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Commercializing chemical warfare: citrus, cyanide, and an endless war

Adam M. Romero

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Abstract Astonishing changes have occurred to agricultural production systems since WWII. As such, many people tend to date the origins of industrial chemical agricultural to the early 1940s. The origins of industrial chemical agriculture, however, both on and off the field, have a much longer history. Indeed, industrial agriculture's much discussed chemical dependency—in particular its need for toxic chemicals—and the development of the industries that feed this fix, have a long and diverse past that extend well back into the nineteenth century. In this paper, through the narrative of a late nineteenth century creation story, I go in search of a crucial linchpin in that longer history. I argue that industrial pest control has been imbued with the practices, discourse, materials, and ethics of modern chemical warfare since its inception. Faced with pest-induced collapse, Los Angeles citrus growers and scientists of the USDA and UC Agricultural Extension chemically fixed the citrus pest problem by developing and utilizing the cyanide gas chamber. Cyanide fumigation quickly became the toxic cornerstone of the citrus industry, enabling its intensification and expansion as the pest infection became systemic. By the turn the century, furnished with an economic poison made cheap and weapons-grade due to changes in the world gold mining industry, growers transformed cyanide fumigation into a necessary agricultural input. In chemically overriding an agro-ecological contradiction of capitalist agriculture, growers, scientists, and government officials amalgamated industrially organized agriculture to accelerating and endless chemical warfare. These suddenly necessary agricultural practices signaled a state change in world-ecology and agroindustrial organization, thus, the discovery of effective industrial control for citrus pests was not only a pivotal moment in the history of Southern California but it was also an event that has had world-historical implications.

A. M. Romero (✉)
Department of Geography, University of California, Berkeley, 507 McCone Hall, Berkeley, CA 94720, USA
e-mail: adam.romero@berkeley.edu

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Abbreviations

AOX	Alternative oxidase
CF	California Farmer
CSAS	California State Agricultural Society
DA	District Attorney
DAC	Daily Alta California
KCN	Potassium cyanide
LA	Los Angeles
LAT	Los Angeles Times
LAH	Los Angeles Herald
NYT	New York Times
PRP	Pacific Rural Press
R&H	Roessler & Hasslacher Chemical Company
SDU	Sacramento Daily Union
SFC	San Francisco Chronicle
SCH	Southern California Horticulturist
US	United States
USDA	United States Department of Agriculture
WWI	World War I
WWII	World War II

Historiographical Prelude

> In times of peace and prosperity, states and individuals alike follow higher standards… But war is a stern teacher.

Thucydides (1910), *History of the Peloponnesian War*, ~400 BCE

Histories of chemical warfare and the gas chamber are written as twentieth century tales.[1] So too are histories of industrial pest control.[2] And for the most part, these works are written upon separate storylines. Yet, historically, all three of these socioecological phenomena emerge from the same late nineteenth century creation story. In the late 1880s, among insect infested citrus groves on the western floodplain of the Los Angeles River, industrially efficient pest control emerged through the commercialization of chemical warfare and the deployment of the industrial gas chamber.

Historians of all stripes have written about the effects of war on states and peoples. Much less has been written about the effects of war on the environment (Lanier-Graham 1993; Sanders 2009; Slavin 2014). And even less has been written about the links between warfare and longer-term process of environmental change (Hamblin 2013; McNeill and Unger 2013). Agricultural historians, however, have long been interested in the links between agriculture and warfare (Cushing 1957; Perkins 1978; Russell 2001; Rasmussen 2001). It would be hard to study the history of economic or medical entomology and not notice a shared past battling pests on agricultural and military fields (LAT 1916; Howard 1922; Walker and Mills 1926, 1927; Annand 1944; Fries 1928; Abraham 1940; Cecil 1986). Thus, agricultural scholars have deftly shown us that since WWI, technological and scientific efforts to control agricultural and military enemies have developed hand and hand with each other. Industrial pest control and industrial chemical warfare, in other words, have coevolved and fed upon each other.

These scholars, however, situate the beginning of chemical warfare's influence on agricultural practices, and vice versa, with the onset of the First World War. World War I (WWI), regarded as the "chemists war," introduced the public to industrial warfare and weapons of mass destruction (see Fig. 1). Germany's use of chlorine gas on a warm spring day in 1915 is often the event credited with ushering in this new epoch in the evolution of war. Thus, most histories of chemical warfare open upon an April 1915 scene; as such, scholarship that links chemical warfare to pest control opens upon the same spring setting.

But an April, 1915 birthdate for chemical warfare is incorrect as evidence exists that chemical and biological warfare have been practiced for thousands of years (Browne 1922; Kokatnur 1948; Mayor 2008). Even the word *toxic,* in its etymology, reveals the long history of toxicants in warfare. Originating from the Greek word *toxikon*, the word toxic meant in its first iteration "poison for arrows" (OAD 2011). It could be stressed, instead, that WWI marked the first time industrial gases were used directly in warfare. For warfare against humans, perhaps this is true. But the spring of 1915 was not the first time that industrial gas warfare was deployed against an enemy. That took place 28 years prior on a different kind of battlefield.

Historians of WWII and Nazi Germany often claim that "the creation of the gas chamber was a unique invention of Nazi Germany" (Friedlander 1995, p. 93). To scholars like these it isn't just the invention of the gas chamber per se, but it is its industrialization, its creation as an assembly line of death, that makes the Nazi's creation unique (Borin 1978; Jeffreys 2008). Recent scholarship, countering these claims, has argued that the gas chamber is a uniquely American creation that was first put into practice by United States (US) penal authorities in early 1920s (Christianson 2010). And although this recent scholarship links the shared material of death—cyanide—between the first US gas chamber and the California agrochemical company that provided it, it too fails to venture back beyond the Ypres front in the spring of 1915. By 1923, when hydrogen cyanide was first pumped into a specially constructed building in a Reno prison yard, the cyanide-based gas chamber had been in commercial operation for over 35 years, where it was used across the US to disinfect trees, food, and nursery products; even whole train cars (Johnson 1902; Winters 1922).

Cyanide fumigation—the practice of releasing hydrogen cyanide gas under a tented tree—discovered in Los Angeles in the fall of 1886, bought a temporary reprieve from the ravages of industrial pests, allowing grower-capitalists to turn the valleys of Southern California into a citrus empire. The rapid development of industrial chemical control based upon the deployment of portable gas chambers saved the rudimentary Southern California citrus industry from pest-induced collapse by tying the efficient production of high quality citrus fruit to the commercial utilization of chemical weapons. Among the capitalist groves of late nineteenth century Southern California, on the backs of humans and horses, the industrial gas chamber became a working reality.

Despite its formative impact on the agricultural production complex writ large, the story of industrial cyanide has remained largely unexplored among agricultural historians and critics of industrial agriculture. Even those that venture back beyond WWI fail to acknowledge cyanide's impact on agro-industrialization and western development. Were it not for cyanide fumigation, the history of industrial

[1] For example: Fries (1921), Fradkin (1929), Smart (1997), Cook (1999), Harris and Paxman (2002), Jenkins (2002), Coleman (2005), Brophy et al. (2005), Tucker (2006), Christianson (2010).

[2] For example: Carson (1962), Whorton (1974), Perkins (1978, 1982), Russell (2001), Daniel (2005), McWilliams (2008), Ceccatti (2009).

Fig. 1 Orange crate label, ca. 1915. *Courtesy of the Huntington Digital Library* (Schmidt Lithographic Co. 1915)

agriculture and Southern California' citrus industry would have looked much different. But the cleansing power of cyanide was discovered, and for about 6 months every year, as night fell upon the citrus groves, nocturnal executioners sprang to life: mixing chemicals, enshrouding trees, *and* repeating *and* repeating *and* repeating millions of times over.

The nature of industrial pest control

> But here the tailoring, the screening of basic truth, is done, not to suit a party line, but to accommodate the short term gain, to serve the gods of profit and production.
> Rachael Carson, *Women's National Press Club Speech*, 1962

The chemicalized nature of industrial agriculture has certainly resulted in awe-inspiring yields (Cochrane 1993; Evanson and Golin 2003; AP 2014). But it has also resulted in pollution and contamination on such an immense scale that it can now be found anywhere we look (Chen et al. 2012; Collotta et al. 2013; Fu and Kawamura 2010; Malaj et al. 2014). Industrial chemicals, as Rachael Carson said over half a century ago, now permeate the fabric of everyday life from the "moment of conception until death" (Carson 1962, p. 15; Murphy 2008). Children are now born into this world with hundreds of industrially made chemicals already flowing through their blood (Bradman et al. 2005, 2007; Grandjean and Landrigan 2014). Life itself has become a vast repository of contamination, a documentary of exposure (Corcoran et al. 2010; Singer 2011; Mascarelli 2013; Guillette and Iguchi 2012; Altman 2014).

Critics of industrial capitalist agriculture have repeatedly highlighted agriculture's dependence on industrially produced chemical inputs (Goodman et al. 1987; Pollan 2006; Weis 2010; Van Der Ploeg 2010). Using fertilizers derived from natural gas, we mask long-term fertility problems (Khan et al. 2007; Mulvaney et al. 2009). Chasing economies of scale and scope, we simplify, standardize, and intensify, fabricating novel agroecosystems structured around the production for and realization of value in a market (Haila and Levins 1992; Henderson 1999; Moore 2003; Folke et al. 2004; Hobbs et al. 2006;

Lewontin and Levins 2007). And lured by the siren song of nature's control, we conjure ever-newer chemical weapons to override nature's resistance to our hostility (Carson 1962; Naylor and Ehrlich 1997; Ceccatti 2009; Weis 2010; Alyokhin et al. 2014; USDA 2013). In doing so, like Sisyphus with his stone, we have forced ourselves to forever run with Alice and Red Queen. Faster, ever faster we must run, just to stay in the same place (Boyce 1928; Gray and Kirkpatrick 1929; Schainberg 1980; Plucknett and Smith 1986; Jansen et al. 2011). And like Alice, who never figured out how she began running ever faster, the origins of industrial agriculture's toxic dependency have until now remained unknown. But addiction, whether individual or industrial, always has a ground zero—a first time, a first taste—and it to this moment that I turn.

In this paper I traverse the political economic origins of agriculture's chemical addiction by historically navigating a critical threshold between two organizational states, a state before toxic chemicals were necessary for industrial agricultural production and our current state in which a continuous stream of chemotherapeutics are needed to soothe the chronic symptoms of capitalist agriculture. Drawing from Moore's concept of world-ecology, I argue that industrial pest control has been imbued with the practices, discourse, materials, and ethics of modern chemical warfare since its inception (Moore 2003, 2011a, b).

Moore highlights how "capitalism does not develop upon global nature so much as it emerges through the messy and contingent relations of humans with the rest of nature." (Moore 2011b, p. 110) Capitalism, in other words, is an ecological regime that translates complex ecological processes into sites of accumulation while simultaneously being constrained by the state of nature itself (Levins 1968; Levins and Lewontin 1985; Lewontin and Levins 2007). In doing so, capitalism undermines the conditions of its reproduction, (Liebig 1859; Benton 1989; Foster et al. 2011). Thus, world-ecology is nothing if not a theory of socio-ecological organization, where "transitory but identifiable socio-ecological moments" can have revolutionary effects (Moore 2003, p. 432; Scheffer et al. 2001; Folke et al. 2004; Beisner et al. 2003; Barnosky et al. 2012). The discovery of cyanide fumigation was one such moment.

A revolution in capitalist agricultural organization occurred among the citrus trees of late nineteenth Century Southern California when growers and scientists temporarily overcame ecological crisis by tying the production of high-quality citrus fruit to an endless chemical war. This organizational change allowed growers, scientists, and chemical salesmen not only to overcome the growing insect plague descending upon the industrial citrus biome but also to expand and intensify as the infection became systemic. By the turn of the twentieth century, for the first time, chemical pest control crossed an important threshold when it went from being used in an ad-hoc manner to a prerequisite of industrial citrus. In the Southland's citrus-scented killing fields, officially sanctioned commercially efficient mass death became a defining feature of industrial agricultural production (PRP 1888a; Lough 2007; Peck 2010).

Many scholars before me have linked developments in warfare and with developments in industrial pest control, but none have suggested that the ontology of industrial pest control is and has always been a state of war. The dominant structuring force of contemporary world-agriculture is more than just an historical matrix of agro-ecological nature patterned by endless accumulation, as many scholars suggest (Altieri 1998; Magdoff et al. 2000; Moore 2003, 2010, 2011a, b; Perfecto et al. 2009; Weis 2010; Foster et al. 2011). It is also, critically, an agriculture of endless war. We have fulfilled Hobbes' darkest philosophical incantations by turning the production of food and fiber into a state of endless war—a war in which "all life is caught in its violent crossfire" (Carson 1962, p. 8; Kavka 1983). In our war with nature, we are war with ourselves—together, a "community unto death" (Lough 2007). And we do this, not to produce sufficient food, but "in service to the gods of profit and production" (Carson 1998, p. 210, 1962; Perkins 1983; Cochrane 2003). Not in my name.

A narrative history of agroindustrial state-change[3]

> Such are the facts of chemical warfare. They will not be believed because a belief in them would do violence to the sentiments of most people.
> J.B.S. Haldane, *Callincus: A Defense of Chemical Warfare*, 1925

Throughout the 1870s and 1880s, the valleys of Southern California were inundated with immigrants. From all corners of the earth they came, at first just a trickle, but soon a flood, seeking opportunities among the sun-drenched landscapes of the Golden State (McWilliams 1935, 1946; Street 2004; Sackman 2005). These immigrants came in many forms, including people, insects, and plants, even chemicals. At the turn of the twentieth century,

[3] Data and Methods: This history is compiled from the following archives: California State Library and Archive, Hagley Library, UC Riverside Citrus Experiment Station Archive, Chemical Heritage Foundation Archives, UC Irvine Special Collections, Bancroft Library at UC Berkeley, Huntington Library, USC Digital Library. I also draw from multiple newspaper archives including those of the Los Angeles Herald, the Los Angeles Times, the New York Times, and the Pacific Rural Press. Because most newspaper articles do not have author attribution, I use newspaper acronyms followed year (ex. a 2014 Pacific Rural Press article → PRP 2014). A full list of newspaper acronyms can be found at the beginning of the paper.

as the semi-tropical pot-of-gold on the western shores of manifest destiny, Southern California began producing something golden in color yet far sweeter than precious metals: citrus (Guinn 1912; Spalding 1922a, b, c; Webber and Batchelor 1943). Beginning in the 1850s and rapidly accelerating as the turn of the century approached, the flooding of the promised land's valleys with homogenous citrus trees sparked a radical reorganization in the life histories of California's insects and the historical trajectories of California's ecologies.[4] By the early 1880s, as the non-linear population dynamics of native and introduced insects began to realign with an emerging industrial citrus biome, the economic pest problem grew exponentially (Holt 1877, 1880, 1888; Bristol 1878; Rich 1878; SCH 1879).

