than they did in 1920. According to the USDA's Bureau of Agricultural Economics, the removal of horses and mules made available an addition 25,500,000 acres of cropland in that same period (See figure 4).[141]

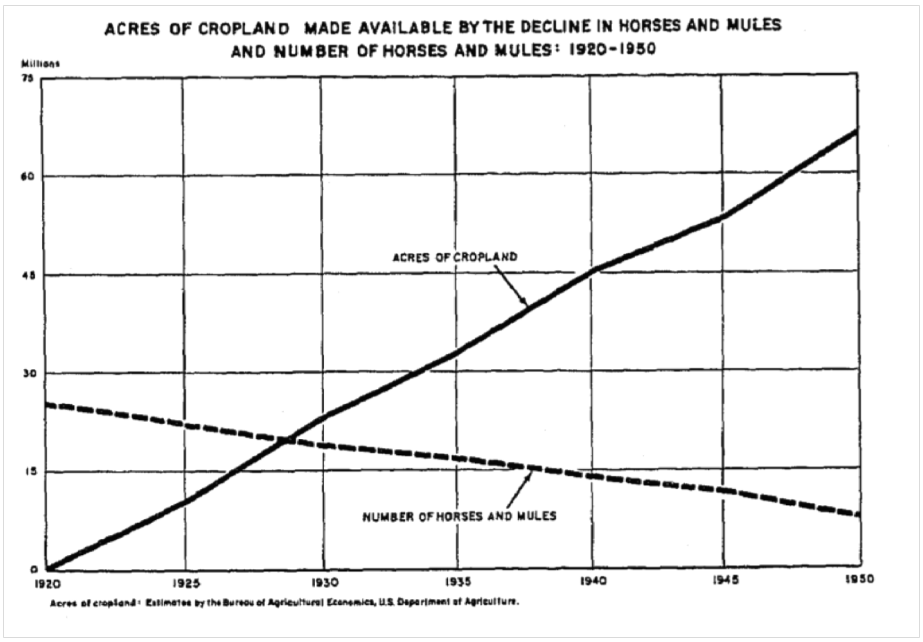

Figure 4

While states with large cutover land reclamation projects naturally received the majority of the surplus war explosives, ordinary farmers engaged in the ecologically transformative practice independent of state-wide movements. In the winter of 1923-1924, the Extension Service in Oregon distributed approximately 1,000,000 pounds of sodatol to its farmer constituents who desired to remove stumps. One of the state's county agents, O. T. McWhorther, "secured 217,000 pounds of sodatol for farmers in his territory" near Portland.[142] Because the state had not organized any formal efforts, agricultural engineer for the Oregon State College, Geo. W. Kable explained, "The demand for sodatol was quite beyond our expectations,

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[141] *Ibid.*
[142] "Sodatol for Land Clearing," *Semi-Annual Digest of Co-operative Agricultural Extension Workers' Activities* Vol. 5, No. 2 (September 1924), 13.

inasmuch as no large reclamation projects were on hand." While major developments provoked the bulk of the forest land transformations, independent efforts, in the aggregate, amounted to significant ecological restructuring as well.

The transformation of cutover lands demonstrates the collaborative efforts involved in the transformation of forest lands into productive farmland. Farmers, business owners, chemical manufacturers, and public officials, driven by economic motives, collectively established agroecosystems where forests once stood. Though largescale human intervention into the ecological order that defined the region since the last ice age began with the logging industry, the implementation of chemical high explosives' energies elevated the region to a new "plateau of development."[143] The lumber industry exploited forest products creating vast cutover lands, but chemical high explosives' energies allowed humans to assert greater environmental control in what W. B. Greeley, Chief of the U.S. Forest Service, called the "struggle between human wants and natural resources."[144] But as the failed farmlands in Bemidji showed, ecological and economic barriers remained.

