Boll Weevils and Bureaucrats:
Leland O. Howard and the Transition to Chemical Insecticides
in the United States, 1894-1927
By James E. McWilliams

"Sing to me of the man, Muse, the man of twists and turns, driven time and again off course . . .sing for our time too." (The Odyssey, 1:1-10)

In the fall of 1865 writers for the *Practical Entomologist* editorialized that "if the work of destroying insects is to be accomplished satisfactorily, we feel confident that it will have to be the result of no chemical preparations." Fifty years later the United States was manufacturing over $23 million worth of chemical insecticides a year, annually saturating American crops with 90 million pounds of arsenicals, 73 million pounds of sulfur, 10 million gallons of kerosene, 21 million pounds of naphthalene, and 21 million pounds of pyrethrum. By 1937 chemical use had become standard practice in American agriculture, so much so that a prominent Stanford scientist could write that the only reasonable response to ineffective agricultural chemicals was "to develop new insecticides of an entirely different kind." With DDT just around the corner, he had no idea how fertile opportunities would soon be to do just that. Clearly, the hopeful editors of the nation's most prominent entomological magazine had, back in the dark ages of 1865, been proven wrong.[1]

History has been relatively silent on the question of why. As Rachel Carson made dramatically evident in 1962 with the publication of *Silent Spring,* the transition to chemical insecticides in the United States was a defining moment in the course of human

[1] *The Practical Entomologist* (1) 4 (1865); J. K. Hanzlitt, "Heath Hazards of Chemo-Enemies in Contaminated Food," *The Scientific Monthly* (May 1937, 439; USDA, *Chronological History of the Development if Insecticides and Control Equipment from 1854 through 1954* (ASDA Agricultural Research Service, 1954); Thomas R. Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, New Jersey: Princeton University Press, 1981), 39-55.

affairs. Every life, she insisted, was in one way or another affected by the chemicals Americans were indiscriminately spraying on their crops. Yet for all the impact of insecticides on American science, agriculture, and public health, we still know next to nothing about the precise historical developments fostering their emergence. To be sure, leading histories of insecticides in America have effectively placed the chemical transition in the context of larger historical developments, including the professionalization of entomology, the political imperatives of the Progressive Era, the commercialization of agriculture, the impact of knowledge specialization, and the rise of the "government scientist." Layered and sophisticated as these contexts might be, however, they remain only that: contexts. For all their explanatory power, these broader themes do not specifically or directly tackle the question of how farmers and entomologists overwhelmingly came to favor chemical insecticides over other potential solutions—most notably biological and cultural controls—by the early 1920s.

James Whorton, in his landmark study *Before Silent Spring,* asserts that the first chemical insecticides were a *"fait accomplis"* by the time scientists were uncovering the first hints of their dangers. Nevertheless, another historian writing about insecticides in the late 1990s could still announce that "it is difficult to specify why or even when economic entomology came to emphasize insecticides over other methods." Given the pervasiveness of these chemicals within American agriculture—a *fait accomplis* no less!—this essay offers a viable and historically grounded explanation for this elusive and all-encompassing agricultural and environmental transition.[2]

[2] Published volumes on the history of insecticides, and works that provide much of the background for this article, include James Whorton, *Before Silent Spring: Pesticides and Public Health in Pre-DDT America* (Princeton, 1974); the quote is from xii; Richard C. Sawyer, *To Make a Spotless Orange: Biological Control in California* (Iowa State University Press, 1996), xix; V. G. Dethier, *Man's Plague: Insects and*

Leland O. Howard

Predictably, the answer to the question of the nation's initial embrace of chemical insecticides centers on the familiar suspect: a dead white male. Leland O. Howard was an ambitious scientist who reigned over the Bureau of Entomology from 1894 until 1927.[*] While in no way single-handedly responsible for the nation's relatively rapid transition to chemical insecticides, Howard was a kind of wizard behind history's curtain, manipulating contemporary circumstances to promote his pro-insecticide agenda with the reliable handmaidens of the federal government, corporate America, the scientific establishment, and, to the extent that they were even paying attention, the American people. Howard did not *cause* the transition to chemical insecticides—such an historical claim would be crudely determinative. But had a less ambitious man, a man with more ambiguous goals, or a less bureaucratically skilled man filled his shoes during these critical years, the outcome would have been very different than the wholesale adaptation of manufactured chemical insecticides. In short, Howard epitomized what historians of science have called the "government entrepreneur," a man who powerfully mediated

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Agriculture (The Darwin Press, 1976); John Perkins, *Insects, Experts, and the Insecticide Crisis* (The Plenum Press, 1982); W. Connor Sorenson, *Brethren of the Net: American Entomology, 1840-1880* (University of Alabama Press, 1995); Paola Palladino, *Entomology, Ecology, and Agriculture: The Making of Scientific Careers in North America, 1885*-1985 (Amsterdam: harwood Academic Publishers, 1996); unpublished accounts include Edmund Paul Russell, "War On Insects: Warfare, Insecticides, and Environmental Change in the United States, 1870-1945," (PhD dissertation, The University of Michigan, 1993); Hae-Gyung-Geong, "Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870-1930," (PhD dissertation, The University of Wisconsin-Madison, 1999). Steven Stoll confirms the general lack of an explanation with his claim that insecticides became a business "while no one was looking." See "Insects and Institutions: University Science and the Fruit Business in California," *Agricultural History* (69) 2 (Spring 1995), 216-239.

[*] The Division of Entomology became the Bureau of Entomology in 1904.

among agriculture, industry, and science to promote expertise through a well-endowed bureaucracy.[3]

Throughout the early history of insecticides, the strongest supporters of manufactured chemical solutions to insect pests were, for the most part, well-intentioned men wanting to solve a serious economic and environmental problem. Howard was no exception. He came by his predilections honestly. His temperament and background strongly prepared him to favor chemical solutions as the preferred approach to massive insect infestations that were taking a serious toll on American agricultural production. Whereas his two predecessors as Bureau directors—Townend Glover and Charles V. Riley—entered the profession because their work on farms nurtured an earthy fascination with insects in an agricultural setting, Howard's route was more academic. As a student attending the best private schools in Ithaca, New York, where his father practiced law, Howard read earnestly in the field of natural history before matriculating at Cornell. After taking a class with the charismatic John Henry Comstock, however, he found himself hooked on insects. Comstock had recently been appointed Cornell's first professor of entomology and he proved eager to take Howard, an adoring acolyte, under his wing and introduce him to his library of entomological volumes. Howard, whose "fieldwork" almost always took place in either a lab or a library, sat in Comstock's mahogany-

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[3] Charles E. Rosenberg, "Science, Technology, and Economic Growth: The case of the Agricultural Experiment Station Scientist, 1875-1914," in *No Other Gods: On Science and American Social Thought* (Baltimore: Johns Hopkins, 1978), 153-172; Robert Kohler, "Warren Weaver and the Rockefeller Foundation Program in Molecular Biology: A Case Study in the Management of Science," in *The Sciences in the American Context*, Nathan Fiengold, ed., (Washington, DC: Smithsonian, 1979), 249-293; Alexandra Oleson and John Voss (eds.), *Organization of Knowledge in Modern America*, 1860-1920 (Baltimore: Johns Hopkins, 1979); Geong, "Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870-1930," 50-60; Trudy H. Peterson, *Farmers, Bureaucrats, and Middlemen: Historical Perspectives on American Agriculture* (Washington: Howard University Press, 1980); Gerald Geison, "Scientific Change, Emerging Specialties, and Research Schools," *History of Science* 19 (1981), 20-40.

paneled office and consumed the works of American entomology's old masters—Asa Fitch, Benjamin Walsh, and Charles Riley—while composing perfunctory papers on the morphology of wasps and the respiratory system of the Dobson fly.[4]

If the commandments of economic entomology's founding fathers influenced Howard—that is, if he was swayed by the expectation that he work closely with farmers much as his predecessors had done—it did not show. Instead of expressing enthusiasm for homegrown agricultural wisdom, Howard distanced himself from what economic entomology's founder, T. W. Harris, called "the noble cultivators of the soil." Howard repeatedly mentioned, for example, his disappointment in his former boss' "emphasis on agriculture," going so far as to declare in 1872 that "the practical importance of entomology did not appeal to me . . . I studied insects simply as a fascinating form of life." In other words, he fancied himself more of a "pure" scientist, and he believed that it would be through pure science that he could best solve the nation's insect problems. Howard's dispassionate distance from the messy practicalities of American agriculture thus predisposed him to favor insect control methods that were generally divorced from the vagaries of farmers' daily experience. His hands (in this case literally) were clean.[5]

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[4] Geong, "Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870-1930," 48; L. O. Howard, *Fighting the Insects: The Story of an Entomologist* (New York: MacMillan, 1933); Arnold Mallis, *American Entomologists* (New Brunswick: Rutgers University Press, 1971), 79-92; Pamela Henson, "The Comstock Research School in Evolutionary Entomology," 159-177; the split between economic and systematic entomology is explained in Palladino, *Entomology, ecology, and Agriculture*, 26-27 and Pamela Henson, "Evolution and Taxonomy: J. H. Comstock's Research School in Evolutionary Entomology at Cornell University, 1874-1930," (PhD diss., University of Maryland, 1990), 405-406: Rosenberg, *No Other Gods*, 153-160; Samuel H. Adams, "Leland Ossian Howard," *The American Magazine* 52 (1911), 721-723; F. C. Bishopp, "Leland Ossian Centennial, 1857-1957," *Bulletin of Entomological Society of America* 3 (1957), 1-3.