The number of citrus trees offers a quantitative proxy for the radical social and ecological change that came to the valleys of Southern California. In 1870, there were less than 35,000 citrus trees in the entire state of California, with only 8,000 of them in Los Angeles (LA) (CSAS 1872). By the mid-1880s, there were more than 500,000 citrus trees on 13,000 acres in LA County alone. By 1900, there were over 3 million citrus trees of only a few varieties bearing fruit across Southern California, with millions more coming into production over the next decade (see Fig. 2) (Spalding 1885; Coit 1915; Webber and Batchelor 1943; Sackman 2005). The winter ripening Navel orange, that emigrated from Brazil via Washington DC in 1873, dominated the arid inland "citrus belt" that ran along the eastbound line of the Southern Pacific from Pasadena to Riverside. The summer ripening Valencia orange, imported from the Azores in 1876, was grown in the coastal valleys from San Diego to Santa Barbara, and the ever-bearing Eureka lemon, originating in Los Angeles from Italian seed stock in the late 1850s, was grown in both regions.

In 1841, William Wolfskill planted the first commercial orange grove in Los Angeles, at what is now the corner of 4th and Alameda (Spalding 1885; Coit 1915). Securing trees from the San Gabriel Mission, he planted two acres of oranges. William Wolfskill, a trapper who arrived in Los Angeles from Kentucky after a brief detour into Mexico, was a founding member of the city of Los Angeles and perhaps California's first agro-capitalist (DAC 1858; LAH 1882; Barrows 1902; Wilson 1965). On his extensive lands, which he had received from the Mexican government in 1836 (hence the detour), he planted vineyards and fruit trees, made wine, and grazed sheep (Wolkskill 1836; DAC 1852). He even planted a banana grove.

By the 1850s, with the help of his neighbor, Jean-Louis Vignes—also known as the father of California Wine and the first to import French varieties into California—William Wolfskill and other growers had turned the fertile lands near the Los Angeles River into a major wine producing region (DAC 1863). By the mid-1850s, he had over 40,000 grape vines in production, and cuttings from his "celebrated vineyards" were sold across California (SDU 1851; DAC 1854). In 1870, these floodplain vineyards produced almost 20 % of the wine made in the United States (Carosso 1976; Wilson 1957). Thus, it was not preordained that citrus would come to dominate the agricultural production of Southern California.

By the mid-1850s, William Wolfskill had added more than two thousand more citrus trees to his Los Angeles groves, and by 1860, he had over 70 acres of citrus, mostly orange, but also lemon, lime, and citron. He also had extensive lands and plantings in the San Gabriel Valley and southern Los Angeles near what is now the city of Vernon. Upon his passing in 1866, his land—the richest agricultural property in Los Angeles County—was divided with most of it deeded to his two sons, Louis, and J.W. (DAC 1866; Wolfskill 1866; Solano 1871). Louis received his father's holdings in the San Gabriel valley and J.W. received his father's LA groves, as well as large swaths of land east of the LA River (Knox 1886; Hansen and Solano 1888). J.W. would take up where his father left off, expanding and intensifying citrus production, as well as becoming the first local producer of cut flowers (PRP 1872). In the early 1870s, in conjunction with a grape disease outbreak (*phylloxera*), J.W. turned away from grapes, razing his vineyards and planting more citrus (SDU 1874). Lewis turned his attention toward the railroads, the development

[4] I use the term *life history* throughout the narrative for two reasons, one passive and one active. The first is that the term *life history* was used in the late 19th century to describe a particular type of economic entomological study. The study of an insect's life history—defined in this case as a descriptive analysis of the ecological physiology of an insect—was critical to determining what stages of an insect's life were most susceptible to economic poisons. For example, the egg stage of reproduction was often the least vulnerable to economic poisons. The second, active meaning of *life history* resonates from current evolutionary and ecological theory (Sterns 1976, 1992; Byrne 2011; Selman et al. 2012; Nik-Zainal et al. 2012). In this case *life history* describes the influence of eco-evolutionary selection on an organism's developmental/reproductive/senescent timing and duration to maximize fitness (defined as offspring survival). Thus, when I use the term, I use it in both senses, as way to describe the adaption of insects' ecological physiology—for example, their rate of reproduction or instar size—to new niches created by value-oriented agroecological change, and as a way to link the developmental stages of a insect's life (and the historical study of this) with industrially efficient death. Although I disagree with fitness described solely in terms of maximum offspring survival, I like the term *life history* because it captures the complexity of insect's physiology/behavior over dynamic ecological space and generational time and because it also can be used to view agricultural pests and pesticide resistance as effects of anthropogenic eco-evolutionary forcing (Levins 1968). In this way agricultural pests embody both object and subject, both passive non-agent and active agent, in dialectical tension over time and space (Levins and Lewontin 1985; Mitchell 2002; Odling-Smee et al. 2003; Lewontin and Levins 2007; Peck 2010; Kirksey and Helmrich 2010; Monosson 2015).

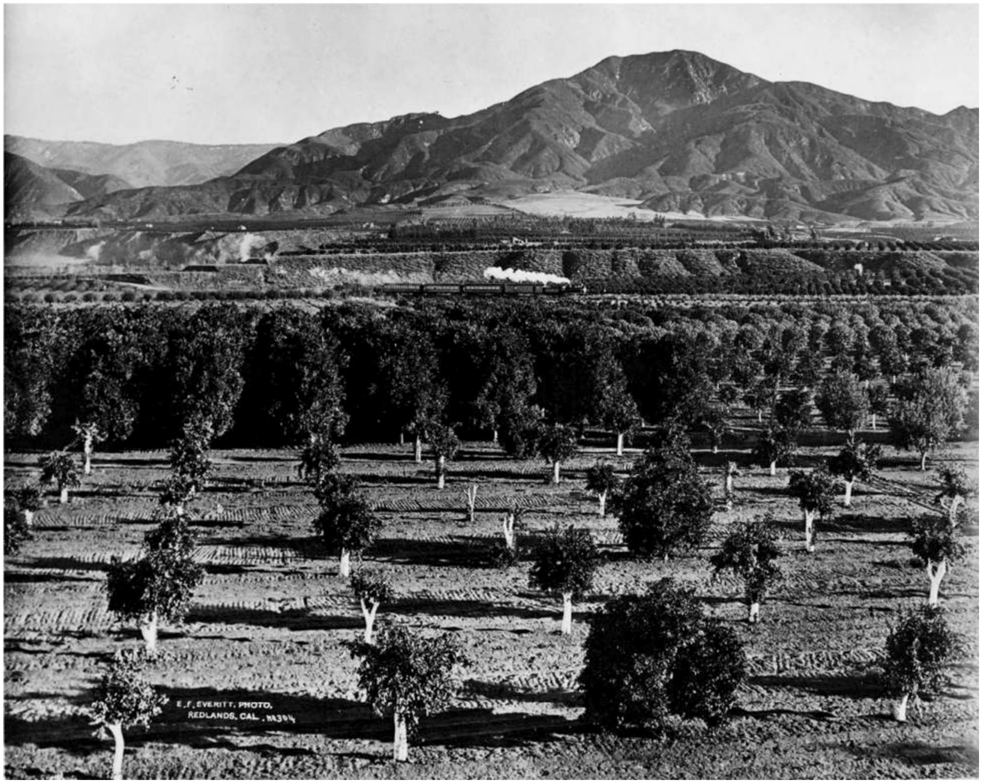

Fig. 2 Redlands orange groves, various ages, ca. 1880. Note the Southern Pacific Railroad in the background, *Courtesy of the University of Southern California, on behalf of USC libraries* (Everitt 1880)

of a cooperative warehouse and shipping association, and eventually politics (Wilson et al. 1874; LAH 1874).

In 1877, J.W. Wolfskill loaded a carload of his oranges onto a Southern Pacific train bound for St. Louis in what was the first commercial interstate export of oranges from Los Angeles (CF 1878; SDU 1880). By the early 1880s, J.W. Wolfskill's Los Angeles grove, a product of his father's initiative, his business acumen, and the sweat of countless laborers, bordered by Third street on the north and Sixth street on the south, Alameda on the east and San Pedro on the west, was the pinnacle of progressive agriculture (PRP 1877a, b; LAH 1878; Street 2004). The arrival of the Santa Fe railroad in 1885 and the subsequent decline in shipping costs that resulted from its competition with the Southern Pacific meant that by 1886, East Coast markets were becoming more lucrative (DAC 1885). On February 4, 1886 the first special train loaded only with citrus left Los Angeles bound for St. Louis.

Since the Wolfskill groves were the first commercial citrus groves planted in California, it is not a coincidence that by the mid-1880s they were some of the more heavily infested, "dirty," groves (PRP 1883). The intensive production of a single crop over a large geographic area was a historically novel set of socio-ecological environments for insects, both foreign and domestic, to colonize. Attracted by the irrigated, fertilized, and repetitious flesh of citrus, insects colonized these new ecological niches, integrating their life histories with the rapidly expanding industrial citrus biome.

The creation of intensive monocultural agriculture in the second half of the nineteenth century was increasingly complicated by insects and pathogens that rode piggyback on the rapid expansion of the transportation and communication networks developed throughout the first half of nineteenth century. Sometimes these introductions were intentional, sometimes not. The European gypsy moth, (*Lymantria dispar*), an insect that has caused untold damage to US agriculture and forestry since the mid-1870s, was imported into Boston in 1869 for the purpose of creating an American "silk" industry (Elkinton 2003). The white or cotton cushiony scale (*Icerya purchasi*) was inadvertently introduced into California from Australia on nursery stock that arrived at the port of San Francisco sometime in the late 1860s. It was first identified in Southern California in 1872, again, on infested nursery stock. By the late 1870s, white scale had spread throughout the established groves in Los Angeles (Coquillet 1888a). By 1884, white scale, along with red and black scale (also foreign invaders) was causing serious commercial damage to citrus in many Southern California locations.

In 1885, much of the orange crop failed “because of the ravages of insects” (Kercheval 1885). Even the Wolfskill groves—“the pride of Southern California”—were reduced to fields of stubs alive with insect pests (DAC 1885). Without any effective recourse, many growers burned their trees. Many others simply abandoned their groves. Growers, politicians, horticultural commissioners, and local businessmen foresaw a complete collapse of commercial citrus (Kercheval 1885, 1886; Coquillet 1886, b, c, 1891; LAH 1886).

In 1885, C.V. Riley, Chief Entomologist of the USDA Division of Entomology, after years of persistent grower appeal, finally recognized the magnitude of the citrus scale problem and deputized D. W. Coquillet, a trained entomologist and Southern California resident originally from Illinois to investigate the scale problem and to devise a solution (Henry 1889; Coquillet 1890, 1891). Asked about the pest situation by a Los Angeles Times reporter shortly after his appointment, Coquillet lamented, “Only a few years ago it was one of the boasts of California that we had no fruit pests–or scarcely any. They have been brought in, however, and the climate of this State seems to suit them as well as it suits other animate beings, for they have increased and multiplied at an alarming rate, and are now more destructive than in the East. By far the most dangerous to citrus fruit trees is the white cotton cushiony scale (*Icerya purchasi*)” (Coquillet 1888a).

For Coquillet, scale infestation was more than scientific problem to decipher (Coquillet 1887). It was foremost a commercial problem. In 1886, Coquillet approached perhaps the most progressive grower in Los Angles, J.W. Wolfskill, and his orchard manger, Alexander Craw, with the desire to couple their resources in the hopes of finding a solution to the plague that was descending on Southern California. Because the Wolfskill groves were the pinnacle of intensive horticulture (see Figs. 3, 4), yielding more than $1000 in profit per acre in the late 1880s, J.W. Wolfskill had both more to lose and more to gain than others if a solution could be worked out, and he had made the research and development of citrus pest control a commercial priority (DAC 1886; Essig 1931).

Two years earlier, growers declared war on the unwanted occupants of the rapidly expanding industrial citrus biome. Skirmishes with soaps and other sprays had flared between growers and citrus pests across Southern California since the late 1870, but in 1884, these battles escalated into full-fledged war (PRP 1883). Alexander Craw, manager of the Wolfskill orchards during the 1880s and 1890s recalled, “Previous to the year 1884, we had only black scale (*Lecanium oleae*) to contend with and only in the Wolfskill orange groves, and these were kept in check by application of whale-oil soap in the form of a spray; one application every two years was sufficient. In the fall of the year 1884 we found a few trees on the south side of the large grove infested with the Cottony Cushion-scale (*Icerya purchasi*). They became infested from an adjoining grove. We prepared for war…” (Craw quoted in Coquillet 1888b). Indeed they did.

Throughout late 1884 and 1885, they threw every weapon in their arsenal at the scale. In recalling the events of 1885, Alexander Craw wrote that no matter what they hurled at the scale, it “would not check this prolific

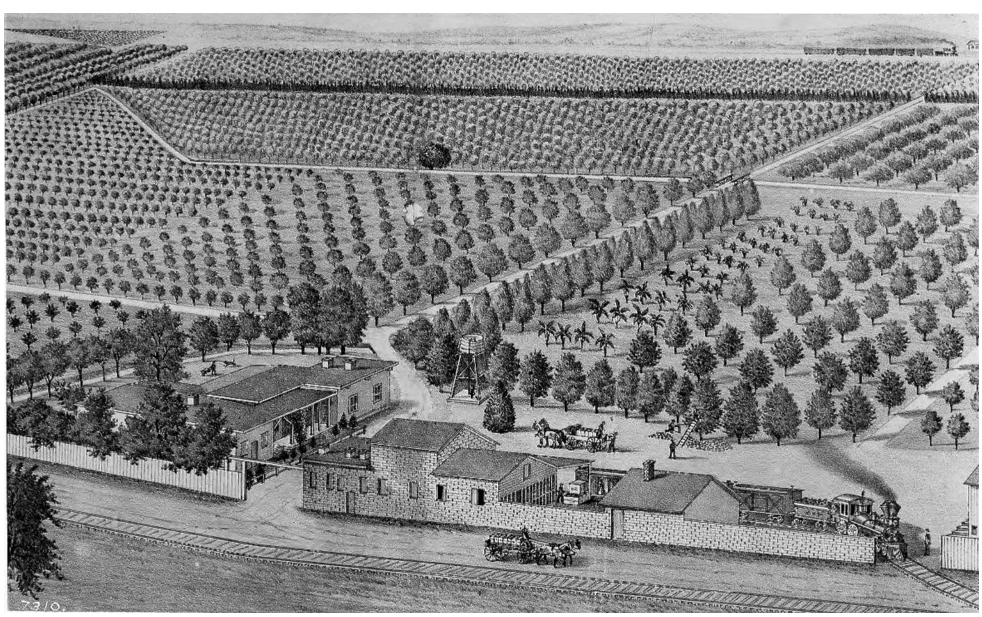

Fig. 3 Artistic representation of the Wolfskill Grove circa 1882. *Courtesy of the University of Southern California, on behalf of USC libraries* (CC Pierce & Co. 1882)

Fig. 4 The Wolfskill Orchard ca. 1885, *courtesy of the Bancroft Library at UC Berkeley* (Taber 1885)

creeping curse" (Craw quoted in Coquillet 1888b). The following year, the scale cottony front advanced across Los Angeles so that many trees were, as a horticultural commissioner in the Los Angeles Times put it, "literally white with the voracious and virile insects in all stages of development, every leaf, limb and twig being coated completely" (Kercheval 1888).