Unlike arid land reclamation where the Bureau of Reclamation led the projects, state and local enterprises commanded the transformation the cutover lands. According to the 1921 report of the Tri-State Land Development Congress, "the reclamation of the cut-overs…is primarily a task that can be done by the individual," and "perhaps nothing is more indicative of land clearing effort than the use of explosives." The USDA division of Agricultural Engineers cooperated in these efforts, but ordinary farmers did most of the work and used tens of millions of pounds of

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[143] Historian Donald Worster uses this phrase to describe how engineering expertise and technological developments furnished new levels of control over water in the American West. Similarly, I am using the term to describe the role of chemical high explosives in controlling ecosystems. Donald Worster, *Rivers of Empire,* 64.
[144] Greeley, *The Relation of Geography to Timber Supply,* 1.

high explosives to reclaim these lands in the first three decades of the twentieth century. In the first three years after World War I, Wisconsin alone reclaimed approximately 300,000 acres, and representatives from the Tri-State congress estimated that farmers used between 2,500,000 and 3,000,000 of high explosives per 100,000 acres of land cleared.[145] In 1921, Minnesota farmers blasted "2,000,000 pound of dynamite" and cleared 40,000 acres.[146] In the aggregate, these farmers participated in the broader contest between human desire for economic development and nature. Every stump blasted was an expression of dominance, the physical erosion of an existing ecology, and the emergence of a new agroecological order in which human desire ultimately restructured landscapes.

Creating a Narrative for Localized Transformations

Well-organized and cooperative efforts to expand agricultural production in the early twentieth century reclaimed the country's arid and cutover lands. Even though ordinary farmers, especially in the transformation of cutover lands, actively engaged in the labors of these developments, state and federal programs acted as vital catalysts. But the transformative ends of explosive agriculture went beyond these well-organized projects. New forms of explosive agriculture, many of which were described in the first chapter, were themselves a form of ecological restructuring. As Americans reimagined chemical high explosives as a tool for the farm, farmers directed dynamite's energies towards economic productivity while also rationalizing landscapes. Best illustrated in the advertisement campaigns of explosive manufactures and in popular media accounts, the individual uses of chemical high explosives on

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[145] *Minutes and Papers of the Third Annual Tri-State Development Congress of Wisconsin, Michigan and Minnesota* (March 1922), 59-61, 87-88.

[146] M. J. Thompson, "The Land Clearing Movement in Minnesota," *Tri-State Development Congress Minnesota—Wisconsin—Michigan: Report of Proceedings of the First Convention Held at St. Paul, Minnesota, January 26-27, 1921* (St. Paul: Webb Publishing, 1921), 82.

the farm, including tree planting, subsoiling, drainage work, and the diversion of streams, fueled a larger media-driven narrative that painted agricultural development as a battle between nature and progress. Chemical high explosives helped turn the tide of this ongoing war.

In their efforts to cultivate an agricultural market for their explosive products, chemical manufacturers influenced this development. In many cases, the advertisement campaigns of Hercules and Du Pont directly addressed the environmentally transformative capabilities of their explosive products. In 1918, one Du Pont advertisement coined dynamite "the builder of nations" and "a titanic laborer—wresting…Mother Earth." That same year Du Pont asked the farm owning readers of the *Literary Digest* if their property had a "crooked, land-eating stream waiting to be straightened." Personifying the stream as the "land-eating" enemy, the advertisement cast dynamite as an effective agent in the contest between the environment and profitable farming. In 1919, Hercules ran its "Dynamite Makes Fertile Fields of Swamp Land" campaign in which the marketing department touted dynamite's ability to transform "sixty million acres of swamp land" into "the most fertile farm land."[147] In promoting their products, chemical manufacturers created a narrative in which the progress of industrial agriculture depended on the domination of nature.

In virtually every application, manufacturers depicted dynamite as the solution to environmental barriers to agricultural progresses. The marketing department at Du Pont created an advertisement in 1918 titled, "Does Labor Shortage Worry You?" While the text of the advert touted dynamite's ability to "save time, money, and work," the illustration highlighted the rationalizing effects of their explosive products (See Figure 2). Depicted is a clenched fist

[147] E. I. du Pont de Nemours and Company, Advertisement, *Literary Digest* (February 23, 1918), 61; E. I. du Pont de Nemours and Company, Advertisement, *Southern Planter* (November 1918), 667; Hercules Powder Company, Advertisement, *Literary Digest (*October 4, 1919), 72.