[5] Charles E. Rosenberg, "Rationalization and Reality in the Shaping of American Agricultural Research, 1875-1914," *Social Studies of Science* (7) 4 (November 1977), 401; Richard Hofstadter, *The Age of Reform* Vintage: New York, 1955), 148-164; Charles V. Riley, "Recent Advances in Economic Entomology," *Proceedings of the Philosophical Society of Washington* (246th meeting), February 2, 1884, 10; Howard, *Fighting the Insects*, 3. An example of how pervasive this insecurity was comes from J. C. Neal, a Florida

In addition to Howard's background, there was the age in which he matured as a professional entomologist. The inertia of historical change (in my opinion) too often replaces the force of personality and ambition in explaining the past. Nevertheless, the historical context within which Howard acted does matter; it is, after all, the context that he so brilliantly manipulated. The latter half of the nineteenth century was a time when science in America was specializing as it never before had. And it was specializing in ways that made *status* more relevant than ever. Entomology—traditionally dismissed as a branch of science full of crusty old bug catchers—had always occupied the lower rungs of the professional ladder. Entomologists were routinely stereotyped as out of step with cutting edge developments in the more rarified realm of pure science. Laboratory experiments with chemical insecticides, however, automatically pulled the entomologist into a more prestigious fold of inquiry. Testing insecticides in a lab with the scientific method enabled entomologists to think in theoretical terms rather than react haphazardly to random agricultural problems. In a scientific atmosphere where "abstractness correlated closely with status," distance from the old venues—the family farms and agricultural journals—held seductive appeal to a formally trained scientist hoping to make his professional mark. Howard proved strongly inclined to exploit this opportunity, in large part because he knew that backing insecticides lent the status-conscious entomologist an automatic dose of prestige.[6]

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entomologist, who wrote, "It is very common to ridicule the efforts of practical entomologists, and belittle the results obtained by their methods of preventing or mitigating the ravages of insects." Quoted in F. H. Fowler, *Insecticides and their Application* (Boston: Wright and Potter, April 1891); in her very informative dissertation, Hae Gyong-Geong stresses Howard's emphasis on field work as an attribute of his tenure as Bureau Chief. Not only does this assessment overlook Howard's clear favoritism for laboratory science, but it only looks at his position of fieldwork in the vacuum of his tenure. Before him the division was far more decentralized and involved in local matters through hands-on work with common farmers.

[6] Charles E. Rosenberg, "Rationalization and Reality in the Shaping of American Agricultural Research, 1875-1914," *Social Studies of Science* (7) 4 (November 1977), 401; Richard Hofstadter, *The Age of Reform*

Politics shaped Howard's mindset as well. The contemporary political environment—one defined by a combination of populist and progressive agendas—served as a welcoming context for advocates of chemical insecticides. Progressivism, for its part, demanded that problems addressed by federal and local governments were quantifiable by a team of credentialed "experts." Under tightly controlled conditions many insecticides delivered their blows with lightening speed and, predictably, faster concrete results were more politically palatable than delayed ambiguous ones. This was a bureaucratic reality that Howard never ignored. Pragmatism was the philosophical foundation of the day, and it was a philosophy that promoted "truth" as whatever "worked" in a publicly applicable fashion. Populism complemented progressivism (which is often mistakenly seen as a strictly urban movement) by urging the federal government in particular to address the economic needs of agriculture. For a scientist already sympathetic to chemical insecticides, Howard became head of the Division of Entomology at an opportune political moment. This political environment, in addition to Howard's predilection for pure science and high status, were all critical background factors influencing the actions he would soon take as the nation's top insect cop.[7]

Vintage: New York, 1955), 148-164; Charles V. Riley, "Recent Advances in Economic Entomology," *Proceedings of the Philosophical Society of Washington* (246th meeting), February 2, 1884, 10. Howard, *Fighting the Insects*, 3. An example of how pervasive this professional insecurity was comes from J. C. Neal, a Florida entomologist, who wrote, "It is very common to ridicule the efforts of practical entomologists, and belittle the results obtained by their methods of preventing or mitigating the ravages of insects." Quoted in F. H. Fowler, *Insecticides and their Application* (Boston: Wright and Potter, April 1891), 3; Geong, "Exterting Control: Biology and Bureaucracy in the Development of American Entomology, 1870-1930," 75-81; H. Fernald, "The Fundamental Principles of Spraying," *Journal of Economic Entomology* 1 (1908): 265-267.

[7] One example of the imperative to bring the government to bear on national problems came from Seaman A. Knapp, professor of agriculture at Iowa State, who in 1877 wrote that the "magnitude" of agriculture's problems "is too great for individual enterprise, or even associated enterprise . . .national government is the only party which has the means to carry out successful termination investigations upon a scale commensurate with the interests involved." See "Agricultural Experiment Stations," *Western Stock Journal and Farmer* 6 (1877), 246. On progressivism and populism in general, a bibliography would consume an entire volume. My own thoughts on the populism-progressive elision come from a critical

The Earliest Insecticide Studies

It would be one thing if Howard was pushed by precedent to support chemical insecticides. That is, had he inherited the Division of Entomology's established quest for insecticidal control and run with it, any explanation of Howard's advocacy of insecticides would be greatly simplified. In point of fact, though, Howard's evolving interest in chemical options ran against a powerful wealth of evidence culled from research that the Division had done under the guidance of Howard's predecessor, Charles V. Riley. With Howard as his deputy, Riley oversaw Bureau studies on the first commercial chemical insecticides entering the agricultural market in the late 1870s. These studies yielded results that were, in the most generous assessment, inadequate. The most common negative charge to come from experiment stations and test farms was that the insecticides under review were useless. After assessing the impact of Paris green, London purple, and white arsenic—three of the most common early insecticides, all arsenic-based compounds—a team of Vermont entomologists concluded that "[n]o benefit was derived from the application of the poison." In another report kerosene was found to have "no insecticidal value." New Jersey state entomologists decided that an insecticide called salimene caused "no perceptible effect as the scale developed as freely on unsprayed trees." The same bulletin deemed an arsenic-based insecticide "absolutely ineffective" while dismissing the impact of lime and sulphur as "so small as to be hardly noticeable." Sulfite of soda was "ineffective," potassium sulfide yielded results "not good enough to justify recommending the mixture," and trees doused with caustic soda "were as bad as

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reading of Hofstadter's *Age of Reform* and Elizabeth Sanders, *Roots of Reform: Farmers, Workers, and the American State, 1877-1917* (Chicago: University of Chicago, 1999); also see Charles E. Rosenberg, *No Other Gods,* 173-178.

ever." A California report concluded after a lengthy study of insecticides for scale insects that, "it was better not to spray at all." A pyrethrum compound had "no effect whatever" on plant lice, according to an official report, while a dusting of pyrethrum on grub worms ended up nurturing a brood of "healthy pupae." Other descriptions from other reports reveal such conclusions as "a perfect failure," "nonsense," and, last but not least, "worthless."[8]