In the early summer of 1886, J.W. Wolfskill and Alexander Craw undertook what can be considered the most sophisticated scientific experiments to date for the chemical control of citrus pests (Coquillet 1887; Koebele 1887). The fact that they were using a canvas tent, bathed in linseed (flax) oil, to enclose a tree and introduce a gas produced in situ, was more than cutting edge. It was downright revolutionary. The first use of economic poisons, particularly the arsenical dusts, dates back two decades prior in the US, and examples of the previous experiments with greenhouse and tent fumigation can be found (Dimmock 1877). But none of these were done with the determination that came from expansive disquiet of California's late nineteenth century industrial landscapes (McWilliams 1935; Moses 1995; Stoll 1998; Henderson 1999; Igler 2000, 2001; Walker 2001, 2004; Sackman 2005).

Wolfskill and Craw first used stoves to raise the temperature inside a tented tree, but while this appeared effective against black scale, cotton cushiony scale, the Aussie emigrant, seemed to thrive on the heat. Then they tried steam, tobacco, sulfur, muriatic acid, chloroform, arsenic fumes, and carbon disulfide. The only promising experiment involved carbon disulfide, but this required fumigation with noneconomic concentrations of highly explosive carbon disulfide for at least three h.

By late summer, Dr. Coquillet of the USDA had joined their research. He was so impressed with the carbon disulfide fumigation results that he decided to lead the USDA mandated "crusade" on scale the following month in the Wolfskill groves (PRP 1887; Coquillet 1888b, c). Enlarging the scale of their "science in the orchard", Coquillet first tried a strong solution of whale-soap, but it was so strong that while it appeared to remove the scale, all the trees used in the experiment were defoliated (Hilgard 1895). Although the scales appeared to be wiped out, the treated trees were soon infested again. During September of 1886, Coquillet performed 163 experiments with soaps, sprays, and fumigants, including caustic soda, caustic potash, chloride of lime, chloroform, muriatic acid, methyl alcohol, whale-soap, sheep-dip, vinegar, Paris Green, and carbon disulfide. But when Coquillet his team removed the tent after the hydrogen cyanide experiment, they witnessed the selective annihilation that would become the biochemical future of industrial pest control (Coquillet 1888b, c).[5] For the first time in the

[5] Without knowing it, growers and scientists turned citrus' alternative oxidase (AOX) biochemical pathway, and scale insects lack thereof, into an agroindustrial exaptation. As streams of hydrogen cyanide gas evolved, under the tented tree the evolutionary characteristic developed over hundreds of millions of years that allows many plants to physiologically resist cyanide meant that plants would emerge from fumigation relatively unscathed while the insects succumbed. Over the next few years, growers unconsciously coopted an evolutionary characteristic of the citrus tree by industrially mimicking the tactical strategies of many higher plants, in turn, recasting the citrus AOX pathway with a capitalist hue and introducing biochemical selectivity as an active participant in the development of the industrial citrus empire (Solomos 1977; Gould and Vrba 1982; Way 1984; Siedow and Berthold 1986; Vanlerberghe and McIntosh 1997; Poulton 1990; Harborne 1993; Zagrobelny et al. 2004).

Wolfskill groves the chemical "mode of warfare" was "extended to trees and plants growing in the open air" (Coquillet 1888c). The machine in the garden now had offensive capabilities.

By combining water and potassium cyanide with sulfuric acid, the team liberated a buoyant, pungent, and lethal gas amongst the branches, leaves, and orange fruits. Under the portable gas chamber of oiled canvas, the hydrogen cyanide front advanced, "permeat[ing] the entire space between branches and leaves of a tree," chemically seeking out the scale (Coquillet 1888b). As the cyanide swirled around the interstitial spaces between the branches, leaves, and fruit, some of it found the innermost biology of the scale insects, where it bound irreversibly to the metal cofactors buried deep inside *Icerya purchasi's* cytochrome oxidase, internally suffocating them. Among intensively managed monocultural citrus trees on the western floodplain of the Los Angeles River, Coquillet, Wolfskill, and Craw created the first effective and economically efficient gas chamber.

Immediately recognizing cyanide's potential, they set out to remedy its only flaw, foliage injury. They found that by removing the water from the reaction, a pure stream of hydrogen cyanide could be produced, killing the scale "without even injuring a blossom" (Coquillet 1888b). After a bit of practice with the "dry technique" of cyanide gas fumigation, the team of Coquillet, Wolfskill, and Craw could kill black scale (*Lecanium oleae*), red scale (*Aspidiotus aurantii*), San Jose Scale (*Aspidiotus perniciosus*) and their eggs in 10 min, and cotton cushiony scale (*Icerya purchasi*) and its eggs in 30 min. Upon the realization that hydrocyanic acid was an effective economic poison, Wolfskill and Craw rapidly developed an apparatus for faster deployment of tents on tall trees (see Fig. 5).

Coquillet did not immediately publish his findings, which was partly due to the fact that, in late fall of 1886, after only a year of work, he was dropped from the USDA payroll due to funding problems. Coquillet's first publication came following his reinstatement with the USDA in July of 1887 (Coquilett 1888b). However, even without publication, rumors began to spread of Coquillet's success with the gas method (Woodworth and Messenger 1915; Coquillet 1891).

With no official reports published, A.B. Chapman and L.H. Titus, two prominent San Gabriel growers, who were desperately in need of a scale pest solution, became impatient at the appearance of slow progress. Impatience turned to imposition and they appealed to Eugene Hilgard, head of the UC Agricultural Experiment Station to send them a chemist, whose salary and expenses they would provide. In April of 1887, Hilgard sent the UC chemist F. W. Morse to San Gabriel to investigate and determine the efficacy of certain gases as economic poisons for control of citrus pests (Morse 1887a, b, c; PRP 1887).

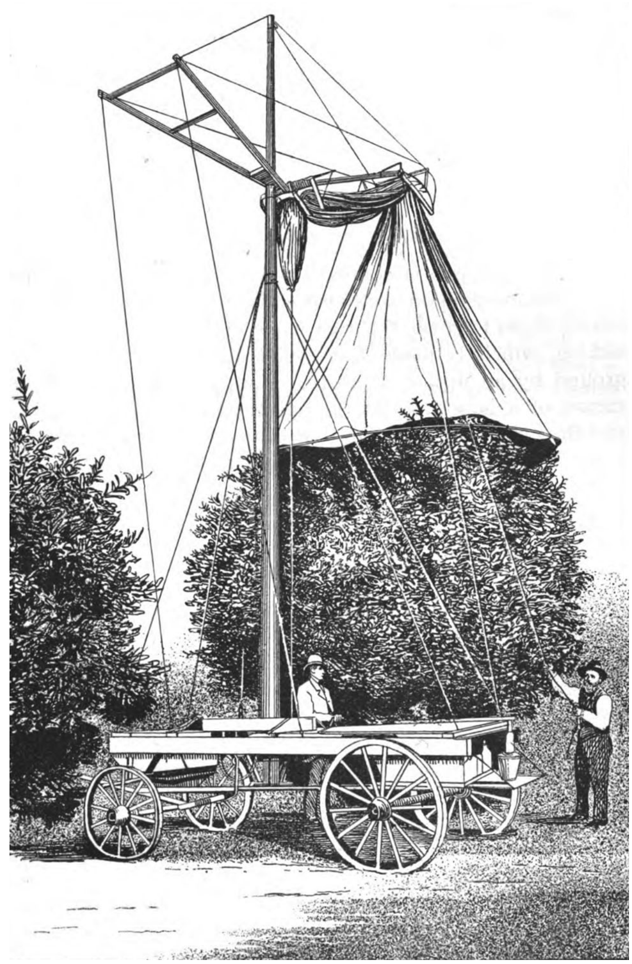

Fig. 5 The Wolkskill Fumigator (Wallace 1896)

By the end of April, Morse had also discovered the cyanide fumigation method in the San Gabriel groves of one of J. W. Wolfskill's main rivals (Morse 1887b, 1891). A witness at one of these trials said that it was the "best killing" they had ever seen (Chapman 1887). In June of 1887, one month before Coquillet, Morse published his findings (Morse 1887b). Morse followed his first publication with an attempt to patent the cyanide fumigation process, but many fruit growers as well as C. V. Riley, head of the USDA Division of Entomology opposed this. Morse never filed the patent (Essig 1931).

In spring of 1888, Coquillet observed that hydrocyanic acid treatment is coming into general use. Patents had been filed for fumigators and others began using fumigators of their own devising (Culver 1887). In a few short years, the cyanide fumigation process had been brought to such a perfection "that the application of the gas is safe, sure, and easy. The only drawback is the cost of the gas" (PRP 1888b). It wasn't just the cost of the gas, however, that limited fumigation's spread.

Impure potassium cyanide was also causing tree injury, some serious enough to question whether fumigation had any benefits. In 1886, potassium cyanide (KCN), while not a new chemical, was a not an industrially made chemical. Still derived from charcoal and slaughterhouse wastes and still made from the alchemical methods of Diesbach and Dippel, the composition of potassium cyanide and in mid 1880s was at best was 60 % pure KCN, and this was after purification (Bosqui 1904; Robine et al. 1906).[6] "Mining cyanide," which was first the first cyanide used by Coquillet and Morse, was only about 30 % pure KCN. During separate experiments in 1887, among rival grower's trees, Coquillet and Morse introduced various gases, such as carbon dioxide, into the tents along with the potassium cyanide and sulfuric acid to see if they would help prevent foliage damage (Morse 1887c, d, e). These protective measures all failed, but from their failure and the results from a chemical assay of the brands of potassium cyanide available in Los Angeles, both Coquillet and Morse concluded that the problem of foliage damage came from impurities in the cyanide. Protectant gases were unnecessary, only better quality cyanide was needed (DAC 1887; Coquillet 1890; 1891).

As cyanide fumigation shifted from scientific experiment to bonafide grower practice, three Los Angeles growers tried to profit from it spread by patenting the fumigation of citrus trees at night. In the fall of 1889, under the consultation of Coquilllet, still an agent of the USDA, amongst a grove of Valencia orange trees in the city of Orange, fumigation moved from a daytime activity to the graveyard shift. Growers, especially in Orange County, had noticed that every fumigation technique they tried produced poor results. (Unbeknownst to them, the humidity levels of the coastal valleys of Southern California created complications for potassium cyanide fumigation). But, W. Wall and A.D. Bishop found that with dark tents they could achieve a sufficient level of commercial control. These painted, oiled, denim tents were cumbersome and much more expensive than the oiled duck tents that other fumigators were using. "Then came the woman on the scene," C.W. Woodworth later recalled, "and Mrs. Bishop asked why, instead of going to the expense of making opaque tents, they did their work at night" (Woodworth and Messenger 1915). The practice of nighttime fumigation was born.

Less than 2 months later, on December 10th 1889, Ball, Bishop, and Jones, filed for a patent for the night process of citrus fumigation (Wall et al. 1891; LAH 1891). Though their patent was granted on January 27, 1891, no grower, county official, or government scientist, paid any heed to it. By the end of the 1891 fumigation season, daytime fumigators had metamorphed into nocturnal executioners, their deeds now hidden in the darkest shadows of the citrus scented killing fields.

Chemical control was not the only solution that growers sought. In 1888, after persistent grower appeal, C. V. Riley sent A. Koeble to Australia to look for parasites of the white cotton cushiony scale (Riley 1889; Doutt 1958). Koeble, a naturalized German immigrant and an "enthusiastic and comical bug hunter," was a USDA scientist first sent by Riley to Alameda, CA, in 1885 to investigate the life histories of California's insects (DAC 1890).

Two important discoveries came from Koeble's first trip to Australia, and these arrived as several packages from December to February of 1888–1889. In December of 1888, Coquillet received Koeble's first shipment of the fly *Cryptochaetum iceruae,* a parasite of the white cotton cushiony scale, discovered few years earlier in a garden in Adelaide, Southern Australia (PRP 1888b). Coquillet released this parasite under tented orange tree in Wolfskill's Los Angeles groves. The following month, after receiving another package, and again in the Wolfskill grove, Coquillet released the Vedalia beetle (*Rodolia cardinalis*) under another tented orange tree that was thickly covered with white scale. The discovery of the Vedalia beetle was pure coincidence and came from Koeble's perceptive eye. Sent to Adaleide to find a parasitic fly, Koeble found the now familiar beetle "feeding upon a large female Icerya" in a garden in Northern Adelaide (Koebele 1890).

By the end of 1889, the "blessed bugs," the 129 beetles sent in 4 shipments, had multiplied into the tens of millions by swarming from one infested orchard to another to feed their voracious appetite (Carr 1889; Dobbins 1889). The effectiveness that the dipterus parasite and the Vedalia beetle had in controlling cotton cushiony scale still stands as the one the hallmarks of biocontrol success in California (Caltagirone and Doutt 1989; Sawyer 1996). However, both the beetle, with its voracious appetite, and the parasitic fly, with its insidious work ethic, could not check the prolific creeping curse of red, brown, black, and purple scale that, by 1890, had launched a sinister counter attack.

[6] Sometime in late 1704, Diesbach, a renowned Prussian colorist, on a quest to make Florentine red, a lake pigment, stumbled upon a new blue color. On that fortuitous day, instead of the deep sheer red that Diesbach expected, he pulled the first "synthetic" pigment from his alchemical fire. Having previously run out of potash, he asked his friend, the infamous alchemist Dippel, for some of his leftover potash residues. Dippel's alkali, however, was contaminated with organic nitrogen compounds that were extracted from the animal blood he had been alchemically probing. Thus, Diesbach accidentally combined organic carbon and nitrogen distilled from animal blood with iron over red heat, synthesizing ferric ferrocyanide, a striking blue compound, naming it Prussian blue for his motherland. Like so many chemical discoveries that followed, Diesbach was a "happy victim of impure reagents." (Ball 2001, p. 242; Hoefer 1842; Clennell 1910) His blue was so true, so fast, and so striking that it continues to marvel us everyday. Prussian blue can further be oxidized into hydrogen cyanide (Prussic acid) and iron oxide.