holding a stick of Du Pont brand Red Cross Dynamite emanating from which is four clouds of explosive gases. In each cloud is a drawing of different applications for dynamite on the farm where a farmer is seen engaged in stump removal, rock removal, ditch digging, and subsoiling, symbolizing the capabilities of the expanding gases of chemical high explosive in rationalizing these natural barriers to economic progress.[148]

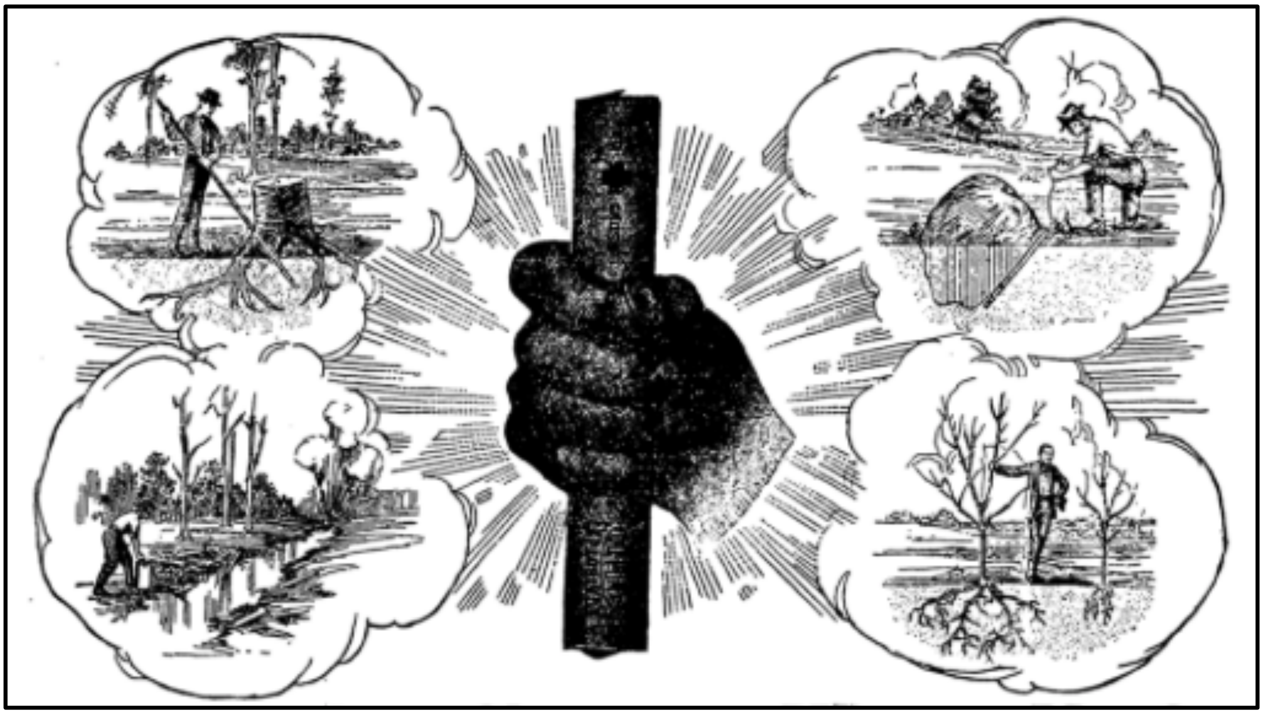

Figure 5

Creating a narrative, these advertisements effectively bolstered individual farmers' efforts to environmentally rationalize their farms. In 1922, Minnesota farmer L. G. Kaufman instructed four of his laborers to excavate a 700-foot ditch, "12 feet wide, and 4 ½ feet deep," to drain 200 acres of swamp that prevented him from cultivating the entirety of his property. Placing charges 20 inches apart and working in section of 200 feet at a time, the workers managed to create an effective ditch in "half a day." Dynamite's explosive energies effectively drained the swamp and

[148] *Southern Planter,* Advertisement, 667

converted Kaufman's property into "valuable farm land."[149] Kaufman restructured the ecological order of his Minnesota farm.