The discovery that an insecticide had no effect actually came as a relief to many researchers working with Riley's office. After all, it was not uncommon for an insecticide to be worse than worthless—it could be counter-productive. "All the treated trees," according to a New Jersey station's evaluation of a lime-sulfur-salt mixture, "were as bad or worse than when the work was begun." A California study revealed that, "those orchards which had not been sprayed were found upon examination to be freer from scale than those which had been sprayed annually." Crude oil and other "distillation products" produced oranges covered in scaly white spots due to the fact that "the chief injury to vegetable tissue from oils was caused by a penetration of oils into the interior of the plants." An apple tree treated with London purple was "very badly scorched." A peach sapling sprayed with crude petroleum in September was dead by the next July; the scientists "dug it out and found that [the death] had been from the root up." Apple trees in another experiment were "worse affected by the apple worm than the check trees not

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[8] Prof. S. A. Forbes, "Synopsis of Recent Work with Aresnical Insecticides," 319; E. V. Wilcox, "Some Results of Experiment Station Work with Insecticides," 250; *Insect Life* (IV) 3-4 (November 1891), 154; John B. Smith, "Insecticide Experiments for 1904," *Bulletin 178* [New Jersey Agriculture Experiment Stations], 3-5; F. W. Malley, "The Boll Worm of Cotton," *Bulletin No. 24* [U. S. Department of Agriculture: Division of Entomology, 1891], 41-43; no author, "Reports of Observations and Experiments in the Practical Work of the Division," *Bulletin No. 3* [U. S. Department of Agriculture: Division of Entomology, 1883], 20-23; "Dosing Trees with Sulphur and Other Substances," *Insect Life* (I) 7 (January 1889), 223; "Alum as a Current Worm Remedy," Ibid., 229-230; J. K. Haywood, "Insects and Fungicides," 12. The actual results of these studies have, to my knowledge, been systematically overlooked in most histories of American insecticides. It is hard to agree, therefore with what are often positive assessments of insecticides' early performance. See, for example, Palladino, *Entomology, Ecology, and Agriculture*, 29-31.

treated" while a test of London purple was "thoroughly unsatisfactory," with the mixtures "defoliating or at least badly damaging, the trees, and not protecting the fruit." On and on the reports went.[9]

A comprehensive 1886 report published by the Division of Entomology confirmed the ambiguous test results that were coming in from dozens of experiment station investigations. Eighty-six experiments testing a variety of insecticides on a plentitude of pests did little to promote the benefits of these applications. In only three experiments were all the larvae killed. Aside from those, only 9 out of 86 experiments could be classified as successful (with over 50% of the bugs or larvae destroyed). Thus, fully 85% of the experiments were failures, both in terms of being useless or causing damage. The remarks after each experiment summary were telling indications of the overall mood regarding insecticides: "all worms have returned to the leaves and are actively feeding" . . . "this injured both plants, one quite seriously" . . . "the larvae did not seem to suffer any inconvenience" . . . "cannot see that any were destroyed" . . . "three days later, the beetles had returned" . . . "the ants had returned to work in the old burrows." Surveying the results, Riley concluded, "a pretty strong case is made against the [insecticide] remedy." The survey, in short, provided good reason to question whether or not C. H. Fernald's 1896 labeling of the late nineteenth century as "the period of insecticides" was little more than propaganda.[10]

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[9] John B. Smith, "Insecticide Experiments for 1904," 3-5; S. A. Forbes, "Synopsis of Recent Work with Arsenical Compounds," 315-317; John B. Smith, "Crude Petroleum as an Insecticide," *Bulletin No. 138*[New Jersey Agriculture Experiment Station, 1899], 5; E. V. Wilcox, "Some Results of Experiment Station Work with Insecticides," 250; *Insect Life* (IV) 3-4 (November 1891), 154. On the general disapproval that many entomologists had with these insecticides, see C. V. Piper, *Orchard Enemies in the Pacific Northwest, U. S. Department of Agriculture Farmers' Bulletin No. 153* (Washington: GPO, 1902), 71.

[10] F. M. Webster, "Reports of Experiments with Various Insecticide Substances," *Bulletin No. 11* [US Department of Agriculture: Division of Entomology, 1886], 9-22; C. H. Fernald, "The Association of

Gypsy Moths and Boll Weevils

The studies that Howard inherited thus not only offered little to build upon, they posed genuine problems for his insecticide plans in an entomological milieu that still entertained other forms of control. They also leave us with hard questions. Why did Howard not eventually behave in a manner consistent with the negative reports when he assumed the mantle of bureau chief in 1894 and set the agenda for the next thirty-five years? What were the initial pivots upon which he turned the Bureau away from biological and natural control toward chemical options? What were the steps he initiated in the process of institutional conversion to a one-size-fits-all approach? A brief examination of Howard's experience with two insect pests helps at least frame these questions, revealing an important preliminary stage in the process of making a more complete transition to chemical options. If there was a single theme running through Howard's strategies, it would be that he would link the idea of "success" to the idea of "efficiency." The motivation to do so began with a pest that remains very much with us today, the gypsy moth.

Lymnatria dispar, which the French astronomer Leopold Trouvelot accidentally released in the 1860s, bred in a vacant lot next to Trouvelet's Medford, Massachusetts house and quickly underwent a population bomb. By 1900 it had reached critical mass, defoliating and destroying trees throughout New England. Trouvelot was a tinkering amateur experimenting with the cross fertilization of silk-worm breeds when the moths broke free. Howard, now the nation's top professional entomologist, determined to solve the problem with convincing, media-attended results. Perhaps cowed by the poor

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Economic Entomologists—Address by the President . . ." *Science* (IV) 94 (October 16, 1896), 544: Rosenberg, *No Other Gods*, 153-172.

insecticide reports, or possibly deferring to Charles Riley's relative success with biological control, Howard began in a way that radically countered his future work: he pursued a biological option. Much as his predecessor Riley would have done, he visited Europe to ferret out the moth's natural enemies. Although Howard had little knowledge of the gypsy moth's ecology, he did discover that it had no less than fifty predators. Importing them, releasing them, and waiting for them to do their work would be, he correctly predicted, "extremely complicated." But, more hopeful than confident, he persevered in his plans.[11]

Howard's apprehensions were quickly confirmed. This strategy turned out to be a complete bust. Imported parasites and predators died upon release, disappeared, failed to breed, and, in cases where they did attack the moth, made no more than a dent in the population. It was not that the strategy of biological control per se was fundamentally flawed—Howard would not reach this conclusion until much later in life—but rather that it needed significantly more research before it could be systematically employed. The upshot was obvious: his time-consuming demand melded poorly with a bureaucratic, progressive-era mentality that called for rapid outcomes by expert scientists. Howard began the gypsy moth project with the bold assessment that he needed only three years to get the moth under control. Ten years later he was admitting failure based on inadequate knowledge of his chosen strategy. And by 1933 he was condemning his early faith in biological control as "nothing less than absurd." The entire experience, in historian

[11] A.S. Packard, "The Mode of Extrication of Silk-Worm Moths from their Cocoons," *The American Naturalist* (12) 6 (1878), 379; L. Trouvelot, "The American Silk Worm (Concluded)," *The American Naturalist* (1) 3 (1867), 145-149; "A Dangerous Insect Pest in Medford, Mass," *Science* (14) 357 (December 1889), 381-382; "Howard, "Danger of Importing Insect Pests," *USDA Yearbook* (1897), 529-552.