With the discovery of cyanide fumigation, a suite of private fumigation companies quickly formed. Some tried to develop and sell new fumigating machines for practical use, some to organize outfits to fumigate groves, and others to provide the necessary chemical inputs and fumigation supplies. Fumigation equipment was very expensive and out of the reach of most growers, making fumigation prohibitably expensive. But by using fumigation outfits, growers were only liable for the cost of chemicals and the labor of the outfit, and not the large upfront capital outlay needed to buy fumigation equipment. Designs for fumigators and tent enclosures varied widely, but by 1890, most fumigation outfits had settled on generation of hydrocyanic gas using the dry pot method (no water) and the use of oiled No. 2 Duck (linseed oil and often the juice of the prickly pear cactus) tents rigged to a cumbersome system of pulleys (Lelong 1890; Woodworth 1899) (see Figs. 6, 7).

For the first three years of use, citrus fumigation was commercially haphazard and driven by the desire to rid citrus trees of the white cottony masses that collected on the branches of infested groves. By 1890, most scientists and growers working to perfect citrus fumigation had turned to trying to control red scale (LAT 1889). As the Vedelia "phalanx" advanced, white scale exponentially declined, and the red scale, an immigrant from Southern China and a pest first recognized more than decade earlier on citrus trees in Los Angeles, was taking its turn as the apex predator of the industrial citrus tree, exploding as a commercial pest across Southern California (Dobbins 1889; Coquillet 1890; LAT 1892). This pattern would repeat, and still repeats to this day. With the control of one pest, others would realign their life histories to fill the abruptly vacant niches that chemical toxicity continuously brought to the industrial citrus ecosystem. Control of the red scale menace was followed by black scale outbreak, the purple scale problem, the Argentine ant invasion, the yellow scale question, the red spider threat, and then red scale again, but now resistant to hydrogen cyanide gas (Bennet 1896; LAT 1902, 1906, 1912; Chapman 1909; Horton 1918; Boyce 1928; Gray and Kirkpatrick 1929; Woglum 1923, 1925; Essig 1909, 1931). And all this took place before the outbreak of WWI.

Between 1887 and 1893, fumigation practice expanded from Los Angeles to all of the satellite citrus growing regions—the counties of Riverside, Orange, San Diego, Santa Barbara, and San Bernardino—and to all varieties of citrus. As it spread, the three men that had patented the

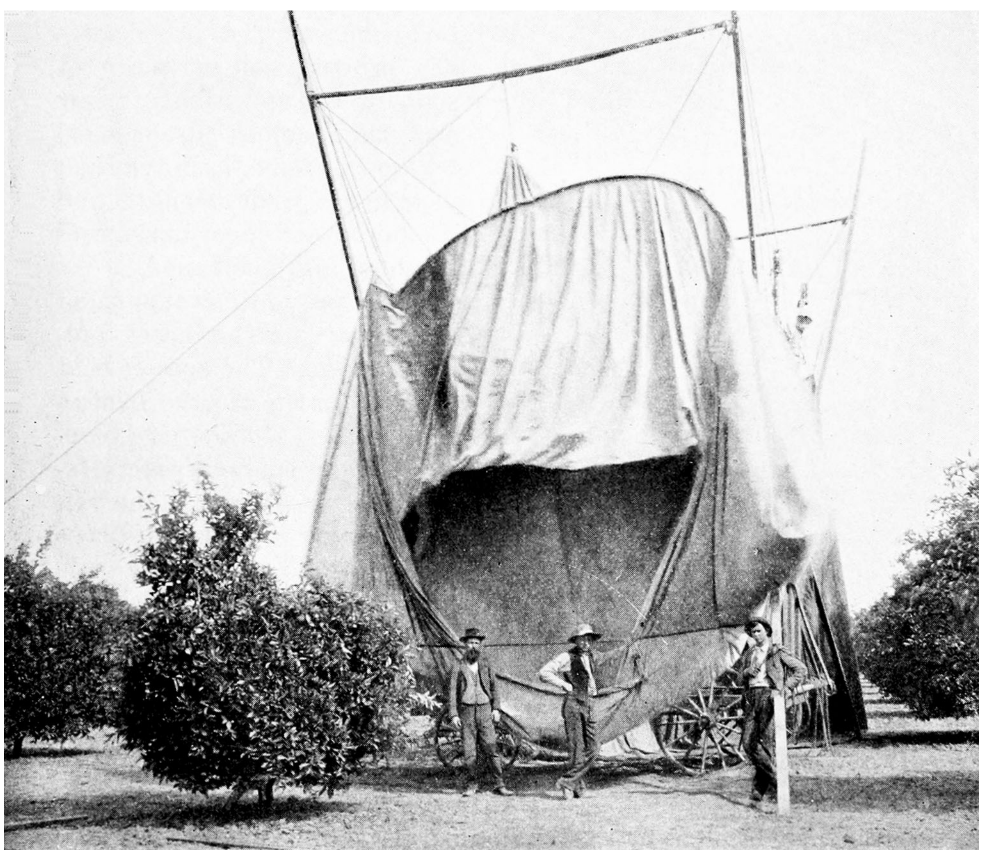

Fig. 6 Crew with fumigating derricks and tents, Chino Valley, ca. 1893, (Shinn 1893)

Fig. 7 Example of fumigation derricks and tents, ca. 1895, *Courtesy of the University of Southern California, on behalf of USC libraries* (Anonymous 1895)

nighttime fumigation process grew increasing frustrated with the fact that they had not received any royalties, nor profited in any way from the expansion of cyanide fumigation. In the late summer of 1893, Wall, Bishop, and Jones decided to test the validity of their patent by getting the police to arrest two growers who had recently fumigated (W.L. Adams and H.N. Kellum) and charge them with patent infringement. They sought to redress their lack of compensation by suing Adams and Kellum in Los Angeles circuit court, seeking license fees and any profit that resulted from using their invention (LAT 1893).

News of Adams' and Kellum's arrest spread rapidly throughout the citrus growing regions. If Wall and Jones were successful with their lawsuit, the rapid expansion of fumigation would slow, and perhaps stop in many areas. It would also open up the possibility of taking the citrus growing counties to court, seeking compensation for use of the nighttime process. Because of the high initial cost of fumigation equipment, counties would often front the cost for the equipment and then rent it out to the growers in their district at nominal cost (Shinn 1893; Bennet 1896; Wallace 1896). It was in the county's best interest to maintain groves free of infestation, and thus they made sure that as many growers had access to fumigation as wanted it.

On Tuesday, the 15th of October 1893, the District Attorney (DA) of Los Angeles County called together an emergency meeting in San Bernardino to address the fumigation situation and devise an organized approach (LAT 1893). Present at the meeting were the DAs of all of the citrus growing regions, as well as legal advisors and some prominent growers. The legal position that emerged from discussions was that the fumigation process was public property and thus non-patentable. The District Attorney of Los Angeles took this same legal position in court, arguing that the process was general knowledge.

Then the DA pulled out the big guns and called Coquillet to the stand. Coquillet not only explained how he was the first to discover cyanide fumigation, but he also brought plenty of evidence to prove that the plaintiff's lawsuit was entirely erroneous. Two items in particular in were quite damming (LAT 1894). The first was that Coquillet had the paperwork to prove that Bishop, who was listed on the patent but not on the lawsuit, participated in some of the first fumigation experiments in the fall of 1886 at the Wolfskill grove. On the 26th of September, 1886, Bishop was part of fumigation team when Coquillet, Wolfskill, and Craw fumigated seven lemon trees at night to much success.

On April 9, 1894, Judge E.M. Ross of the Federal Court of Southern California invalidated the patent on the night process. The basis for his decision was twofold: (1) doing something at night does not make it novel and (2) the original discovery was made by the USDA and the Patent Office's interpretation of the Hatch Act provisions made sure the discoveries of the USDA and the state agricultural experiment stations remained public property (Coquilett 1894; LAT 1894).

Between 1895 and the early 1900s, millions of citrus trees across Southern California were in production, millions more reached commercial age, and millions of others were just planted. Every tree planted was another tree to be infested; scale infestation became the multicolored silhouette draped on the contours of citrus expansion. Every year that the industrial citrus ecosystem matured, every year that it spread across Southern California's valleys, the infection became more systemic, and the demand for fumigation grew with it. By the late 1890s, county fumigation outfits of the early 1890s gave way to outfits organized by cooperative associations. This change magnified the expansion of fumigation through multiple means, but the most basic reason was a decrease in the cost of fumigation per tree by tapping into the agroeconomies of scale that resulted from the formation of citrus cooperatives. By buying chemical inputs in large lots, especially potassium cyanide, the unit price of cyanide fumigation per tree rapidly fell. And by coordinating fumigation labor, cooperatives were able to streamline fumigation practices, fumigating more trees per person-hour. Taken together, cooperatives were often able to cut the cost of fumigation per tree in half (PRP 1898; SFC 1902).

In 1896, the Covina association of the Southern California Fruit Exchange was the first branch to undertake the general fumigation of all its "stockholders through the cooperative plan" (LAT 1896b, c). However, recognizing the need to inaugurate a "general crusade" against red and black scale, which was causing increased damage, they also offered their services to non-exchange members in the hope of cleansing as much of the district as possible. Leaving pockets of uncleansed groves meant cooperative groves would be more easily reinfested. With its high costs and selective labor requirements, not everyone was convinced of fumigation's promise and many growers turned to sprays as their weapon of choice in the assault against scale in their groves.

In the first two decades of chemical control in California there were no state or federal statues regulating anything about economic poisons—production, composition, use, waste—which meant there were as many brands of citrus treatments for sale as there were brands of citrus. These concoctions contained plants extracts, coal-tar extracts, soaps, acids, caustic sodas, and arsenicals, but the only group of possible poisons that showed any promise were the various distillate fractions of crude oil that were available in increasing amounts from Southern California refineries as byproducts of kerosene and gasoline production (Woodworth 1912; Gray 1914, 1918a, b). These crude distillates were emulsified in water with soap, glue, blood, or another binder, and sprayed under pressure onto trees, in the hope that they would coat the tree with a deadly film (Cooper 1905). Reflecting the state of crude oil refining at the time, these sprays, while physically similar, often differed in chemical composition from batch to batch (Vickery 1920; Gray and deOng 1926; deOng 1928; Essig 1931; Ellis 1934; Williamson et al. 1963). This meant that repeated spraying with the same brand could bring widely varying results, including damaging groves to point of killing all the trees. Other growers tried resin washes and arsenic based sprays, which although much cheaper than fumigation, they did not provide the disinfection power needed and damaged foliage and fruit. Responding to a promoter of distillate spays, one fumigation operator quipped that the "answer to all this is seen in the endless array of fumigation tents now in operation in the orchards of Southern California." These tents "make no mistake in summing up the impotency of all other methods" (LAT 1900a).

What began to convince growers of the value of clean orchards, more than the site of tents extending to the horizon, was the higher price that growers received for their fumigated fruit. No one wanted to have to fumigate, "few citrus growers look[ed] with favor upon any tree wash or spray" (Jeffreys 1900). Economic poisons were not only highly toxic, they were also very expensive and labor intensive to apply. However, after 1886, as the final destination of Southern California's citrus moved east progressive growers began to rethink the way they envisioned loss from pests. Wholesale sellers began looking for citrus with the best carrying quality, that is, citrus that that would arrive unspoiled, in prime eating condition, a week or more later in cities across the Midwest and East Coast (see Fig. 8).

Throughout the 1890s, oranges from groves where fumigation wasn't practiced often had to be washed to make them sellable to eastern markets. The honeydew excrement of scale insects that rained down from the encrusted branches above led to "black smut," a sooty mold, on the fruit. Consumers could be picky and any blemishes on the skin of the fruit would ruin the consumer's increasingly constructed conception of the orange as a condensed nugget of California's healing sunshine.

Since eastern buyers did not want fruit with black smut, cooperatives and their branches organized washing houses as end-of-pipe solutions to dirty fruit. The presence of smut and the rudimentary practices and technology of early

Fig. 8 Packinghouse of the Covina Citrus Association ca. 1900, Covina, CA, *Courtesy of the University of Southern California, on behalf of USC libraries* (Anonymous 1900b)

washing houses (which spread decay causing organisms), would decrease the carrying quality of citrus by inducing the rapid onset of decay (Powell 1905, 1908). This fruit had to be sold and shipped east immediately (Coit 1915). Sellers had to take the first offer; they could not wait for another. When fumigation was done effectively, the fruit harvested on the cleaned trees usually did not have to be scrubbed and was of prime quality for shipping east. Now blessed with first-rate produce not prone to decay, wholesalers had the upper hand; they could sit on the boxes until their price was met. By the turn of the century, as scale pests became generalized throughout Southern California the difference between a carload of prime shipping citrus and one that lacked any carrying quality was the difference between fumigated and non-fumigated fruit (Jeffreys 1900; Webber and Batchelor 1943; Reuther et al. 1989).

A Popular Science Monthly writer summed the new agricultural market conditions the best. “How goes the fight?” he asked rhetorically. “The statistics of the fruit industry answer this question. The cost of destroying insect pests has become a permanent item of expense, the results of which are increased profits. Care and management of orchards now include preparation of the soil; selection of varieties adapted to the place; planting and culture of the trees; pruning, according to different systems for different species and localities; the use of special fertilizers, and the destruction of noxious insect life” (Shinn 1893). As citrus markets moved east, industrial pest control, “active warfare,” became a necessary industrial input.[7]

[7] By this time cyanide fumigation had also become a common industry practice of west coast nurseries and quarantine operations. In 1894, L.O. Howard, recently appointed Chief of the USDA Bureau of Entomology, introduced cyanide fumigation to East Coast nurserymen in a USDA Circular and by 1896 it was in limited but general use in the nursery trade across the US (Howard 1894; Howard and Marlatt 1896; Howard 1899). By 1900, there was network of specialized buildings across the US constructed for the sole purpose of fumigating nursery stock, creating a nodal and agglomerative geography of agroindustrial gas chambers. Cyanide fumigation was also introduced to other commercial orange growing regions in the 1890s. For example, C. V. Riley, former Chief of the Bureau of Entomology introduced it to Montserrat, British West Indies in 1894 and word of its success reached Capetown, South Africa, about the same time (Pugsley 1897; Tyrrell 1999). Although UC Agriculture Extension and the USDA would eventually help the practice spread to citrus growing regions around the world (Quayle 1910), early extension of the practice into other citrus growing regions was met with commercial failure, likely due in part to the lack of intensive and economically efficient (cooperative) organizational structure of Southern California’s industry and the lack of government subsidy that first brought cyanide fumigation within reach of the average grower. R. S. Woglum of the USDA introduced Florida citrus to California’s fumigation techniques in 1905 (Essig 1931).