Figure 6—Image from *Popular Science Monthly* showing water filling the ditch on Kaufman's farm immediately after blasting

Before the 1920s, the winding trajectory of the Elkhorn River near Waterloo, Nebraska limited farmers' abilities to exploit the region's nutrient rich soils. To address this limitation, farmers collectively worked to cut a two-mile channel that created a more straight and direct flow for the river. Using dynamite to blast the right of way before finishing the cut with a dredge, workers eliminated eight miles of the meandering river and opened up many additional acres for cultivation.[150] In rationalizing the river, farmers not only engaged in the restructuring of its flows but created streamlined plots of land. The idea of 160-acre square plots of land, written into the Homestead Act of 1862, was itself incompatible with the geographical makeup of the contiguous United States. The order of nature did not conform to the legally dictated cookie cutter

[149] "Dynamite Digs 700-Foot Ditch in Spit Second," *Popular Science Monthly* Vol. 100 (May 1922), 51.
[150] "An Eight-mile River Cut-Off," *Du Pont Magazine* Vo. 23, No. 4 (April 1929), 23.

homestead, and as such, the agricultural state, ordinary farmers, and chemical manufacturers worked to conform nature to their rationalized vision of agricultural development. For many years these efforts proved unattainable due to limited funding or lack of technical development and engineering knowhow, but chemical high explosives changed that fact.

Less directly, the development of agricultural explosives with weather resistant and regionally specific properties propagated the idea of a contest between humans and nature. In the spring of 1920, Du Pont released its updated formula of "straight dynamite," the companies standard and most universally applicable explosives. "While possessing all the desirable feature of the old straight" explained Du Pont Technical Representative, S. R. Russell, the new formulation had "the additional [feature] of being extremely low freezing." He announced, "During the past winter the new Du Pont Straight Dynamite remained soft and in good condition at 10 degrees."[151] Seasons and climate no longer determined blasting schedules. In the first decade of the twentieth century, Du Pont developed Pacific Stumping Powder "particularly for blasting the large stumps of the Pacific Northwest." In 1922, the company reworked the formula to give the regionally specific explosive low freezing characteristics as well.[152] In designating the explosive as regionally specific, Du Pont's engineers implicitly cast their products as environmentally transformative. The need for these new products resulted from the limitation that nature, through environmental conditions such as climate and geographic place, imposed on agricultural production and blasting.

[151] "Du Pont Straight Dynamite Now Practically Freeze-Proof," *Du Pont Magazine* Vol. 14, No. 6 (May-June 1921), 3.
[152] E. I. du Pont de Nemours and Company, *Clearing Logged off Lands: Instruction in the Use of Explosives for Clearing and Draining Land, tree Planting, Subsoiling and other Purposes* (Wilmington: 1923), 7.

By the 1920s, contested views on dynamite's application in subsoiling had largely passed the experimental stage, and its uses, though not universal, were accepted as beneficial. In an April 1925 issue of *Popular Science,* it was reported that "This particular use of dynamite has become widespread, in the setting out of orchards, for example. Moreover, extraordinary results are on record where orchards have practically ceased bearing and were rejuvenated through the loosening of the soil with dynamite." The Du Pont pamphlet *New Farms for Old Through Deep Plowing with Du Pont Red Cross Low Freezing Dynamite* and periodical *Vertical Farming* made this application widely known and highlighted the utility of subsoiling as early as 1911. As explained in *New Farms for Old,* subsoiling with dynamite:

> breaks up the hardpan and permits the roots to take their downward course into the lower strata of the soil in which plenty of plant food elements are available. Under these conditions one tree in not interfered with by another; each one receives the benefits of all of the soil allotted to it at the time the surface was measured and aid out at planting time.[153]

In many ways, subsoiling with dynamite was no different than its uses in irrigation and cutover land reclamation. In part because of media accounts and chemical manufacturers' advertisement campaigns that cast explosives as environmentally combative, farmers used high explosives to gain more control over the environments in which they worked to establish control in their agroecosystems.