Edmund Russell's words, "put egg on his face." As he wiped it away, Howard began to better appreciate the comparative benefits of chemical control.[12]

The boll weevil, *Anthonomus granis*, only intensified Howard's sense of helplessness while furthering his interest in chemical options. The boll weevil entered Texas in 1892, crossing the border with a vengeance and quickly burning a wide swath throughout the Deep South. The Bureau confronted the problem in 1894 by sending to Texas C. H. Townsend, an entomologist working in Jamaica, to study the boll weevil's habits and life cycle. After surveying the situation, Townsend made an earnest plea for cultural control. The most efficient way to handle this pest that was consuming up to 90% of a farmer's cotton crop, he explained, was to strategically burn fields, allow hogs to forage, rotate crops, and create "no cotton" zones. At the same time, he suggested that the Bureau send an agent to Mexico to search for natural enemies of the boll weevil and study ways to make existing parasites more efficient. Howard, again perhaps still lurking in Riley's shadow, embraced these recommendations wholeheartedly, and he even persuaded the Texas governor to take action on the plan. However, overwhelmed by protests, the Texas legislature ultimately balked at regulating cotton crops. The governor,

[12] Letter to General Appleton from H. Kirkland, Superintendent for the Suppressing the Gypsy and Brown Tail Moth (January 15, 1906) Massachusetts Society for the Propagation of Agriculture (Mass. Historical Society: Ms N 517, box 10, folder 118); Letter from H. M. Aiken to "the editor," February 9, 1906 (MHS, box 10, folder 112). Letter from C. S. Sargeant to General Appleton, April 12, 1905 (MHS, box 15); Howard-Burgess Correspondence, "general Correspondence," The National Archives (RG 7); Dunlap, *DDT: Scientists, Citizens, and Public Policy*, 34-35; Edmund Russell, "War on Insects: warfare, Insecticides, and Environmental Change in the United States, 1870-1945," (PhD dissertation, The University of Michigan, 1993), 42; Thomas Dunlap, *DDT: Scientists, Citizens, and Public Policy* ((Princeton: Princeton University Press, 1981), 33-34. In 1911 Howard wrote that "the published information concerning these enemies [imported to control the gypsy moth] was deficient and unreliable." See L. O. Howard and W. F. Fiske, "The Importation into the United States of the Parasites of the Gypsy Moth and the Brown Tail Moth," *USDA Bureau of Entomology Bulletin No. 91* (Washington: Government Printing Office, 1911), 305; Richard C. Sawyer, *To Make a Spotless Orange* (Ames, Iowa: Iowa State University Press, 1996), 62-63; L. O. Howard, "The Gypsy and Brown-tail Moths and their European Parasites," *U.S. Department of Agriculture* (1905), 123-128.

Howard, and the Bureau were left holding an excellent blueprint without the builders willing to carry it through.[13]

Although Texas would be left to its own devices, Howard and the Bureau continued to pursue cultural control methods elsewhere. After lobbying congress for boll weevil funding (by, in part, showing up for a hearing with a two foot long paper mâché model of the weevil), Howard went national with his plans. Every southern state soon learned about the benefits of cotton crops that matured early (before weevil populations exploded) and the virtues of removing the stalks where weevils "over-wintered." But once again politics brought the plan to naught. There was little doubt that these cultural methods would have worked, but farmers needed to act comprehensively and in unison, a performance that only loophole-free legislation could reasonably choreograph. Because no southern state was able to marshal enough political will to pass regulatory laws, the massive problem of the boll weevil was, as the Texas state entomologist concluded in 1901, "to be met and mastered by the planters themselves." In his memoirs, Howard would remember thinking that "the action of the world as a whole seemed rather slow." The impact at the time, however, was a bit more dramatic. By the early twentieth century Howard began to think about chemicals as the Bureau's exclusive and most efficient answer to the problems he was supposed to be solving. These early missteps, he learned

[13] Dunlap, "The Triumph of Chemical Pesticides in Insect Control," *Environmental Review* (1) 5 (1978), 42-45. The crux of the problem was that early burning would have driven the weevils into an early and thus malnourished hibernation while forcing the farmer to harvest cotton before the season ended. Farmers were mostly tenant farmers, and thus did not have an incentive to accept an immediate sacrifice for long term gains. What mattered to them was the current year and the current year alone. "Few farmers," writes Dunlap, "were willing to gamble on a better crop next year, particularly if there seemed a good chance for a late picking. ("Triumph," 44)

from these two pests that continue to plague American agriculture, would not be repeated.[14]

Howard's First Concrete Steps toward the Chemical Option

Howard's first concrete efforts to bureaucratize and promote chemical insecticides were subtle. One technique he employed was to focus an unusual amount of the Bureau's attention on shade trees. Unlike fields of crops that sprawled across political jurisdictions, shade trees were consolidated in urban regions with defined municipal boundaries and well-to-do constituents who hated to see their streets denuded of beautiful foliage. This important difference made it more feasible for Howard to advocate chemical solutions under the assumption that a centralized commission would oversee its application with proper organization and cohesive public support. Such was the situation when he insisted in 1905 that "[t]he only thoroughly satisfactory safeguard against the [elm leaf beetle] consists in spraying the trees with an arsenical solution." Howard took pride in the fact that "[t]en years ago" such a claim "would have been received with ridicule," but was now so conventional that "there is no hesitancy in commending it to more general city use." All that was needed were "annual appropriations" for cities to buy chemicals and pumps, because (no doubt thinking of the boll weevil experience) "it

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[14] C. H. T. Townsend, "Letters and Reports received from C. H. T. Townsend," in Records of the Division of the Southern Crop Insect Investigations, National Archives. Russell, "War on Insects," 42-47; Howard, *Fighting the Insects,* 156; Mallis, *American Entomologists*, 391; Frederick W. Malley, "The Mexican Cotton Boll Weevil," *USDA Farmers' Bulletin No. 130* (Washington: Government Printing Office, 1901), 23; W. D. Hunter, "The Boll Weevil Problem," *USDA Farmers' Bulletin 344* (Washington: Government Printing Office, 1909),. 46; Richard C. Sawyer, "Monopolizing the Insect Trade: Biological Control in the USDA, 1888-1951," *Agricultural History* (64) 2 (Spring 1990), 276; L. O. Howard, "The Mexican Cotton-Boll Weevil," *U. S. Division of Entomology Circular* (1895), 219-226; ibed, "The Mexican Boll Weevil," *U.S. Division of Entomology Circular* (1896), 1-8; Thomas R. Dunlap, *DDT: Scientists, Citizens, and Public Policy*, 31; B. R. Coad, "Killing Boll Weevils with Poison Dust," *USDA Yearbook* (1920), 241-252; ibid, "Recent Studies of the Mexican Cotton Boll-Weevil," *USDA Bulletin 231* (1915), 1-34; Thomas R. Dunlap, "The Triumph of Chemical Pesticides in Insect Control," *Environmental Review* (1) 5 (1978), 39-42.

is unreasonable to expect that a private individual" will responsibly undertake a "public duty." It was thus with a new level of civic enthusiasm that Howard advocated, to cite one example, the spraying of maple trees with creosote to protect them against the tussock moth, an insect that, only a few years earlier, he insisted could be controlled biologically. Parasitism had burned him with the gypsy moth and boll weevil, but chemicals, if Howard chose the right battles, could become associated with progress.[15]

Howard's early promotional strategy for chemical insecticides came with a literary twist. Aware that a proper history of American entomology had yet to be published, Howard took it upon himself to write one. He did so, however, in a way that made the embrace of chemical insecticides seem like the logical next step in the field's inexorable progression. There were three elements to this crassly revisionist agenda. First, Howard mocked the "chaos of experimentation" that characterized the earliest phase in economic entomology, dismissing the first systematic prescriptions for insect control—mostly cultural methods—as "frequently nonsensical," "rather amusing," and containing "practically nothing original." Second, he downplayed the contributions of his old boss, Charles Riley. Riley's work with the Division of Entomology (which is to say his successful work with biological control) went conspicuously unrecognized. In a related example of tactical omission, Howard's narrative skipped from the "utterances of impractical and ignorant persons" (Riley's cohort) to "a new era in remedies" (Howard's

[15] L. O. Howard, "Insect Enemies of Shade Trees," *USDA Farmers' Bulletin No. 99* (Washington: Government Printing Office, 1905?), 10-25; Support for biological control and the tussock moth comes from Howard, A Study in Insect Parasitism," *USDA Division of Entomology Technical Series No. 5* (Washington: Government Printing Office, 1897), 6; Howard, "Danger of Importing Insect pests," reprint from *The Yearbook of Department of Agriculture for 1897*. The idea of associating chemicals with a broader notion of "success" has been limited in the historiographical literature on war. Indeed, the performance of chemicals during war did a great deal to promote their positive reputation of being indispensable, but these local efforts cannot be overlooked as integral to the popular reaction after 1914. See Edmund Russell, *War and Nature*, 64-66 and Thomas R. Dunlap, *DDT: Scientists, Citizens, and Public Policy*, (check #).

era) marked by Paris green, other arsenical compounds, hydrocyanic acid gas, and kerosene emulsions—all described as profound "discoveries" for Howard's generation to exploit. Finally, Howard, ignoring scores of studies highlighting the dangers of insecticides, declared any concerns about these insecticides' safety to be downright pedestrian. At length he quoted, and then debunked, Riley for claiming that Paris green was "eminently dangerous" and that it never should be used until "every other available remedy had been tried." Such fear made little sense, Howard concluded, when Paris green was "the first great start which the new economic entomologist received." Chemical solutions, which Howard portrayed with a strong teleological thrust, were the only truly effective tools in the entomologist's box. History, after all, said as much.[16]

Subtle measures, however, eventually gave way to more overt ones. Beginning in the early twentieth century, Howard seized on an insect that had heretofore been of only minimal interest to applied entomologists: the mosquito. The mosquito ultimately revealed Howard's ingenious ability to strategically expand the Bureau's emphasis from agriculture to public health in a larger effort to tout chemical insecticides.[17] The critical pretext for the new emphasis was malaria. "The discovery . . .of the carriage of the malaria by certain mosquitoes," Howard wrote, "was of the greatest importance to all

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[16] Howard, "Progress in Economic Entomology in the United States," *Yearbook of Department of Agriculture* (1899), 135-156.