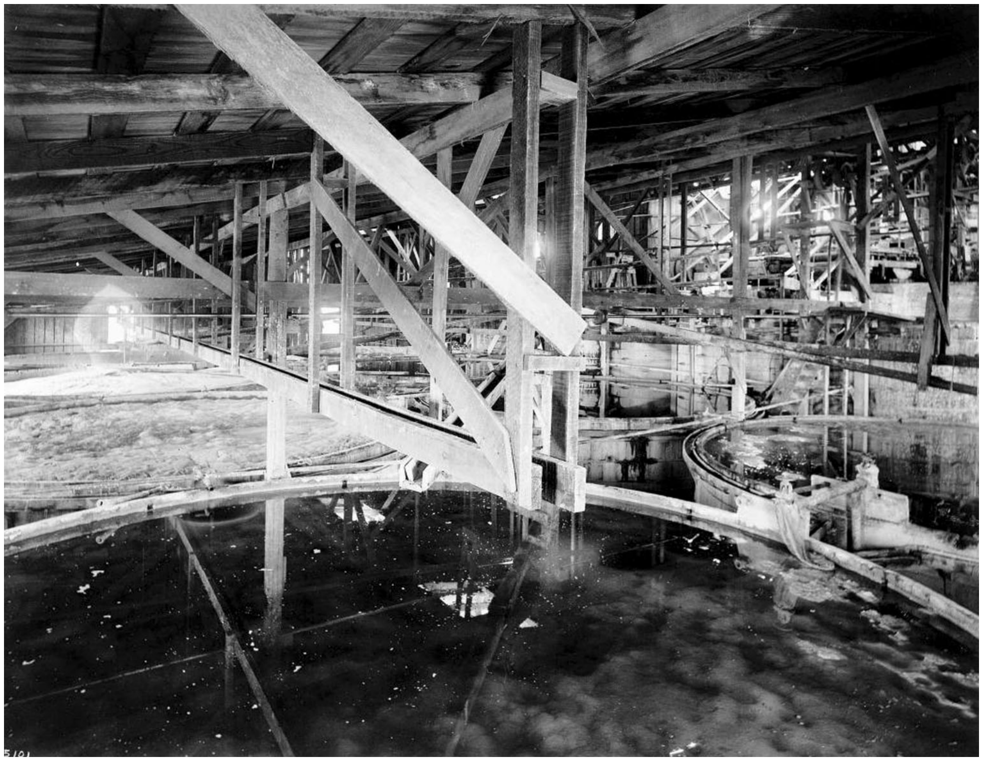

Fig. 9 Cyanide tanks, Karma Mining Company, Mojave mining district, Kern County, ca. 1900, *Courtesy of the University of Southern California, on behalf of USC libraries* (Anonymous 1900c)

As growers converted more and more sunshine, water, and capital, into more and more citrus fruit for Eastern markets, more and more cyanide was needed to cleanse the industrial citrus tree of its insect enemies. From box to wagon to train load, with each harvest season that passed, the agricultural demand for potassium cyanide grew (SFC 1903; Woglum 1923; Woodworth 1912). However, synthetic cyanide didn't arrive in Southern California as a pesticide.

It was cyanide's ability to separate gold from ore, eventually perfected by the MacArthur and the Forest Brothers in Scotland in 1887, that first brought cyanide to the mineral rich west (Scheidel 1894; MacArthur 1905). With cyanide, miners could unlock the refractory gold bearing quartz ores that remained once the thin layer of placer gold was scraped off in the mad dash gold rushes of the 1850s, 1860s, and early 1870s (NYT 1896; Economist 1921). The subsequent boom in industrial cyanide production in Scotland, Germany, and New Jersey to meet the mining demand in Southern Africa, Australia, and the US, was critical in making potassium cyanide available—geographically, economically, compositionally—for a rapidly industrializing citrus industry (YAM 1900; Braun 1915; Wolf 1985; Loughheed 2001).

With the introduction of synthetic chemicals into mining, the potential of California's mining landscapes were recast with the pungent hue of potassium cyanide. Suddenly ores once considered low-quality or waste became profitably exploitable resources (Young and Smith 1891; Preston 1895; Packard 1897; LAT 1899; Economist 1911). In the late 1880s, miners armed with industrial cyanide, made from the blood of Europe's abattoirs, ventured deep underground into pyritic and sulphureted quartzes, in turn not only shifting the geography of gold mining across the world, but also revolutionizing the industrial art of winning gold from the earth (Munroe 1905; Mudder and Botz 2004) (see Fig. 9).

In California, the geography of gold mining shifted south and the desert mines Southern California began to complete with the once glorious mother lode for the title of biggest gold producing region (LAT 1900b; Dittmar 1899; Dunbar 1902). This shift to industrial chemical extraction across the world brought with it demand for industrially made chemicals and new industries arose to produce and provide these chemicals to the mining industry (Robine et al. 1906; Wolf 1985; Loughheed 2001).

The resurgence of California mining in late 1880s and early 1890s and the influx potassium cyanide into Southern California for mining coincided with an uncontrollable pest outbreak among the commercial citrus groves of Los Angeles (SFC 1895; NYT 1896; Hobart 1898; Wynn 1963). Thus, as industrial mining moved on from its mechanical birth, amalgamating itself to the chemicalized nature of the second industrial revolution, it helped agriculture make the leap as well by providing the toxic material that allowed for the intensification of citrus production in the face of pest outbreak. In the late 1880s, only a few years removed from the antagonist relationship of agricultural and hydraulic mining capital that raged in the courthouses of Sacramento—resulting in ban on hydraulic mining in the Sierra foothills—a chemo-economic synergism fulminated between the desert mines of Southern California and the groves of the Los Angeles Basin (YAM 1900; Braun 1915). Mining and citrus, two industries faced with crisis—one geological, one ecological—both subsumed cyanide's materiality into an industrial logic, whereby cyanidation became the chemical practice around which the two industries developed. In other words, in the late 1880s, industrial cyanide became the critical material—the chemical fix—that allowed for the intensification of both gold mining and citrus.

Chemical companies, however, would not consider agricultural use a serious commercial outlet until after the turn of the century. Thus, it was mining that brought potassium cyanide to the chemical markets of Southern California. It was demand from the global mining industry that spurred competition among cyanide manufactures, leading to increased purity and lower prices (Robine et al. 1906; Loughheed 2001). It was only with the general shift to hard rock mining in the late 1880s and early 1890s that Southern California's uniformly-beautiful-sun-kissed-citrus became possible.

The first potassium cyanide used in the mines and groves of Southern California was made in small batches in crude laboratories across Europe, making its way in small amounts to cities like New York and San Francisco via the German company DEGUSSA, the sales agent for most of the cyanide produced in the world before the discovery of its use for mining (Wolf 1985). This cyanide would then be distributed and sold through various middlemen, chemical wholesalers, and pharmacists across the United States. Before 1887, emergent electroplating and photography industries consumed most of the crude cyanide imported into the US (Clennell 1910).

Following the discovery of the MacArthur-Forest process, the global cyanide industry rapidly reconfigured to meet the explosive demand for potassium cyanide by mining. By the mid-1890s, almost all the potassium cyanide industrially consumed in the US was made in New Jersey. At their plant in Perth Amboy, the Roesslacher & Hasslacher Chemical Company (R&H), a partial subsidiary of DEGUSSA, manufactured 98 % pure potassium cyanide and other chemical products for the American market (Robine et al. 1906; Braun 1915; DuPont 1930; Anonymous 1929). And although it was not R&H cyanide that Coquillet introduced into the experimental fumigation tents in the fall of 1886, it was R&H cyanide that was pumped under tent-enclosed citrus trees millions of times over by the turn of the century. It was R&H cyanide that made its way by the ton to the deserts east of Los Angeles, where it provided the chemical power to unlock refractory ores, and to the valleys of Southern California, where it provided power to disinfect the industrial citrus tree. It was R&H cyanide that provided the selective power needed for both the separation of gold from base metals and the industrial control of citrus pests.[8]

At the close of the twentieth century, the cost of cyanide had fallen by half since fumigation began in 1886 (Woodworth 1899; SFC 1902). As the costs of fumigation plummeted, as the demand of distant markets grew, grower-capitalists continued to unfurl the industrial citrus ecosystem upon the valleys of the promised land. In the process cyanide fumigation crossed an agroindustrial threshold and became a critical yet ordinary input of industrial citriculture (Shinn 1893). These new agricultural practices signaled a state change in world-ecology, one in which toxic chemicals became necessary for the industrial agriculture. In overriding an agro-ecological contradiction of capitalist agriculture, growers, scientists, and government officials amalgamated industrially organized agriculture to an accelerating and endless war. In "service to the gods of production and production," industrial agriculture irreversibly bound itself to an endless reliance on ever-newer toxic chemicals (Carson 1962).

By 1900, the Faustian bargain that allowed industrial citrus to flourish in the face of ecological crisis was more than a decade removed and rapidly spreading (see Fig. 10 and footnote 8). A Los Angeles Times reporter, after spending a week shadowing fumigation crews summed it up best. "Perhaps never in the history of the world" he said, "have there been so many specimens of animal life slaughtered by artificial means as are now succumbing to the cyanide process. As the shades of night fall upon the orange groves, one hundred, five hundred large sheets of canvas enshroud the trees, and when they are drawn away death has claimed every living thing within them ..." (LAT 1900a). Industrial death, "active warfare," saved an industry from collapse and made possible the industrial production of commercial quality citrus fruit. Chemical

[8] Cyanide extraction tanks also contributed to the mass death of birds, fish, and insects via tank effluent disposed in water bodies or by birds and insects drinking from or landing on the tanks (cf. Donato et al. 2007). "Birds and insects by the millions have been killed by drinking from the cyanide tanks. At first contact they fall dead" (LAT 1896a). "Another place [for birding in the desert], and a most deadly trap it proved judging from the dead birds floating on its surface, was the cyanide tanks… Birds that essayed to quench their thirst at this fount toppled over dead in an instant" (Daggett 1902).

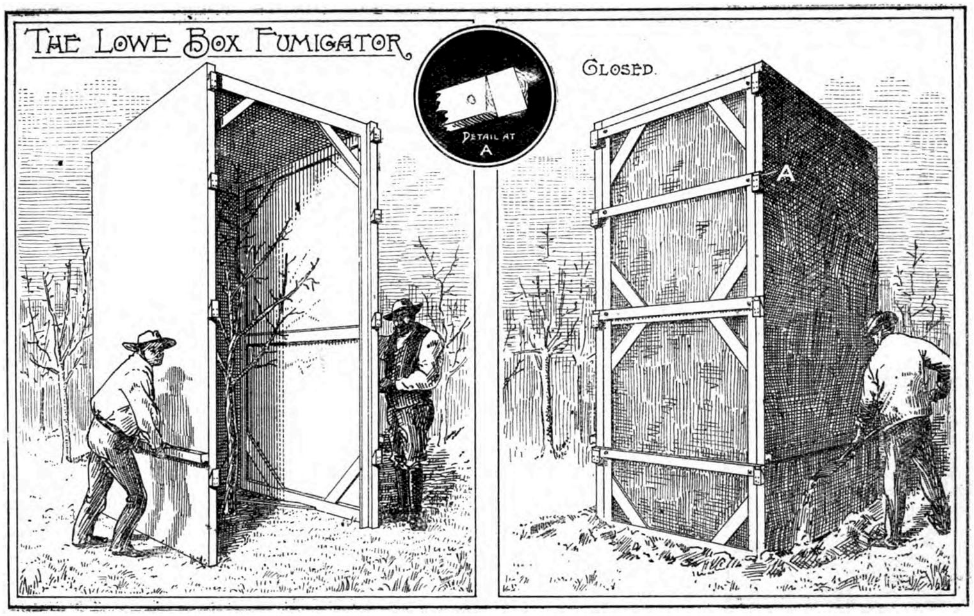

Fig. 10 A box cyanide fumigating method for deciduous fruit trees developed in Cape Town, South Africa, ca. 1900 (Lounsbury 1902)

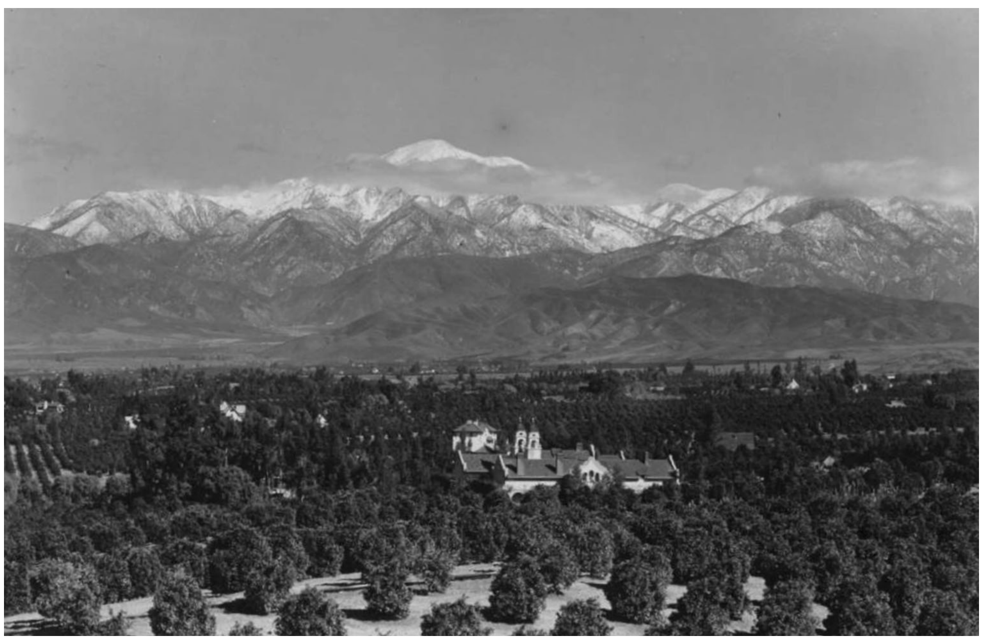

Fig. 11 Redlands in winter looking north toward the San Gabriel Mountains, ca. 1900, *Courtesy of the University of Southern California, on behalf of USC libraries* (Anonymous 1900a)

warfare became the battlefield practice that enabled the full-fledged industrialization of citrus groves on the western shores of the capitalist world (Woodworth 1899; Woglum 1923; Essig 1931; Moses 1995).

The vast citrus empire that once occupied Southern California's valleys has receded from view (see Fig. 11. For younger generations, only street names and city festivals reveal its past glory. After WWII, the citrus industry packed its bags and moved to the artificially greener pastures of the Central and Imperial Valleys, ceding its once dominant claim over Southern California's golden sunshine to the colonists of tract houses, strip malls, and traffic jams. Although the industrial citrus biome has given way to the concrete oasis of today, the chemcalized nature of industrial agriculture that emerged among LA's trees still confronts us every day, no matter where we live, with every bite, with every breath. We are both participants and casualties of a totalizing chemical war, forever altering humanity's life history (Eskenazi et al. 2010; Guthman 2011; Vandenberg et al. 2012; Friedrich 2013; Monosson 2015).