Conclusion

In 1929, A. J. Schwantes, Assistant Professor of Agricultural Engineering at the University of Minnesota, described the importance of power increases in agriculture since the 1850s. Schwantes explained that in 1850, "the average agricultural worker in the United States

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[153] "Of Dynamite," *Popular Science* Vol. 106, No. 4 (April 1925), 33; *Vertical Farming* Vol. 1 No. 1 (February 1915); Du Pont, *New Farms for Old Through Deep Plowing with Du Pont Red Cross Low Freezing Dynamite* (1911), 7.

had at his disposal about 1½ horse power" and that "all of this power was furnished by animals." By the 1890s, with the democratization of pack animals and advent of steam engines, access increased to approximately 2½ horse power. With the introduction of tractors, electricity, and gas engines, farm workers had access to an average of 3 ¾ horse power per worker by 1920. The next major development in farm power was dynamite. The reinvention of chemical high explosives as a tool for the farm was emblematic of the transition to new forms of energy that occurred across the country. As gasoline and coal supplanted wood and water power, so too did chemical high explosive supplant human and animal labor on the farm. This transition did not mark the start of ecological transformations through development in agriculture as much as it was an acceleration of the efforts, made possible through increased access to energy. While dynamite's energies could not be used for harvesting and other jobs on the farm, the new "farm power" accelerated erosion of environmental barriers to agricultural development and facilitated the processes of farm mechanization.[154]

Irrigating the desert, clearing cutover lands, and engaging in local farm improvements, the agricultural state, chemical manufacturers, and ordinary farmers employed chemical high explosives to environmentally transformative ends. Their desires to increase agricultural outputs translated into a wholesale effort to conform nature to the rationalized vision of agrarian development. But the command of nature was not universal. Many acres of reclaimed lands failed to perform as farmland, and areas that did produce contributed to the problems of overproduction that plagued agriculture in the 1920s and 1930s. Moreover, dynamite lacked the capacity to address the falling global demand for farm products, and while it proved useful in clearing land and watering deserts, dynamite's energies could not improve nutrient deficient soils

[154] A. J. Schwantes, "Dynamite a Form of Farm Power," *Better Farm Equipment and Methods* Vol. 2, No. 3 (November 1929), 8-9.

and agriculturally unfavorable climate conditions. When Americans restructured environments for agriculture, they crystalized new dependencies on the chemical and technology required to produce food in ecologically unviable landscapes.

Epilogue:

Chemical Dependencies in Modern American Agriculture

In 1891, special agent Robert Dyrenforth of the U.S. Department of Agriculture tried to use dynamite to make it rain. Inspired by Civil-War stories where the concussive blast of artillery shells reportedly caused precipitation, Dyrenforth conducted a series of investigations into the matter. Stationed on a cattle farm near Midland, Texas where the flat topography and proximity to water made irrigation impractical, Dyrenforth set out to water Great Plains' farms with the aid of dynamite. The research party organized tests along three lines, "each some two miles in length and placed about one-half mile apart." The first line contained charges of ground-placed dynamite and rackarock, another nitroglycerine-based explosive. The second consisted of cloth kites, "flown to a considerable height with electric wires, bearing dynamite charges…to be fired high in the air." A third line featured explosive balloons filled with hydrogen and oxygen gas. With charges in place, the explosions began on August 18. Dyrenforth's team detonated ground explosives for 12 hours and periodically ignited "balloon explosions," but the region's high winds rendered the second line of kites impracticable. Nevertheless, ground crews "kept up their roar" until the early evening when the "clear and beautiful" sky yielded to "drenching rain which fell in torrents for two and a half hours." Satisfied with the results, Dyrenforth proclaimed that "the concussion from explosions exerts a marked and practical effect upon the atmospheric conditions in producing or occasioning rainfall." Or put more simply, dynamite could make rain.[155]

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[155] Robert G. Dyrenforth and Simon Newcomb, "Can We Make it Rain?," *North American Review* (October 1891), 393-397.