[17] Arnold Mallis, *American Entomologists* (Rutgers, New Jersey, 1971), 79-86; L. O. Howard, *Fighting the Insects: The Story of an Entomologist* (New York, 1933), 116-138; Robert Matheson, *A Handbook of Mosquitoes of North America* (Springfield, Illinois, 1929), 66-71; L. O. Howard, *Mosquitoes: How they Live; How They Carry Disease; How they are Classified; How they May Be Destroyed* (New York, 1901), 167-173: E. O. Essig, *A History of Entomology* (New York, 1931), 909; Gordon Harrison, *Mosquitoes, Malaria, and Man: A History of the Hostilities Since 1880* (New York, 1978), 167-168. Riley left the Bureau of Entomology after being passed over for a position as Assistant Secretary of Agriculture. (See Mallis, *American Entomologists*, 78.

mankind." He delivered this declaration immediately after hearing that Ronald Ross, a British scientist, had finally confirmed a vector theory of malaria transmission.[18]

Howard fully appreciated the implications of Ross' discovery for the fate of chemical insecticides. "I felt," he recalled, "that I was no longer engaged in work that might be called of comparatively little importance . . . The horizon opened up very greatly." As a man who had initially defined his career around the challenges posed by agricultural pests, Howard could now, as head of the Bureau of Entomology, directly apply his knowledge to a threat not limited to farmers per se, but one that affected humanity at large. With Ross' discovery, there was never any doubt in Howard's mind about the route he would take to fight what was sure to be a Manichean battle. He had been personally interested in mosquitoes from a young age, and the youthful anecdote that he chose to record in his autobiography foreshadowed the future tone of his professional response. "I had not only studied their transformations out of mere curiosity," he wrote, "but I had found that in this aquatic stage they were readily killed by pouring a few drops of kerosene on the surface of the water." Howard, who had already started to lobby for chemical control, could not have asked for a better reason to decisively act upon his youthful discovery and fully embrace the chemical option.

[18] The story of Ross' discovery has been often told and, naturally, often embellished, most often by Ross himself, who, predictably, was running neck and neck with other scientists aiming to pinpoint the same vector. Sober accounts of this famous, somewhat cut-throat event in the annals of science can be found in Andrew Spielman, Sc.D., and Michael D'Antonio, *Mosquito: A Natural History of Our Most Persistent and Deadly Foe* (New York, 2001), 86-92; Harrison, *Mosquitoes, Malaria, and Man*, 72-80. Also useful is the article "Ross and the Discovery that Mosquitoes Transmit Malaria Parasites," published by the Centers for Disease Control and Prevention (www.cdc.gov/malaria/history/ross.htm).

Mosquitoes were insects primed for chemical attack, but only now, with the linkage to malaria, did Howard have justification to plot their eradication.[19]

Indeed, kerosene became Howard's point of departure. As Walter Reed—who as the head of Yellow Fever Commission had confirmed the mosquito as the vector of yellow fever—made abundantly clear in a 1901 letter to Howard, kerosene was the only trustworthy weapon to use against mosquitoes. "The mosquito theory for the propagation of yellow fever is no longer a 'theory,'" Reed bragged, "but a *well-established fact.* Isn't it enough to make a fellow happy?" He went on, "Anopheles and Culex [two species of mosquitoes] are a gay old pair! . . . what havoc they have wrought to our species during the last three centuries!." Reed then got to the point: "But with Howard and Kerosene we are going to knock them out."[20]

Howard knew that, as the mosquito menace caused panic, the place to make his case was on the federal level, within the halls of Congress, where the impact would be magnified nationally. In 1910, after years of lobbying, he scored a major victory for the future of chemical insecticides when Congress passed the Federal Insecticide Act, one of the first pieces of federal legislation to confront the physical well-being of U. S. citizens. The act passed with considerable support from prominent entomologists who, under the leadership of E. Dwight Sanderson (New Hampshire State Entomologist) had worked

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[19] Howard, *Fighting the Insects*, 53; Mallis, *American Entomologists*, 81. Howard explained, "We are fond of saying that circumstances have conspired to bring about such-and-such a result, and surely a series of different things led me naturally to take a great interest in the subject of the insect carriers of disease." (*Fighting the Insects*, 116); U. S. Congress, *Yearbook of the United States Department of Agriculture.* Serial Set Vol. No. 3693, session vol. no. 65. H. Doc 454 (1897); Howard, "An experiment Against Mosquitoes," *Insect Life* 5 (1893), 12-14; idem. "Mosquitoes as Transmitters of Disease," *Review of Reviews* 24 91901), 192-195; idem., "How to Distinguish the Different Mosquitoes of North America," *US Division of Entomology Circular* 40 (1900), 1-7.

[20] Howard, *Fighting the Insects*, 123, 116-117, 53; Harrison, *Mosquitoes, Malaria, and Man*, 161-162; Mallis, *American Entomologists*, 79-85; L. J. Bruce Chwatt, "Leland Ossian Howard (1857-1950) and Malaria Control: Then and Now," *Mosquito News* 41 (1981), 215-225.

through the Standing Committee on Proprietary Insecticides of the Association of Economic Entomologists to ensure that, when it came to insecticides, "one may know with what he is dealing." The nation's earliest commercial producers of chemical insecticides—companies like Sherwin Williams, Sharp and Dohme, Marshall Oil, Carbola Chemical, Zenner Disinfectant, Parke & Davis, and Ansbacher—backed the standards enthusiastically. These firms welcomed the law's ability to remove quack patent insecticides from an increasingly competitive market. Plus, largely due to the Bureau's savvy politicking, companies were able to play a direct role in shaping the legislation's most critical provisions. (As the bill circulated through Congress, Sanderson accurately predicted "a widespread sentiment . . . in favor of such legislation" among the corporate class.) Federal legislation, whatever its strengths and weaknesses, lent an invaluable imprimatur to kerosene, commercial insecticides in general, the companies that made them and, by extension, Howard's developing plans to take on insects not just as a matter of agricultural production, but public health. This shift, in essence, was the new horizon of which Howard spoke.[21]

War

[21] The most comprehensive work on insecticide legislation is Adelyne Hiller Whitaker, "A History of Federal Pesticide Regulation in the United States to 1947." (Ph.D. dissertation, Emory University, 1974). My discussion of the Insecticide Act of 1910 comes from pages 81-85; evidence of industry's input into the process of legislation writing can be found in a letter from A. B. Ansbacher & Co. to Alfred B. Kittredge, May 1, 1908, reprinted in "Correspondence," *Oil, Paint, and Drug Reporter* (LXXIII) (May 4, 1908), 17. Farmer support for the bill can be found in *Journal of the National Grange of the Patrons of Husbandry* (Concord, NH, 1908), 81; *ibid.* (1909), 52. Allan K. Fitzsimmons, "Environmental Quality as a Theme in Federal Legislation," *Geographical Review*(70) 3 (July 1980), 318; J. K. Haywood, "Insecticide and Fungicide Legislation in the United States with Especial Reference to the Federal Insecticide Act of 1910, *Journal of the Association of Official Agricultural Chemists* 4 (1920-1921), 19.

Throughout all these efforts—the decision to take on shade trees, the penning of revisionist histories, and the linkage of entomology with public health through mosquitoes—advocates of more traditional insect control measures managed to keep their plans alive. By 1914, however, the horizon ahd opened even more. In 1914 the world went to war, and when the United States joined the allies in 1917 they fought more than just the axis powers. They also fought the insect pests that fought the allies. And if there ever was a specific geopolitical context that had complete disdain for gradualist, multifaceted, and ecologically sensitive approaches to insect control, war was it. After the war, cultural and biological approaches to insect control became permanently peripheral, a status it still maintains today. Howard, once again, would brilliantly exploit a non-agricultural event—in this case a world war—to pave the way for an insecticidal approach that would soon control twentieth-century agriculture. The details of this coup are worth unraveling.