For our food and our fiber we wage endless war. But "[w]ar… like the effect of a fog or moonshine," as Carl Von Clausewitz (1832) said, "gives to things exaggerated dimensions and an unnatural appearance." Thus, pesticide protagonists past and present, by appealing to our deep seeded fears of starvation and famine, exaggerate the need for toxic inputs by giving their historical use an unnatural appearance (ex. CLA 2014). Pesticides have never been necessary for the US to produce sufficient food as the mythology still suggests (Mullen 1933; Wallace 1933; Cochrane 1959, 1993, 2003; Cochrane and Ryan 1976; Perkins 1983). The story of cyanide fumigation, industrial agriculture's first chemical fix, and the historical record make this abundantly clear. Pesticides, however, have been critical to the production of other goods and services—goods and services critical not to the survival of the population but to the survival of a particular form of political economy (Romero forthcoming). All of this is not to say that there isn't a need for agriculture to manage pests but that these techniques should be "geared to realities, not to mythical situations, and the methods employed must be such that they do not destroy us along with the insects" (Carson 1962, p. 9). A fog of endless war has descended upon agriculture, and all life is caught in the crossfire. Not in our name.

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References

Abraham, G. 1940. Policeman's tear gas used for fumigating the garden. *New York Times*, D10.

Altieri, M.A. 1998. Ecological impacts of industrial agriculture and the possibilities for truly sustainable farming. *Monthly Review* 50: 60–71.

Altman R. 2014. On what we bury. *Interdisciplinary Studies in Literature and Environment* 21(1): 1–11.

Alyokhin, A., D. Mota-Sanchez, M. Baker, W. Synder, S. Menasha, M. Whalon, and W. Moarsi. 2014. The Red Queen in the potato field: Integrated pest management versus chemical dependency in Colorado potato beetle control. *Pest Management Science*. doi:10.1002/ps.3826.

Annand, P.N. 1944. The war and the future of entomology. *Journal of Economic Entomology* 37(1): 1–9.

Anonymous. 1895. Fumigating equipment, workers and children in a citrus orchard, ca. 1892–1910. In *California Historical Society Collection, 1860–1960, CHS-1376*. Los Angeles, CA: USC Digital Archive.

Anonymous. 1900a. Orange orchards during midwinter in Redlands, ca. 1900. In *California Historical Society Collection, 1860–1960, CHS-43108*. Los Angeles, CA: USC Digital Archive.

Anonymous. 1900b. Men and women working inside of an orange packing house, probably Covina, CA, ca.1900. In *California Historical Society Collection, 1860–1960, CHS-1348*. Los Angeles, CA: USC Digital Archive.

Anonymous. 1900c. View of cyanide tanks at a mining operation in the Mojave desert. ca. 1900. In *California Historical Society Collection, 1860–1960, CHS-5101*. Los Angeles, CA: USC Digital Archive.

Anonymous. 1929. History of American chemical industries: Roessler and Hasslacher—Partners. *Industrial and Engineering Chemistry* 21 (10):989–991.

AP. 2014. USDA boosts corn, soybean harvest to new records. *Associated Press*, 12 September. www.agweb.com/article/usda_boosts_corn_soybean_harvest_to_new_records_NAA_Associated_Press/. Accessed September 12, 2014.

Ball, P. 2001. *Bright earth: Art and the invention of color*. Chicago, IL: University of Chicago Press.

Barnosky, A.D., E.A. Hadly, J. Bascompte, E.L. Berlow, J.H. Brown, M. Fortelius, W. Getz, J. Harte, A. Hastings, and P. Marquet. 2012. Approaching a state shift in Earth's biosphere. *Nature* 486(7401): 52–58.

Barrows, H.D. 1902. William Wolfskill, the pioneer. *Annual Publication of the Historical Society of Southern California and of the Pioneers of Los Angeles County* 5(3): 287–294.

Beisner, B.E., D.T. Haydon, and K. Cuddington. 2003. Alternative stable states in ecology. *Frontiers in Ecology and the Environment* 1(7): 376–382.

Bennet, J.E. 1896. Black scale pest. Lively enemy of the California horticulturist. *Los Angeles Times*, March, 1.

Benton, T. 1989. Marxism and natural limits: An ecological critique and reconstruction. *New Left Review* 178: 51–86.

Borin, J. 1978. *The crime and punishment of I.G. Farben*. New York: The Free Press.

Bosqui, F.L. 1904. *Practical notes on the cyanide process*. New York: Engineering and Mining Journal.

Boyce, A.M. 1928. Studies on the resistance of certain insects to hydrocyanic acid. *Journal of Economic Entomology* 21(5): 715–720.

Bradman, A., B. Eskenazi, D. Barr, R. Bravo, R. Castorina, J. Chevrier, K. Kogut, M. Harnly, and T. McKone. 2005. Organophosphate urinary metabolite levels during pregnancy and after delivery in women living in an agricultural community. *Environmental Health Perspectives* 113(12): 1802.

Bradman, A., D. Whitaker, L. Quirós, R. Castorina, B. Henn, M. Nishioka, J. Morgan, D. Barr, M. Harnly, and J. Brisbin. 2007. Pesticides and their metabolites in the homes and urine of farmworker children living in the Salinas Valley, CA. *Journal of Exposure Science & Environmental Epidemiology* 17(4): 331–349.

Braun, F.W. 1915. The manufacture of sodium cyanide. *School of Fumigation*: Conducted by C. W. Woodworth, University of California, Pomona, CA.

Bristol, S. 1878. The oleander and orange scale-bug. *Southern California Horticulturist* 1(12): 374–375.

Brophy, L.P., W.D. Miles, and R.C. Cochrane. 2005. *Chemical warfare: From laboratory to field*. Honolulu, HI: University Press of the Pacific.

Browne, C.A. 1922. Early references pertaining to chemical warfare. *The Journal of Industrial and Engineering Chemistry* 14(7): 646.

Byrne, M. 2011. Impact of ocean warming and ocean acidification on marine invertebrate life history stages: Vulnerabilities and potential for persistence in a changing ocean. In *Oceanography and Marine Biology: An Annual Review*, ed. R. Gibson, R. Atkinson, J. Gordon, I. Smith and D. Hughes, 1–42. New York: Taylor & Francis.

Caltagirone, L., and R.L. Doutt. 1989. The history of the Vedalia beetle importation to California and its impact on the development of biological control. *Annual Review of Entomology* 34: 1–16.

Carosso, V.P. 1976. *The California wine industry, 1830–1895: A study of the formative years*. Berkeley, CA: University of California Press.

Carr, J.C. 1889. The blessed bugs. *The Pacific Rural Press*, May 18.

Carson, R. 1962. *Silent spring*. Boston: Houghton Mifflin.

Carson, R. 1998. Women's national press club speech. In *Lost Woods: The discovered writing of Rachel Carson*, ed. L. Lear. Boston, MA: Beacon Press.

Ceccatti, J.S. 2009. Natural selection in the field: Insecticide resistance, economic entomology, and the evolutionary synthesis, 1914–1951. *Transactions of the American Philosophical Society* 99(1): 199–217.

Cecil, P.F. 1986. *Herbicidal warfare: The ranch hand project in Vietnam*. New York: Praeger Publishers.

CF (California Farmer). 1878. Orange Culture. *California Farmer and Journal of Useful Sciences*, September 5.

Chapman, A.C. 1887. Letter to the editor. *Pacific Rural Press*, June 18, 539.

Chapman, C.C. 1909. The purple scale in Fullerton. *Claremont Pomological Club Proceedings*, March 22, 4–5.

Chen, M., E. Ha, T. Wen, Y. Su, G. Lien, C. Chen, P. Chen, and W. Hsieh. 2012. Perfluorinated compounds in umbilical cord blood and adverse birth outcomes. *PLoS ONE* 7(8): e42474.

Christianson, S. 2010. *The last gasp: The rise and fall of the American gas chamber*. Berkeley: University of California Press.

CLA. 2014. About crop protection. *CropLife America*. http://www.croplifeamerica.org/crop-protection. Accessed April 20, 2014.

Clennell, J.E. 1910. *The cyanide handbook*. New York: McGraw-Hill Book Company.

CC Pierce & Co. 1882. Drawing depicting William Wolfskill's Pasadena orange and lemon grove and residence, between Alameda and San Pedro Streets, Los Angeles, ca. 1882. In *California Historical Society Collection, CHS-7310*. Los Angeles, CA: USC Digitial Archive.

Cochrane, W., and M.E. Ryan. 1976. *American farm policy: 1948–1973*. Minneapolis: University of Minnesota Press.

Cochrane, W. 1959. Farm technology, foreign surplus disposal and domestic supply control. *Journal of Farm Economics* 41(5): 885–889.

Cochrane, W. 1993. *The development of American agriculture*. Minneapolis, MN: University of Minnesota Press.

Cochrane, W. 2003. *The curse of agricultural abundance: A sustainable solution*. Lincoln, NE: University of Nebraska Press.

Coit, J.E. 1915. *Citrus fruits: An account of the citrus industry with special reference to California requirement and practices and similar conditions*. New York: The MacMillan Company.

Coleman, K. 2005. *A history of chemical warfare*. New York: Palgrave Macmillan.

Collotta, M., P. Bertazzi, and V. Bollati. 2013. Epigenetics and pesticides. *Toxicology* 307: 35–41.

Cook, T. 1999. *No place to run: The Canadian corps and gas warfare in the First World War*. Vancouver, BC: University of British Columbia Press.

Cooper, E. 1905. *Insects and insecticides*. Pamphlet. Sacramento, CA: California State Commission of Horticulture.

Coquilett, D.W. 1894. The patent on hydrocyanic acid gas process declared invalid. *Insect Life VII* 3: 257–258.

Coquillet, D.W. 1886. Farm and range: Cotton cushiony scale, experiments with remedies for their destruction. *Los Angeles Times*, July 18.

Coquillet, D.W. 1887. *US Department of Agriculture Report for 1886*. Washington, DC: USDA.

Coquillet, D.W. 1888a. Talks with citizens. *Los Angeles Times*, May 27.

Coquillet, D.W. 1888b. Insect killing by fumigation. An essay read at the Santa Barbara convention of fruit growers. *Pacific Rural Press*, May 5.

Coquillet, D.W. 1888c. Report on the gas treatment for scale insects. *Agriculture Yearbook for 1887*. Washington, DC: USDA.

Coquillet, D.W. 1890. Another foe of Icerya. *The Pacific Rural Press*, December 27.

Coquillet, D.W. 1891. Entomological: Origin of the gas treatment for scale insect. *Pacific Rural Press*, September 5.

Corcoran, J., M.J. Winter, and C. Tyler. 2010. Pharmaceuticals in the aquatic environment: A critical review of the evidence for health effects in fish. *Critical Reviews in Toxicology* 40(4): 287–304.

CSAS. 1872. Table of statistics. *Transactions of the California State Agricultural Society*. Sacramento: California State Agricultural Society.

Culver, J.P. 1887. Tree Cover and Fumigator. *United States Patent Office*. USA: Patent No. 367,134.

Cushing, E.C. 1957. *History of entomology in World War II*. Washington, DC: Smithsonian Institution, The Lord Baltimote Press.

DAC. 1852. San Joaquin news: Sheep. *Daily Alta California*, June 15.

DAC. 1854. Later from the south: Arrival of the southerner. *Daily Alta California*, September 5.

DAC. 1858. Wolfskill of Los Angeles and his vineyard. *Daily Alta California*, December 20.

DAC. 1863. California wine-growers association: Secretary's report. *Daily Alta California*, June 25.

DAC. 1866. Death of William Wolfskill. *Daily Alta California*, October 5.

DAC. 1885. Agricultural notes. *Daily Alta California*, February 28.

DAC. 1886. State notes. *Daily Alta California*, June 30, 1886.

DAC. 1887. Horticulture. The fumigation of trees without the use of carbonate of soda. *Daily Alta California*, December 9.

DAC. 1890. Chasing a beetle: Our foreign relations with the Icerya purchasi. An enthusiastic entomologist, surprising adventures of one of our state department diplomats in search of a bug. *Daily Alta California*, April 30.

Daggett, F.S. 1902. Winter observations on the Colorado desert. *The Condor* 4(2): 37–39.

Daniel, P. 2005. *Toxic drift: Pesticides and health in the Post-War South*. Baton Rouge: Louisiana State University Press.

deOng, E. 1928. Specifications for petroleum oils to be used on plants. *Journal of Economic Entomology* 21(5): 697–702.

Dimmock, G. 1877. The Effect of a Few Common Gases on Arthropods. *Psyche: A Journal of Entomology* 2(35–36): 19–22.

Dittmar, M.E. 1899. Southern California. In *California mines and minerals*, ed. E.H. Benjamin, 395–405. San Francisco: California Miner's Association.

Dobbins, J.R. 1889. Extracts from correspondence: The spread of the Australian Lady-bird. *Insect Life* II: 112.

Donato, D., O. Nichols, H. Possingham, M. Moore, P. Ricci, and B. Noller. 2007. A critical review of the effects of gold cyanide-bearing tailings solutions on wildlife. *Environment International* 33(7): 974–984.

Doutt, R.L. 1958. Vice, virtue, and vedalia. *Bulletin of the Entomological Society of America* 4(4): 119–123.

Dunbar, A.R. 1902. *Western mining directory embracing the principal operating mines, stamp mills, smelters, dredges, cyanide and chlorination plant in Arizona, California, Colorado, Idaho, Montana, Wyoming, British Columbia and Mexico*. Denver, CO: Western Mining Directory Company.

DuPont. 1930. Digest, R&H Chemical Company, subsidiaries and affiliates. In *Absorbed Companies*, edited by Records of E.I. du Pont de Nemours: Euleutherian Mills Historical Library, Hagley Museum.

Economist. 1911. The world's production of gold. *The Economist*, November 11.

Elkington, J.S. 2003. Gypsy moth. In *Encyclopedia of insects*, ed. V. Resh, and R. Cardé, 493–497. New York: Academic Press.