But could it? Other government officials had their doubts. For Simon Newcomb, a U.S. Naval Observatory astronomer and member of the National Academy of Science, Dyrenforth's experiments were at best inconclusive and at worst fundamentally flawed. Dyrenforth's team had foolishly blasted the sky during the rainy season, which, Newcomb argued, invalidated any causal relationship between the explosions and the precipitation. More fundamentally, Newcomb objected, any conclusions about concussive rainmaking were woefully premature because the scientific community lacked a sufficient understanding of how rain formed in the atmosphere. Ideally, further experimentation would yield this vital knowledge, but for now, uncertainty was the order of the day.[156] But still, even if the explosions had caused the rain, Dyrenforth's methods, Newcomb lamented, were at this point far too expensive. The two- and one-half hours of rain cost American taxpayers $9000, a large sum of money for a relatively limited supply of water.[157]

Beginning in the late nineteenth century, farmers, businesses, and arms of the state experimented, often times haphazardly if not desperately, to see what dynamite could do. While they would eventually learn that making rain exceeded chemical high explosives' capacious capacities, their enthusiasm for determining explosives' other possibilities would not be defused. In fact, popular conceptions of chemical high explosives, as able to reduce "to a minimum the opposing forces nature has placed in the various highways advancing civilization," remained strong and fueled the scientific processes responsible for dynamite's proliferation in

[156] Kristine Harper, *Make it Rain: State Control of the Atmosphere in the Twentieth Century* (Chicago: University of Chicago Press, 2017), 28-30.
[157] Dyrenforth and Newcomb, *North American Review*, 394.

agriculture.[158] By the 1920s, experimentation, reinvention, and faith in new technologies and energies had made high chemical explosives a vital arm of modern, industrial agriculture.

As late-nineteenth- and early-twentieth-century Americans blasted the way to agricultural development, they renegotiated human relationships with the natural world. Raising farm crops had long required human management of agroecosystems, but in the early-twentieth century this intensified in part because of explosives. Before the 1870s, the locations in which these managed environments could exist and thrive depended on such environmental conditions as weather, soil composition, and proximity to sufficient water sources. With the advent of new high explosives in the late 1860s and their application to farming and farm-related industries, Americans of this period maximized the productivity of existing farmland and greatly expanded the total acreage of potential farmland by redefining what potential farmland was. Providing elevated access to energy and facilitating mechanical implantation, chemical high explosives liberated agricultural expansion from natural, environmental, and geographic constraints and ushered in a new era of agricultural development in which explosive energy rationalized, from contemporaries' perspective, previously unproductive and underproductive lands. Indeed, this was the promise of modern agriculture, a promise that explosives helped Americans achieve.

Expanding into these newly redefined farming regions, ordinary farmers, chemical manufacturers, and the agricultural state put their faith in the power of chemicals to solve many if not all problems. This rising chemical addiction informed experimentation and reclamation efforts, but at times, chemical high explosives' capabilities fell short of expectations. This was

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[158] Manuel Eissler, *The Modern High Explosive. Nitro-glycerine and Dynamite: Their Manufacture, Their Use, and Their Application to Mining and Military Engineering; Pyroxyline, or Gun-cotton; The Fulminates, Picrates, and Chlorates. Also the Chemistry and Analysis of the Elementary Bodies which Enter into the Manufacture of the Principal Nitro-Compounds* (New York: John Wiley and Sons, 1893), iii; "Clearing out Stumps and Rocks," *New York Evangelist,* Mar. 9, 1882; "Blasting Agents," *Railway Times,* Jun. 13, 1868; "Use of Dynamite on the Farm," *American Farmer,* December 1876.

largely the case in the arid West. In the Reclamation Service's twenty-third annual report in 1924, Commissioner Elwood Mead stated:

> Discussion in Congress, official reports, and articles in the press, all bear testimony to the fact that a change is taking place in our conception of what is needed to make national reclamation by irrigation a social and economic success. All are agreed that a lofty purpose animated the framers of the national reclamation act; yet all familiar with its history realize that not all the conditions under which it would operate were foreseen, and that the results are unlike those anticipated.[159]

Explosives aided the construction of irrigation works, but Americans soon discovered that sustained production in the region would necessitate further inputs. By the 1920s it was clear that modern industrial agriculture would depend upon synthetic, chemical energy and increasingly, fossil fuel energy to put as much land into production as possible.