When the allies settled into European trenches to make the world safe for democracy, American entomologists were potentially in a position to make the war safe from infestation. As with mosquitoes, Howard was quick to realize the impact such an event might have on the future of both entomology and chemical insecticides. "[W]ar conditions," he wrote in 1919, "have intensified the work of the entomologists and have enabled them to make the importance of their work felt as almost never before." Whereas entomologists were once dismissed as men "trained to count the spots on a mosquito wing," they could now, as scientists working in the interest of national security, be valued as "competent investigators whose advice and help meant everything in the warfare against insect life." Not only did Howard pen a solicitous letter to the surgeon general of the army mentioning a plethora "men well trained in applied entomology who could be used to advantage and who were anxious to serve," but he effectively laid out the precise ways in which they could contribute. The status of professional entomologists could only go up, he explained, as they confronted the insect pests that endangered soldiers, protected the food that fed them, and cleared the trenches in which they camped. What made Howard's efforts all the more significant was that war was, by necessity, overtly hostile to naturalistic methods of pest control. As one historian of science explains, this was a time when "the need for immediate remedies took precedence" over everything else, especially ecologically-driven notions of biological and cultural control. Howard sensed that, if he could send the Bureau of Entomology into the fog of war, an even further onslaught of powerful chemicals to fight the insect menace was bound to follow. War, in short, could normalize the chemical option.[22]

Howard's inspiration to link war and American entomology began with a British zoologist named A. E. Shipley. Howard recalled being influenced by Shipley's articles in the *British Medical Journal* from 1907-1912. The pieces were later collected for the 1915 publication of a book called *The Minor Horrors of War.* "I deal with certain little Invertebrata," Shipley wrote in his introduction, "animals which work in darkness and in stealth . . .little animals which in times of War may make or unmake an army corps."

[22] L. O. Howard, "Entomology and the War," *The Scientific Monthly* (8) 2 (February 1919), 109-117; idem., *Fighting the Insects*, 138-139; J. S. Ames, "The Trained Man of Science in the War," *Science* (48) 1243 (October 25, 1918), 403; A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge, Mass.: Harvard University Press, 1957), 324; Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to* Silent Spring (Cambridge, Eng.: Cambridge University Press, 2001), 20, 75-78; Avner Offer, *The First World War: An Agrarian Interpretation* (Oxford: Clarendon Press, 1989); Howard, "'On Some Presidential Addresses': The War Against the Insects," *Science* 54 (December 30, 1921), 641-651; idem., "U. S. Wages Insect War," *Science News Letter* 10 (November 20, 1926), 127; R. H. Hutchinson, "A Maggot Trap in Practical Use: An Experiment in House Fly Control," *USDA Bulletin 200* (1915), 1-15.

Lively chapters on bed bugs, lice, house flies, the flour moth, mites, and ticks condemned these pests as the cause of "minor discomforts of an army," "a frequenter of human habitations," creatures that "infest human sores," and the vectors of disease. Repeating the old adage that "an army marches on its stomach," Shipley obsessed over pests that threatened "our soldiers' food," spent page after instructive page on how to combat insects like the "biscuit moth," and claimed of the fly that "the poisoning of the soldiers' food-supply is its chief role in war." Not a single possible niche that insects might exploit among men at war—maggots in flesh wounds, blow-flies in ear sockets, louse in soldiers' underwear—escaped his attention. The book was, in its own way, a tour de force of applied entomology. Perhaps most importantly, Shipley's reliance on benzene, carbolic acid, sulfur baths, chloride of lime, creosote, and alkaline soaks revealed his steadfast commitment to chemical efficiency. Howard had not been so impressed with the work of another entomologist since his days in Comstock's library and lab.[23]

Brilliantly anticipating the impact that the war would have on U.S. crop production, Howard took the initiative in coordinating a national information network of any and all insect infestations that might impact the war effort. Bringing together state entomologists, experiment station entomologists, university entomologists, and demonstration agents, he created, by his own estimation, "as far as possible a census of

[23] A. E. Sibley, *The Minor Horrors of War* (London: Smith, Elder, and Co., 1916). L. O. Howard, "Entomology and the War," *The Scientific Monthly* (8) 2 (February 1919), 110; Maurice C. Hall, "Parasites in War Time," *The Scientific Monthly* (6) 2 (February 1918), 107. Shipley had an eye for the choice sensationalistic detail, peppering his account with references to "a clotted scab of lice," the "white, legless, repellent maggot," and referring to the fly's reproduction capability as "appalling fecundity" while including a choice drawing of "M. domestica in the act of regurgitating food." Also see Stanhope Bayne-Jones, *The Evolution of Preventive Medicine in the United States Army*, 1607-1939 (Washington, DC: Office of the Surgeon General Department of the Army, 1968); Rennie W. Doane, *Insects and Disease: A Popular Account of the Way in Which Insects May Spread of Cause Some of Our Common Diseases* (New York: H. Holt, 1910); Frederick KNab, "Unconsidered factors in Disease Transmission by Blood-Sucking Insects," *Journal of Economic Entomology* 5 (1912), 196.

insect damage and prospects, so that the earliest possible information should be gained as to any alarming increase in numbers of any given pest." If and when the war machine said "jump," Howard wanted to be sure that American entomologists jumped ably and in unison. He insisted that the disparate information he collected be "received at a common point (Washington) and distributed where it should be of the most good."

These preparations (again, none of which Howard was asked to undertake) paid off. When Congress turned its attention to the nation's "insect enemies" after declaring war in April 1917, entomologists suddenly found themselves thrust to the center of a wartime bureaucratic machine. Ample funding materialized (as it has a way of doing during war) and, as if following the cues of Howard's script, "[entomologists] were assigned to different localities, and took care of the demonstration work against the principle pests of staple crops all over the United States." Insect attacks were now about agricultural production, public health, *and* national security. This latest expansion was profoundly important to the future of entomology and chemicals. Howard had placed his profession's men on the front lines of this new battle, reminding those who had ever doubted the entomologist's place in war that they had,

failed to consider not only how damage by insects to growing crops influences the food supplies of armies, but also how greatly grains and other foods stored for shipment to the front or on the way to the front may be reduced in bulk by the work of the different grain weevils and other insects affecting stored foods. In addition, they did not think of the damage done by insects to the timber which enters into the building of ships, into the manufacture of wings for the airplanes, and that which is used for oars, the handles of picks and spades, and which even occurs in wooden structures and implements after they have been made.

Howard did think of these things, and he knew that the war would need more than conventional weaponry.[24]

The work of insect control during wartime, as well as the public expectations for success, was daunting. "It is hoped," wrote one War Department official, "that our country may be aided in its effort to conserve the food needed to win the war." The *New York Times* upped the rhetoric, noting with respect to the food supply that "Winning the war is the absorbing and imperative business of the American people. Twenty four hours of every day must be devoted to it." An unlikely crop, the castor bean, offered a case in point of the sacrifices and flexibility involved. With the onset of war, the War Department encouraged Americans to show their loyalty to the cause by planting castor beans, primarily because castor oil lubricated airplane cylinders. Small planters throughout Florida and Texas in particular read up on castor bean planting (it had traditionally been done in Mexico) and allotted thousands of acres of land to the stringy legumes. It was not long, however, before the War Department was calling on the Bureau of Entomology for urgent advice. Patriotic farmers soon found their plots of new crops under attack by an unfamiliar pest. One writer noted that his castor beans were "riddled and cut short by boll worms." Howard, who never visited a farm during the war, deemed the culprit a "southern army worm." Whatever the insect, patriotic entomologists fanned across the nation to ensure that castor oil not only continued to lubricate airplane valves, but also, in the *New York Times*' phrase, "the feelings of a cross and anxious nation."[25]

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[24] Howard, "Entomology and the War," 109-111.
[25] Howard, "Entomology and the War," 113; "That Oil for Airplanes," *The New York Times* (September 1, 1918), 27; "Castor Bean Being Raised to Help Aircraft Program," *The Dallas Morning News* (January 6, 1918), 8; "Want Castor Beans Grown for Airplane Lubricant," ibid (January 8, 1918), 7; "How Castor Beans Should Be Planted," ibid. (January 11, 1918), 6; "Willing to Plant Castor Beans on Twenty Acres," ibid (January 10, 1918), 6; Royal Chapman, "Measures for Protecting Wheat-Flour Substitutes from