Ellis, C. 1934. *The chemistry of petroleum derivatives*, vol. 1. New York: The Chemical Catalog Company Inc.
Eskenazi, B., K. Huen, A. Marks, K.G. Harley, A. Bradman, D.B. Barr, and N. Holland. 2010. PON1 and neurodevelopment in children from the CHAMACOS study exposed to organophosphate pesticides in utero. *Environmental Health Perspectives* 118(12): 1775.
Essig, E.O. 1909. A general account of the purple scale (Lepidosaphes beckii). *Claremont Pomological Club Proceedings*, March 22, 5–10.
Essig, E.O. 1931. *A history of entomology*. New York: Hafner Publishing Company.
Evenson, R., and D. Gollin. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. *Science* 300(5620): 758–762.
Everitt, E.P. 1880. Orange grove, showing Southern Pacific passenger train moving in the background, ca. 1880. In *California Historical Society Collection, 1860–1960, CHS-43696*. Los Angeles, CA: USC Digital Archive.
Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C. S. Holling. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics* 557–581.
Foster, J.B., B. Clark, and R. York. 2011. *The ecological rift: Capitalism's war on the Earth*. New York: Monthly Review Press.
Fradkin, E.K. 1929. Chemical warfare—Its possibilities and probabilities. *International Conciliation* 248: 7–191.
Friedlander, H. 1995. *The origins of Nazi genocide: From euthanasia to the final solution*. Chapel Hill, NC: The University of North Carolina Press.
Friedrich, M. 2013. Endocrine-disrupting chemicals. *Journal of the American Medical Association* 309(15): 1578.
Fries, A.A. 1921. *Chemical warfare*. New York: McGraw-Hill Book Company Inc.
Fries, A.A. 1928. By-products of chemical warfare. *Industrial and Engineering Chemistry*, October 1079–1084.
Fu, P., and K. Kawamura. 2010. Ubiquity of bisphenol A in the atmosphere. *Environmental Pollution* 158(10): 3138–3143.
Goodman, D., B. Sorj, and J. Wilkinson. 1987. *From farming to biotechnology: A theory of agro-industrial development*. Oxford: Basil Blackwell.
Gould, S., and E.S. Vrba. 1982. Exaptation: A missing term in the science of form. *Paleobiology* 8(1): 4–15.
Grandjean, P., and P.J. Landrigan. 2014. Neurobehavioural effects of developmental toxicity. *The Lancet Neurology* 13(3): 330–338.
Gray, G.P., and E.R. deOng. 1926. California petroleum insecticides. *Industrial and Engineering Chemistry* 18(2): 175–180.
Gray, G.P. 1914. The workings of the California insecticide law. *The Journal of Industrial and Engineering Chemistry* 6(7): 590–594.
Gray, G.P. 1918a. Economic toxicology. *Science* 48(12): 329–332.
Gray, G.P. 1918b. The consumption and cost of economic poisons in California in 1916. *Industrial and Engineering Chemistry* 10(4): 301–302.
Gray, G.P., and A. Kirkpatrick. 1929. The resistance of black scale (*Saissetia Oleae* Bern.) to hydrocyanic acid fumigation. *Journal of Economic Entomology* 22(6): 893–897.
Guillette Jr, L., and T. Iguchi. 2012. Life in a contaminated world. *Science* 337(6102): 1614–1615.
Guinn, J.M. 1912. From cattle ranch to orange grove. *Annual Publication of the Historical Society of Southern California* 8(3): 145–157.
Guthman, J. 2011. *Weighing in: Obesity, food justice, and the limits of capitalism*. Berkeley, CA: University of California Press.
Haila, Y., and R. Levins. 1992. *Humanity and nature: Ecology, science, and society*. London: Pluto Press.
Haldane, J.B.S. 1925. *Callinicus: A defense of chemical warfare*. New York: E. P. Dutton & Company.
Hamblin, J. 2013. *Arming mother nature: The birth of catastrophic environmentalism*. Oxford: Oxford University Press.
Hansen and Solano Co. 1888. Moulton Crystal Springs property of J.W. Wolfskill on the east side of the Los Angeles River. In *Maps, #313637*. San Marino, CA: Huntington Digital Library.
Harborne, J.B. 1993. *Introduction to ecological biochemistry*. New York: Academic Press Limited.
Harris, R., and J. Paxman. 2002. *A higher form of killing: The secret history of chemical and biological warfare*. New York: Random House.
Henderson, G. 1999. *California and the fictions of capital*. Oxford: Oxford University Press.
Henry, W.A. 1889. Pacific coast work of the division of entomology. *Insect Life II* 5: 141–144.
Hilgard, E. 1895. Science in the orchard. *Riverside Daily Press*, April 16.
Hobart, F. 1898. Our mineral wealth. The progress of American mining—Its great extent and Promising Outlook. *New York Times*, Feb 21.
Hobbs, R.J., S. Arico, J. Aronson, J.S. Baron, P. Bridgewater, V.A. Cramer, P.R. Epstein, J.J. Ewel, C.A. Klink, and A.E. Lugo. 2006. Novel ecosystems: Theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* 15(1): 1–7.
Hoefer, F. 1842. *A history of chemistry*. Paris.
Holt, L. 1877. Orange tree diseases. *Southern California Horticulturist* 1(2): 61–62.
Holt, L.M. 1880. The red scale on citrus trees. *Pacific Rural Press*, January 31.
Holt, L.M. 1888. *The future of citrus culture in california*. Sacramento, CA: California State Board of Horticulture Report for 1888.
Horton, J.R. 1918. *Control of the Argentine Ant in orange groves*. Vol. 928, *Farmer's Bulletin*. Washington, DC: US Dept. of Agriculture.
Howard, L.O. 1894. An important enemy to fruit trees. The San Jose Scale (*Aspidiotus pernidosus*): Its appearance in the Eastern United States; Measures to be taken to prevent its spread and destroy it. *Circular, Second Series*. Washington, DC: USDA Division of Entomology.
Howard, L.O. 1899. Progress in economic entomology in the United States. *Yearbook of Department of Agriculture for 1899*. Washington, DC: USDA.
Howard, L.O. 1922. War against insects. *Nature* 109(2725): 79–80.
Howard, L.O., and C.L. Marlatt. 1896. The San José scale: Its occurrence in the United States with a full account of its life history and the remedies to be used against it. *Bulletin, New Series*. Washington, DC: USDA Division of Entomology.
Igler, D. 2000. The industrial far west: Region and nation in the late nineteenth century. *The Pacific Historical Review* 69(2): 159–192.
Igler, D. 2001. *Industrial cowboys: Miller & Lux and the transformation of the Far West, 1850–1920*. Berkeley, CA: University of California Press.
Jansen, M., A. Coors, R. Stoks, and L. Meester. 2011. Evolutionary ecotoxicology of pesticide resistance: A case study in daphnia. *Ecotoxicology* 20(3): 543–551.
Jeffreys, D. 2008. *Hell's cartels*. New York: Metropolitan Books.
Jeffreys, J.W. 1900. The land: Orchard, farm, garden, rancho and stockyard. *Los Angeles Times*, August 17.
Jenkins, D. 2002. *The final frontier: America, science, and terror*. New York: Verso.
Johnson, W.G. 1902. *Fumigation methods: A practical treatise for farmers, fruit growers, nurserymen, gardeners, florists, millers,*

grain dealers, transportation companies, colleges and experiment station workers, etc. New York: Orange Judd Company.
Kavka, G.S. 1983. Hobbes's war of all against all. *Ethics* 93(2): 291–310.
Kercheval, A.F. 1885. What shall we do about the scale? *Los Angeles Times*, March 22.
Kercheval, A.F. 1886. Shall the white scale go, or shall we? *Los Angeles Times*, July 11.
Kercheval, A.F. 1888. Letters to the times: Are the bugs sick? *Los Angeles Times*, October 4.
Khan, S., R. Mulvaney, T. Ellsworth, and W. Boast. 2007. The myth of nitrogen fertilization for soil carbon sequestration. *Journal of Environmental Quality* 36(6): 1821–1832.
Kirksey, S.E, and S, Helmreich. 2010. The emergence of multispecies ethnography. *Cultural Anthropology* 25(4): 545–576.
Knox, G.C. 1886. *Map of the Wolfskill orchard*. In Maps: Huntington Digital Library.
Koebele, A. 1887. *US Department of Agriculture Report for 1886*. Washington, DC: USDA.
Koebele, A. 1890. Report of a trip to Australia made under direction of the entomologist to investigate the natural enemies of the fluted scale. *Division of Entomology Bulletin 21*. Washington, DC: USDA.
Kokatnur, V. 1948. Chemical warfare in ancient India. *Journal of Chemical Education* 25(5): 268.
LAH. 1874. Railroad meeting. *Los Angeles Herald*, December 20.
LAH. 1878. Growing interest—The money in raising oranges. *Los Angeles Herald*, August 25.
LAH. 1882. History of the orange in Los Angeles. *Los Angeles Herald*, April 5.
LAH. 1886. The white scale: Some terribly infested orange groves. Where are the inspectors? *Los Angeles Herald*, June 12.
LAH. 1891. Patent twilight: The orange tree fumigator patent to be bought. *Los Angeles Herald*, May 30.
Lanier-Graham, S. 1993. *The ecology of war: Environmental impacts of weaponry and warfare*. New York: Walker.
LAT. 1889. Horticultural commission: What the Australian bugs doing for Southern California. *Los Angeles Times*, September 8.
LAT. 1892. The bug phalanx: The horticultural enemy moving close column by division. *Los Angeles Times*, August 13.
LAT. 1893. The night process. The gas treatment in the courts. *Los Angeles Times*, October 20.
LAT. 1894. The patent on the gas treatment declared void. *Pacific Rural Press*, April 28.
LAT. 1896a. Arizona news—Deadly cyanide of potassium. *Los Angeles Times*.
LAT. 1896b. Covina. *Los Angeles Times*, August 9.
LAT. 1896c. Covina. *Los Angeles Times*, August 23.
LAT. 1899. San Bernardino county. *Los Angeles Times*, January 1.
LAT. 1900a. The land: Orchard, farm, garden, rancho, and stockyard. *Los Angeles Times*, October 5.
LAT. 1900b. Industrial mining & citrus exhibit. *Los Angeles Times*, March 3, I.
LAT. 1902. Hunting for enemies of the red scale: Mischievous foe of oranges is hard to combat. *Los Angeles Times*, November 23.
LAT. 1906. Purple scale disappearing: Speaker at farmers' institute meeting gives encouraging address on tree fumigation. *Los Angeles Times*, September 20.
LAT. 1912. After the scale pest: Black and purple varieties especially guarded against by county horticulturist. *Los Angeles Times*, July 26, II.
LAT. 1916. Millions cost of pest war: Citrus growers prepare for fumigation season. *Los Angeles Times*, August 20.
Lelong, B.M. 1890. Improved fumigating apparatus. *Annual Report*: State Board of Horticulture of the State of California.
Levins, R. 1968. *Evolution in changing environments*. Princeton: Princeton University Press.
Levins, R., and L. Lewontin. 1985. *The dialectical biologist*. Cambridge, MA: Harvard University Press.
Lewontin, R., and R. Levins. 2007. *Biology under the influence: Dialectical essays on ecology, agriculture, and health*. New York: Monthly Review Press.
Liebig, J. 1859. *Familiar letters on chemistry, in its relations to physiology, dietetics, agriculture, commerce, and political economy*. London: Walton & Maberly.
Lough, J.W. 2007. *Weber and the persistence of religion: Social theory, capitalism and the sublime*. New York: Routledge.
Loughheed, A.L. 2001. The anatomy of an international cyanide cartel: 1897–1927. *Prometheus* 19(1): 1–10.
Lounsbury, C.P. 1902. *Fumigation under box covers*. Cape Town: Department of Agriculture.
MacArthur, J.S. 1905. Gold extraction by cyanide: A retrospective. *Journal of the Society of Chemical Industry* XXIV(7): 311–315.
Magdoff, F., J.B. Foster, and F.H. Buttel. 2000. *Hungry for profit: The agribusiness threat to farmers, food, and the environment*. New York: Monthly Review Press.
Malaj, E., C. Peter, M. Grote, R. Kühne, C.P. Mondy, P. Usseglio-Polatera, W. Brack, and R.B. Schäfer. 2014. Organic chemicals jeopardize the health of freshwater ecosystems on the continental scale. *Proceedings of the National Academy of Sciences* 111(26): 9549–9554.
Mascarelli, A. 2013. Growing up with pesticides. *Science* 341(6147): 740–741.
Mayor, A. 2008. *Greek Fire, poison arrows, and scorpion bombs: Biological and chemical warfare in the ancient world*. Penguin.
McNeill, J.R., and C.R. Unger (eds.). 2013. *Environmental histories of the Cold War*. Washington, DC: German Historical Institute and Cambridge University Press.
McWilliams, C. 1935. *Factories in the field*. Berkeley, CA: University of California Press.
McWilliams, C. 1946. *Southern California: An island on the land*. Salt Lake City, UT: Gibbs Smith.
McWilliams, J. 2008. *American pests: Losing the war on insects from colonial times to DDT*. New York: Columbia University Press.
Mitchell, T. 2002. *Rule of experts: Egypt, techno-politics, modernity*. Berkeley, CA: University of California Press.
Monosson, E. 2015. *Unnatural selection: How we are changing life, gene by gene*. Washington, DC: Island Press.
Moore, J.W. 2003. Capitalism as world-ecology Braudel and Marx on environmental history. *Organization & Environment* 16(4): 514–517.
Moore, J.W. 2010. The end of the road? Agricultural revolutions in the capitalist World-Ecology, 1450–2010. *Journal of Agrarian Change* 10(3): 389–413.
Moore, J.W. 2011a. Transcending the metabolic rift: A theory of crises in the capitalist world-ecology. *The Journal of Peasant Studies* 38(1): 1–46.
Moore, J.W. 2011b. Ecology, capital, and the nature of our times: Accumulation and crisis in the capitalist world-ecology. *Journal of World-Systems Research* 17(1): 108–147.
Morse, F.W. 1887a. The uses of gases against scale insects. *California Agricultural Experiment Station Bulletin* 71.
Morse, F.W. 1887b. Use of Hydrocyanic Acid Against Scale Insects. *California Agricultural Experiment Station Bulletin* 73.
Morse, F.W. 1887c. The use of gases against scale insects. *Pacific Rural Press*, June 18.
Morse, F.W. 1887d. Doses of acids of different strengths. *Pacific Rural Press*, September 3.
Morse, F.W. 1887e. Scale insects. The use of hydrocyanic acid to exterminate them. *Sacramento Daily Union*, September 3, 7.