Dynamite's explosive blast did its part in rationalizing landscapes, but the ability of its rapidly expanding gases to generate productive soils and condense water molecules into rain proved a scientific improbability. These limitations revealed new challenges. Americans began to pursue new approaches to farming on reclaimed lands that manifested in increased inputs of capital and energy, tenets of intensive agriculture, to improve harvests. In 1928, the Bureau of Reclamation reported that intensive farming practices were the "only way that success in irrigation can be achieved." In the timbered North, A. U. Morrell of the Tri-State Land Development Congress declared "intensive cultivation" the best way to "ensure larger returns per acre" and to solve "the labor problems on the farm."[160] While reclamation land farming in the

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[159] US Department of the Interior, Bureau of Reclamation, *Twenty-Third Annual Report of Bureau of Reclamation for the Fiscal Year Ended June 30, 1924* (Washington: Government Printing Office, 1924), 1.

[160] US Department of the Interior, Bureau of Reclamation, *Tenety-Fourth Annual Report of Bureau of Reclamation For the Fiscal Year Ended June 30, 1925* (Washington: Government Printing Office, 1925), 3; A. U. Morrell, "Rural Community Planning in the Northwest," *Tri-State Development Congress: Report of Proceedings of the First Convention* (St. Paul: Webb Publishing Co., 1921), 90.

1920s did not mark the beginning of agricultural intensification, it accelerated the process. When World War I ended and farm prices fell, farmers in less productive reclaimed regions were especially susceptible to economic hardship. These farmers turned to chemical fertilizers and to a lesser extent, mechanical implements powered by fossil fuels as they adjusted to the financial situation. This contributed to issues of overproduction that sustained low farm prices and established a system in which agriculture depended on even greater human and synthetic inputs and controls to remain economically viable.[161]

While contemporaries did not entirely understand the environmental significance of these agricultural developments, scientists have recently recognized the broader environmental consequences of nitrogen fertilizers and fossil fuel dependency in intensive agriculture. In 2002 Ronald F. Follet and Jorge A. Delgado, soil scientists for the U.S. Department of Agricultural Research Service, reported that Nitrogen (N) "inputs are necessary for maintaining the viability of intensive agricultural systems" and that "extensive use of N in agricultural systems and the associated transformations of N into various ions or gaseous forms contributes to leaks from the nitrogen cycle." These leaks have had major environmental effects. Water-soluble nitrates leach out of the soil and are "a primary source of the contamination in drinking water" around the globe. Furthermore, when nitrate fertilizers are introduced into agricultural systems, denitrification of nitrates occurs, which creates nitrous oxide and nitric oxide gases that "can contribute to air quality and greenhouse warming impacts."[162] The consequences of fossil fuel dependency are just as alarming. By the first decade of the twenty-first century, American agribusiness was responsible for 20 percent of the nation's annual fossil fuel consumption, and

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[161] Willard W. Cochrane, *The Development of American Agriculture: A Historical Analysis* (Minneapolis: University of Minnesota Press, 1993), 106, 249-250.
[162] R. F. Follett and J. A. Delgado, "Nitrogen Fate and Transport in Agricultural Systems," *Journal of Soil and Water Conservation* Vol. 56, No. 6 (November/December 2002), 402-407.

for every calorie of fossil fuel expending in the industry, farmers produced less than one calorie worth of food.[163] In terms of energy, modern industrial agriculture is engaged in a system of diminishing returns.

The effects of increased chemical dependencies in agriculture are clearly understood in the twentieth-first century, but the origins of these developments can in part be traced back to the rise of chemical high explosives in early twentieth-century agriculture. As ordinary farmers, chemical manufacturers, and the agricultural state reinvented dynamite, they collectively used it to expand farmlands into landscapes that lacked the ecological capacity support agricultural production. Explosive blasts rationalized and streamlined these landscapes to accommodate farm labor such as plowing, irrigation, and planting, but these developments both embodied and further necessitated intensive farming techniques that, unbeknownst to contemporaries, catalyzed new and unsustainable chemical dependencies in modern agriculture.

[163] Tobias Plieninger, "Looking Beyond Corn and Petroleum," *Science* Vol. 315, N0. 5816 (March 2, 2007), 1222; For more information on fossil fuel consumption in agriculture see Michael Pollen, *The Omnivore's Dilemma: A Natural History of Four Meals* (New York: Penguin Press, 2006).

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