Grain and wood storage posed problems of their own, ones which government entomologists were similarly prepared to confront. "The damage to stored grain and grain in shipment," wrote Howard, "soon came to the front." Massive quantities of grain were shipped from American farms to a single warehouse in Brooklyn, New York before being packed and hauled to Europe. Fearful that insects would infest these centralized supplies as they sat in the warehouse, the War Department yet again contacted the Bureau of Entomology, and even established an on-site laboratory for entomologists to stand guard and conduct chemical investigations. "Many of the millers and dealers who handle the cereals which the Food Administration is now requiring as substitutes for wheat flour," wrote one entomologist, "have always recognized them as being subject to insect attack." The collective aim of the entomologists was, through on-site investigations, to minimize those attacks. West coast and southern entomologists undertook similar investigations in the mills and warehouses that temporarily stored grain destined for New York. No less attention was paid to the nation's forest supplies. Entomologists infiltrated the War and Navy Departments after bark boring beetles caused "serious losses of forest resources," in this case a million feet of Mississippi ash logs once destined to become oars and handles. In the Pacific Northwest, entomologists dispatched by the Spruce Production Board worked with loggers to ensure that the spruce wood needed for airplane production remained free from infestation. Their work against tree borers, as entomologist Maurice

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Insects," *Science* (47) 1224 (January 14, 1918), 581; "Important in the Conduct of the War," *The New York Times* (April 12, 1918), 12.

C. Hall so aptly put it, was "warfare as real and as systematic as the conflict of militarism and democracy."[26]

Animals required their own share of entomological attention. Demand for cattle reached new levels during the war, as did efforts to avail them of insects. "Texas fever" and scabies (caused by ticks), as well as worms that caused diseases in pigs and sheep, had always been chronic agricultural problems, but now the U.S. Bureau of Animal Husbandry and the Army Veterinary Corps were entrusted to solve them. Again, tapping Howard's well-organized corps of lock-stepping entomologists, the government drew on entomological expertise to assure the nation that "the last tick will be dipped or collected as a museum specimen, or whatever is appropriate for a last tick, and the tick and Texas fever will become extinct in this country." While cattle-borne diseases had once "cost the country dearly," it could be accurately said that "the savings in wool, leather, mutton, and beef, all unusually valuable in these days of war, constitutes an indemnity that repays us many times for the outlay which it has cost to prosecute this campaign."[27]

Cattle, grain, wood, and castor beans were not the only assets that wartime entomologists sought to protect. There were also soldiers. Malcolm E. MacGregor, a scientist at the Bureau of Scientific Research, best captured the novelty of this responsibility when he wrote, "During the last few years medical entomology has been rapidly establishing itself as an invaluable branch of preventive medicine." With "the numerous biting flies and mosquitoes find[ing] exceptionally favorable opportunities for

[26] Howard, Entomology and the War," 114; Maurice C. Hall, "Parasites in War Time," 112; F. C. Cooke, R. H. Hutchison, and F. M. Scales, *Further Experiments in the Destruction of Fly Larvae in Horse Manure, Bulletin 245, Department of Agriculture* (Washington: GPO, 1915).

[27] W. Moore, "Fumigation of Animals to Destroy their External Parasites," *Journal of Economic Entomology* 9 (1916): 71-78;

breeding in war areas," the Bureau of Entomology charged even deeper into the maw. "Trench fever," infectious jaundice, scabies, wound infections, typhus fever, dysentery, and a number of other ailments that commonly afflicted soldiers meant that body lice, clothes lice, mosquitoes, spiders, maggots, flies, ticks, and any other animals capable of transmitting parasites and germs were declared enemy combatants. It was widely agreed, as Hall put it, "that entomologists versed in medical entomology be attached to our army units." By 1918, scores of expert entomologists, commissioned and non-commissioned, had left for Europe, where they lived in Army camps and worked to control insects that carried disease in military camps. Howard proudly noted how "every suggestion that came to the War Department in regard to control of the body louse was referred to the entomological committee, or to the Bureau of Entomology." It is impossible to measure the impact of the bureau's work with any real accuracy, but one should not discount a contemporary scientist's assessment that "the medical sciences have kept 100,000 American men in fighting trim who would have in 1861 died of disease."[28]

Entomologists thus embraced the opportunity Howard capitalized upon with enthusiasm, competence, and organizational prowess, fulfilling the role of "competent investigators whose advice and help meant everything in the war against insect life." Their method of combat, most importantly, was never in question: they fought the insects with chemicals. The urgency of war, the requirement that every task be accomplished with the utmost efficiency and accountability, and the implicit expectation that the latest

[28] Howard, "Entomology and the War," 113; Hall, "Parasites in War Time," 112; "Microbe and Bug Killers," *The New York Times* (December 13, 1917), 17; "Board Announces Enlarged Embargo," ibid (October 22, 1917), 6; "Makers of Disinfectants are Told to excel if they are Not To Fall Behind Foreigners," ibid (December 12, 1916), 15; R. F. Bacon, "The Industrial Fellowships of the Mellon Institute," *Science* (45) 1165 (April 27, 1917)402; E. Dwight Sanderson, *Insect Pests of Farm, Garden, and Orchard* (John Wiley and Sons, 1921), 670.

technology be employed were only a few of the factors ensuring that World War One was an unprecedented boon for chemical insecticides. If early tests on and experiences with chemical insecticides had proven anything conclusively, it was that these substances could work well in the short term and under controlled circumstances. Cultural or biological methods—both of which required more time, patience, adaptability, and appreciation of the long-term consequences—were simply out of the question under the unique circumstances of war. Chemical poisons were the only option seriously entertained. In turning to them as decisively as it did, the Bureau of Entomology helped establish chemical insecticides as the primary means through which any rational being intent on eliminating insects undertook his work. It perpetuated this opinion, moreover, with the consolidated support of the federal government, substantial economic backing from non-profit foundations, the eager endorsement of insecticide manufacturers, and widespread public approval. The war precipitated all these developments. Howard, in capitalizing upon them, helped further standardize chemical insecticides as the most conventional means of fighting insects, whether abroad or, as quickly became evident, at home.

Back on the Home Front

As they had done in Europe, insecticides at home became associated with the word that everyone wanted to hear: victory. Thomas A. Dunlap writes, "It is impossible to prove, but difficult to resist, the idea that this constant image of battle and war influenced people to choose, or to accept, the use of the use of the only weapons that promised 'victory'." Perhaps it is not so impossible to prove. Although A. L. Melander, a

City College biology professor, made the following remark in 1933, the seed of his idea sprouted during the war. With respect to controlling insects, he wrote, "Chemical warfare on insects has become an accepted part of our yearly life. It will never be outlawed . . .and in time to come it will decide whether man or insects will dominate the world." A few years earlier, E. O. Essig, a University of California entomologist, confirmed the prevalence of the man-versus-nature aspect of the insect war within the war. Speaking of entomologists he wrote, "Ours is not the menial chore so often alluded to as 'chasing bugs,' but rather the gigantic task of saving the human race." In the highly charged wartime atmosphere, with stakes raised so high, insecticides proved to be the most potent weapon of choice. This muscular rhetoric was a far cry from the anti-chemical voices emerging from the pages of the *Practical Entomologist*, and it suggested that, with the war over, there were equally potent battles to be fought.[29]

Indeed, neither Howard nor the advocates of chemical insecticides were prepared to stop using chemicals once the war came to an end. During the war American entomologists and chemists not only applied familiar insecticides but they tested over one hundred new ones, and they had no intention of simply forgetting about these poisons because the ink had dried on the Treaty of Paris. Consider the issue of post-war mosquito control. In Morris and Middlesex Counties the New Jersey Agricultural Experiment

[29] Hall, "Parasites in War Time," 107; Dunlap, *DDT: Scientists, Citizens, and Public Policy*, 36-37; A. L. Melander, "Fighting Insects with Powder and Lead," *The Scientific Monthly* 36 (2) (February 1933), 168; E. O. Essig, "Man's Influence on Insects," *The Scientific Monthly* (28) 6 (June 1929), 506. Some historians have claimed that Howard was not lukewarm towards biological controls. By 1930, however, he certainly was. He wrote in his memoirs, "There has been a tendency for many years for persons with strange beliefs to migrate to California . . .and today southern California is known as the home of all the heterodoxies, and biological control in general: So great an enthusiasm for natural control was aroused in California by the success of the Australian ladybird that the state made apparently made no advances in her fight against insects for many years. Mechanical and chemical measures were abandoned. The subject of natural control held the floor. It is safe to say that a large share of the loss through insects suffered by California from 1888 until, let us say, 1898, was due to this prejudiced and badly based policy." See V. G. Dethier, *Man's Plague? Insects and Agriculture* (Princeton, NJ: The Darwin Press, 1976), 146.

Station tested a pyrethrum larvicide and oil mixture in 1926. Another substance that came into vogue as a mosquito killer after the war was Paris green. “For chemical control,” wrote an Alabama civil engineer, “Paris green is dusted over the surface of the water and poisons the larvae of the Anopheles which eat it.” The dust earned accolades as a viable insecticide even though it had to be “applied in such large quantities as to become an actual menace of poisoning animals and men.” New chemicals, as well as more extensive application of old ones, demanded new equipment. Kerosene and other oils now reached bodies of water with industrial pumps while, with Paris green, “pumps and sprays are replaced by blowers.” Finally, as an indication that the castor oil produced during the war was useful beyond the war, the New Jersey station acquired an airplane from the Ungar Aircraft Association, equipped it with the “necessary apparatus,” and, after lifting off from Hadley Flying Field, performed a stunt that would later drive Rachel Carson to action: it dropped from its belly fifty gallons of an oil larvicide on the Cheesequake salt marsh meadow. “The pilot swoops down as low as possible within safety limits and releases the valve,” recounted the station report. “The liquid flows out by the force of gravity as a fine spray, depositing a thin film on the breeding areas.”[30]

While the war and its emphasis on insecticides thoroughly altered the nature of the mosquito wars, the impact of the chemical transition did not affect one crop, one region, or even one group of people. Because entomology joined itself to the hip of chemistry, its influence after the war touched all humanity. As Howard had said, the

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[30] Joseph M. Ginsberg, “Airplane Oiling to Control Mosquitoes,” *Science* (75) 1951 (May 20, 1932), 542; idem, “Studies of Pyrethrum as a Mosquito Larvicide,” Proceedings of the 17th Annual Meeting of the New Jersey Mosquito Extermination Association,” (1930), 57; L. L. Williams and S. S. Cook, “Paris Green Applied by Airplane in the Control of *Anopheles* Production,” Public Health Report (reprint no. 1140, 1927), 459; Edgar E. Foster, “Mosquito Control on Hydroelectric Projects,” *The Scientific Monthly* (37) 6 (December 1933), 529. Further evidence of the chemical transition to larvicides can be found in Thomas J. Headlee, *The Mosquitoes of New Jersey and Their Control* (New Brunswick: Rutgers University Press, 1945), 289-300.

issue "was of the greatest importance to all mankind." And, therefore, so was its post-war solution. When mosquitoes became subject to insecticidal methods, and when the war validated that approach, not to mention chemical solutions in general, any remaining doubts about the place and prominence of chemical insecticides were put to rest at the Bureau of Entomology. In 1922 W. R. Walton, praising the discipline that Howard had imposed on the Bureau, wrote, "Every executive who possesses even a rudimentary knowledge of his calling knows that the first important requirement is harmony, because this means teamwork, which is a long stride toward success in any organized effort . . .The entomological service is not so very different from that of the army; we have our battles to fight, and organize and mobilize our forces accordingly." Howard reiterated the Bureau's military discipline when he wrote, "it is best to submit to such regulations as are honestly made to fit the great mass of the service or a particular branch of the service." As mosquito control went exclusively chemical, it became much easier in this environment for Americans farmers—whose crops had been thoroughly covered in insecticides during the war—to abandon any systematic plans for biological or cultural control and, with the utmost federal assurance, accept insecticides as a necessary aspect of agribusiness, government, and public health. Whatever hesitation over insecticides that may have existed before the war was put to rest after it. The tools in the box had changed, replaced by the chemicals that were said to have won the war. A path dependency of sorts was set in motion and an important, if somewhat elusive, technological threshold had been crossed.[31]

[31] Quoted in Hae-Gyung Geong, "Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870-1930 (Ph D Dissertation: University of Wisconsin-Madison, 1999), 83; Howard to R. W. Glaser, March 21, 1917, National Archives (RG 7); see Russell, *War and Nature*, 21; on the emergence of new, volatile toxic compounds—synthetic organic insecticides—see E. B. Blakeslee, *Use*

The insecticidal advances made in the decade after the war comprise an extensive laundry list of evidence showing that Americans were soon spraying on an unprecedented level. In 1920, farmers dropped ten million pounds of calcium arsenate dust to control the boll weevil, doing so with recently designed ground equipment. In 1921, orchard keepers began spraying lead arsenate to control for maggots in fruit while scientists recommended arsenic as a mosquito larvicide. The next year witnessed the emergence of rotenone bearing insecticides used to control cattle grubs, calcium arsenate to manage the Mexican bean beetle and boll weevil, and calcium cyanide as an insecticidal fumigant. That same year airplanes first complemented ground sprayers in spraying calcium arsenate on cotton crops. In 1923, carbon tetrachloride and ethylene dichloride fumigated grain mills for the first time. By 1924 Louisiana officials were using airplanes to drop Paris green on state swamps, others began using blimps to drop insecticide dusts over crops, and colloidal sulfur, fluorine compounds, and cryolite were all tested as insecticides. In 1925 scientists discovered an ethylene dibromide fumigant and airplanes were used to dust orchards for the first time. The year 1926 saw the emergence of fish oil used as a spray binder to help insecticide dust stick to plants, lead arsenate used on the clover leaf weevil, the rise of barium fluosilicate and thallium sulfate as insecticides, and chloropicrin as a flour mill fumigant. Nineteen-twenty seven was the year when sodium arsenate sprays hit the market, farmers used calcium arsenate on blueberries, and an ethylene dichloride-carbon tetrachloride mixture saturated stored grain throughout the nation. Americans began to use ethylene oxide and alkyl formates as fumigants on crops and in homes and cryolite doused on coddling moths in the Pacific Northwest. It was also the year that L. O.

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of Toxic Gases as a Possible Means of Control of the Peach Tree Borer, Bulletin 796, USDA (Washington, GPO, 1919), 1-7; Russell, *War and Nature*, 30-35; Charles H. Herty, "The Expanding Relations of Chemistry in America," *Science* 44 (October 6, 1916), 481-483.

Howard, who had become more interested in riding his bike around Washington, D.C. than fighting the insects, decided to retire.

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Due to mosquitoes, World War One, and Howard's effort to bring chemicals under the umbrella of a powerful bureaucracy, the United States had become an insecticide nation.[32] Howard left behind fifty years of workaholic service, a stack of honorary degrees, awards galore, a publication record that spanned a ream, and a sense that, as one colleague put it, "none had so powerful an impact on the world-wide study of harmful insects." Howard always approached the bug wars with creativity, ambition, and the best intentions. Time after time, these impulses—which were consistently buttressed by the cooperative historical context in which he worked—led him to the chemical approach. There were entirely sensible reasons for him to have made this decision. As a progressive scientist it was imperative that he seek measurable solutions that fit within the tight framework of progressive expectations. As the head of the Bureau of Entomology it was imperative that, when mosquitoes were linked with malaria, he pursue options that were quick, cheap, and consistent with the interests of industry and government. As the nation's leading entomologist during a world war, it was imperative that he promote measures that met urgent short-term needs with solutions that were universally applicable, expedient, and powerful.

Ever the pragmatist, ever the career man, ever the believer in the power of science to control the environment in humanity's interest, Howard placed chemical insecticides

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[32] USDA, *Chronological History of the Development of Insecticides and Control Equipment from 1854 through 1954* (ASDA Agricultural Research Service, 1954). This document was published to honor the centennial of professional entomology in the United States. A summary of the report can be read at http://entweb.clemson.edu/pesticid/history/htm; Elton W. Downs and George F. Lemmer, "Origins of Aerial Crop Dusting," *Agricultural History* (39), 130-132.

on a pedestal. Industry and government eagerly ushered them into the 1920s and beyond, fully assured that the only way to win the insect wars was by spraying substances that had proven their mettle in the city streets, European trenches, and coastal swamps of a nation that was still decades away from realizing the full implications of Howard's strategic twists and turns.