Morse, F.W. 1891. Entomological: comments by Mr. Morse. *Pacific Rural Press*, September 5.
Moses, H.V. 1995. The orange-grower is not a farmer: G. Harold Powell, Riverside orchardists, and the coming of industrial agriculture, 1893–1930. *California History* 74(1): 22–37.
Mudder, T., and M. Botz. 2004. Cyanide and society: A critical review. *European Journal of Mineral Processing and Environmental Protection* 4(1): 62–74.
Mullen, R.A. 1933. Why poison bugs, foes or surpluses? *The Washington Post*, June 25.
Mulvaney, R.L., S.A. Khan, and T.R. Ellsworth. 2009. Synthetic nitrogen fertilizers deplete soil nitrogen: A global dilemma for sustainable cereal production. *Journal of Environmental Quality* 38(6): 2295–2314.
Munroe, C. E. 1905. Precious metals recovered by cyanide processes. *Special Reports: Mines and Quarries 1902*: US Department of Commerce and Labor, Bureau of the Census.
Murphy, M. 2008. Chemical regimes of living. *Environmental History* 13(4): 695–703.
Naylor, R.L., and P.R. Ehrlich. 1997. Natural pest control services and agriculture. In *Nature's services: Societal dependence on natural ecosystems*, ed. G. Daily, 151–174. Washington, DC: Island Press.
Nik-Zainal, S., P. Van Loo, D.C. Wedge, L.B. Alexandrov, C.D. Greenman, K.W. Lau, K. Raine, D. Jones, J. Marshall, and M. Ramakrishna. 2012. The life history of 21 breast cancers. *Cell* 149(5): 994–1007.
NYT. 1896. The gold output. *New York Times*, March 9.
OAD (Oxford American Dictionary). 2011. Toxic. In *New Oxford American Dictionary*, ed A. Stevenson and A. Lindberg. Oxford: Oxford University Press.
Odling-Smee, F.J., K.N. Laland, and M.W. Feldman. 2003. *Niche construction: The neglected process in evolution*. Princeton: Princeton University Press.
Packard, G.A. 1897. The cyanide process in the United States. *Transactions of the American Institute of Mining Engineers* XXVI: 709–721.
Peck, S.L. 2010. Death and the ecological crisis. *Agriculture and Human Values* 27: 105–109.
Perfecto, I., J.H. Vandermeer, and A.L. Wright. 2009. *Nature's matrix: Linking agriculture, conservation and food sovereignty*. London, UK: Earthscan.
Perkins, J.H. 1978. Reshaping technology in wartime: The effect of military goals on entomological research and insect-control practices. *Technology and Culture* 19(2): 169–186.
Perkins, J.H. 1982. *Insects, experts and the insecticide crisis*. Berlin: Plenum Press.
Perkins, J.H. 1983. Insects, food, and hunger: The paradox of plenty for US entomology, 1920–1970. *Environmental History Review* 7(1): 71–96.
Plucknett, D.L., and N.J. Smith. 1986. Sustaining agricultural yields. *BioScience* 36(1): 40–45.
Pollan, M. 2006. *The omnivore's dilemma: A natural history of four meals*. New York: Penguin.
Poulton, J.E. 1990. Cyanogenesis in plants. *Plant Physiology* 94(2): 401–405.
Powell, G.H. 1905. Causes of fruit decay. *Riverside Daily Press*, April 7.
Powell, G.H. 1908. The decay of oranges while in transit from California. *Bulletin*. Washington DC: USDA Bureau of Plant Industry.
Preston, E.B. 1895. California gold mill practices. *Bulletin No. 6*. Sacramento: California State Mining Bureau.
PRP. 1872. Agricultural notes: California—Los Angeles. *Pacific Rural Press*, April 6.
PRP. 1877a. Horticulture: Los Angeles fruit growers association. *Pacific Rural Press*, May 19.
PRP. 1877b. Agricultural notes: California—Los Angeles. *Pacific Rural Press*, March 3.
PRP. 1883. Entomological: citrus scale and their foes. *Pacific Rural Press*, March 10.
PRP. 1887. The Gas treatment for scales. *Pacific Rural Press*, July 30.
PRP. 1888a. Killing animals humanely. *Pacific Rural Press*, April 7.
PRP. 1888b. Entomological: more foes of Icerya. *Pacific Rural Press*, December 29.
PRP. 1898. A county fumigation outfit. *Pacific Rural Press*, September 17.
Pugsley, C. 1897. *Gas treatment for scale insects: Treating of the operations of the Horticultural's Board fumigating outfit, the applicability of the fumigation process in Cape Colony, and embodying a full description of the equipment necessary for fumigation with hydrocyanic acid gas*. Cape Town: Horticultural Board of the Cape Colony.
Quayle, H.J. 1910. Correspondence Between H. J. Quayle and the University of California Agricultural Departments as well as horticultural and entomological agencies throughout the World 1908–1914. In *Henry J. Quayle Papers*: UC Riverside Special Collections.
Rasmussen, N. 2001. Plant hormones in war and peace: Science, industry, and government in the development of herbicides in 1940s America. *Isis* 92(2): 291–316.
Reuther, W., E.C. Calavan, and G.E. Carman (eds.). 1989. *The Citrus Industry*, vol. V. Oakland, CA: UC Agriculture and Natural Resources.
Rich, G. 1878. The ravages of the scale bug. *Southern California Horticulturist* 2(1): 30.
Riley, C.V. 1889. Importation of Icerya enemies from Australia. *Pacific Rural Press*, December 21.
Robine, R., M. Lenglen, J.A. Le Clerc, and C.E. Munroe. 1906. *The cyanide industry: theoretically and practically considered*. New York: John Wiley & Sons.
Romero, A. 2016. From oil well to farm: Industrial waste, shell oil, and the petrochemical turn. *Agricultural History* 90(1) (forthcoming).
Russell, E. 2001. *War and nature: Fighting humans and insects with chemicals from World War I to Silent Spring*. Cambridge: Cambridge University Press.
Sackman, D.C. 2005. *Orange empire: California and the fruits of Eden*. Berkeley, CA: University of California Press.
Sanders, B. 2009. *The Green Zone: The environmental costs of Militarism*. Oakland, CA: AK Press.
Sawyer, R.C. 1996. *To make a spotless orange: Biological control in California*. Ames, IA: Iowa State University Press.
SCH. 1879. The red scale. *Southern California Horticulturist II* 9: 280.
Scheffer, M., S. Carpenter, J.A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. *Nature* 413(6856): 591–596.
Scheidel, E.M. 1894. The cyanide process: Its practical application and economical results. In *California State Mining Bureau Bulletin*, ed. J.J. Crawford. San Francisco, CA: CSMB.
Schainberg, A. 1980. *The environment: From surplus to scarcity*. New York: Oxford University Press.
Schmidt Lithographic Co. 1915. Orange crate label: Over there brand. In *Collection of Lithographic and Social History, #323891*, ed. Jay T. Last. San Marino, CA: Huntington Digital Library.
SDU. 1851. Advertisement: Grape cuttings. *Sacramento Daily Union*, April 9.
SDU. 1874. Pacific Coast items. *Sacramento Daily Union*, March 18.
SDU. 1880. Practical agriculture: Orange culture in California. *Sacramento Daily Union*, January 3.

Selman, C., J.D. Blount, D.H. Nussey, and J.R. Speakman. 2012. Oxidative damage, ageing, and life-history evolution: Where now? *Trends in Ecology & Evolution* 27(10): 570–577.

SFC. 1895. California mines. *San Francisco Chronicle*, July, 28.

SFC. 1902. Will study fumigation: Berkeley man will spend a month experimenting in the south. *San Francisco Chronicle*, August 18.

SFC. 1903. Issues bulletin on fumigation: Professor Woodworth settles several important questions for the orchardists. *San Francisco Chronicle*, July 24.

Shinn, C.H. 1893. The fruit industry of California. *Popular Science Monthly* 44: 200–217.

Siedow, J.N., and D.A. Berthold. 1986. The alternative oxidase: A cyanide-resistant respiratory pathway in higher plants. *Physiologia Plantarum* 66(3): 569–573.

Singer, M. 2011. Down cancer alley: The lived experience of health and environmental suffering in Louisiana's chemical corridor. *Medical Anthropology Quarterly* 25(2): 141–163.

Slavin, P. 2014. Warfare and ecological destruction in early fourteenth-century British Isles. *Environmental History* 19: 528–550.

Smart, J.K. 1997. History of chemical and biological warfare: An American perspective. *Medical Aspects of Chemical and Biological Warfare*, 9–86. Washington, DC: Office of the Surgeon General.

Solano, A. 1871. *Land of L. Wolfskill in the Rancho Santa Anita*. In Maps: Huntington Digital Library.

Solomos, T. 1977. Cyanide-resistant respiration in higher plants. *Annual Review of Plant Physiology* 28(1): 279–297.

Spalding, W.A. 1885. *The orange, its culture in California*. Riverside: Press and Horticulturist Steam Print.

Spalding, W.A. 1922a. Early chapters in the history of California citrus culture. *California Citrograph* 7(4): 94–95.

Spalding, W.A. 1922b. Early chapters in the history of California citrus culture. *California Citrograph* 7(4): 122–124.

Spalding, W.A. 1922c. Early chapters in the history of California citrus culture. *California Citrograph* 7(5): 150–151.

Stearns, S.C. 1976. Life-history tactics: A review of the ideas. *Quarterly Review of Biology* 51(1): 3–47.

Stearns, S.C. 1992. *The evolution of life histories*. Oxford, UK: Oxford University Press.

Stoll, S. 1998. *The fruits of natural advantage: Making the industrial countryside in California*. Berkeley, CA: University of California Press.

Street, R.S. 2004. *Beasts of the field: A narrative history of California farmworkers, 1769–1913*. Stanford, CA: Stanford University Press.

Taber, I.W. 1885. Wolfskill Orange Grove. In *Riverside and Los Angeles Area Views, circa 1880–1889, BANC PIC 1905.06211:18*. Berkeley, CA: Bancroft Library.

Thucydides. 1910. *History of the Peloponnesian War*. Translated by R Crawley. New York: E. P. Dutton.

Tucker, J.B. 2006. *War of nerves: Chemical warfare from World War I to Al-Qaeda*. New York: Pantheon Books.

Tyrrell, I.R. 1999. *True gardens of the gods: Californian–Australian environmental reform, 1860-1930*. Berkeley, CA: University of California Press.

United States Department of Agriculture (USDA). 2013. DOW AgroSciences petitions (09-233-01p, 09-349-01p, and 11-234-01p) for determinations of nonregulated status for 2,4-D Resistant Corn and Soybean Varieties. *Draft Environmental Impact Statement*. Washington, DC: USDA APHIS.

Van Der Ploeg, J. 2010. The food crisis, industrialized farming and the imperial regime. *Journal of Agrarian Change* 10(1): 98–106.

Vandenberg, L.N., T. Colborn, T. Hayes, J. Heindel, D.R. Jacobs Jr, D. Lee, T. Shioda, A. Soto, F. Saal, and W. Welshons. 2012. Hormones and endocrine-disrupting chemicals: Low-dose effects and nonmonotonic Dose Responses. *Endocrine Reviews* 33(3): 378–455.

Vanlerberghe, G.C., and L. McIntosh. 1997. Alternative oxidase: From gene to function. *Annual Review of Plant Biology* 48(1): 703–734.

Vickery, R.K. 1920. Petroleum insecticides. *Journal of Economic Entomology* 13(6): 444–447.

Von Clausewitz, C. 1832 (1909). *On War*. Translated by J. J. Graham. Vol. 1. London.

Walker, H.W., and J.E. Mills. 1926. Progress report of work of the Chemical Warfare Service on the Boll Weevil-Anthonomus Grandis. *Journal of Economic Entomology* 19(4): 600–601.

Walker, H.W., and J.E. Mills. 1927. Chemical Warfare Service Boll Weevil investigation. *Industrial and Engineering Chemistry* 19(6): 703–711.

Walker, R. 2001. California's golden road to riches: Natural resources and regional capitalism, 1848–1940. *Annals of the Association of American Geographers* 91(1): 167–199.

Walker, R. 2004. *The conquest of bread: 150 years of agribusiness in California*. New York: The New Press.

Wall, W.B., M.S. Jones, and A.D. Bishop. 1891. Process of fumigating trees and other plants. United States Patent Office. USA. *Patent #445,342*.

Wallace, R. 1896. *Farming industries of the Cape Colony*. Johannesburg: J. C. Juta and Co.

Wallace, H.A. 1933. *Extension service review*. Washington, DC: USDA.

Way, J. 1984. Cyanide intoxication and its mechanism of antagonism. *Annual Review of Pharmacology and Toxicology* 24(1): 451–481.

Webber, H.J., and L.D. Batchelor. 1943. *The citrus industry. Vol. I. History, botany and breeding*. Berkeley, CA: University of California Press.

Weis, T. 2010. The accelerating biophysical contradictions of industrial capitalist agriculture. *Journal of Agrarian Change* 10(3): 315–341.

Whorton, J.C. 1974. *Before Silent Spring: Pesticides and public health in Pre-DDT America*. Princeton, NJ: Princeton University Press.

Williamson, H.F., R.L. Andreano, A.R. Daum, and G.C. Klose. 1963. *The American petroleum industry: The age of energy 1899–1959*. Evanston, IL: Northwestern University Press.

Wilson, B.D., F. Temple, J. Shorb, N. Jones, P. Banning, L. Wolfksill, and L.J. Rose. 1874. Warehouse and shipping association: Articles of association. *Los Angeles Herald*, January 7.

Wilson, I.A. 1957. Early Southern California viniculture 1830–1865. *The Historical Society of Southern California Quarterly* 39(3): 242–250.

Wilson, I. 1965. *William Wolfskill: 1798–1866: Frontier trapper to California ranchero*. Glendale, CA: Arthur H. Clark Company.

Winters, S.R. 1922. Poison-gas chambers disinfect freight. *Popular Mechanics* (April):595–596.

Woglum, R.S. 1923. The history of hydrocyanic and gas fumigation as an index to progress in economic entomology. *Journal of Economic Entomology* 16(6): 518–521.

Woglum, R.S. 1925. Observations on insects developing immunity to insecticides. *Journal of Economic Entomology* 18(4): 593–597.

Wolf, M. 1985. *It all began in frankfurt: Landmarks in the history of Degussa AG*. Frankfurt am Maim: Degussa AG.

Wolfskill, J. 1866. William Wolkskill, the pioneer. *Daily Alta California*, October 12.

Wolkskill, W. 1836. Petition for Guillermo Wolfskill for grant of agricultural parcel. In *Los Angeles City Archives, 1836–1872*: USC Digital Archive.

Woodworth, C.W. 1912. The insecticide industries in California. *Journal of Economic Entomology* 5(4): 358–364.

Woodworth, C.W. 1899. Orchard fumigation. In *Agricultural Experiment Station Bulletin 122*. Berkeley: University of California.

Woodworth, C.W., and M.B. Messenger. 1915. *Introductory lecture: School of fumigation*. School of Fumigation: Conducted by C. W. Woodworth, University of California, Pomona, CA.

Wynn, M.R. 1963. *Desert Bonanza: The story of early Randsburg, Mojave desert mining camp*. Glendale, CA: The Arthur H. Clark Company.

YAM. 1900. Financial Records 2297–2299. In *Mining and Milling Company Records*, ed. Yellow Aster, 1898–1918. Sacramento, CA: California State Library.

Young, T.G., and W. Smith. 1891. The cyanide process for the extraction of gold from low-grade gold ores. *Journal of the Society of the Chemical Industry* 10: 93–98.

Zagrobelny, M., S. Bak, A. Rasmussen, B. Jørgensen, C. Naumann, and B. Møller. 2004. Cyanogenic glucosides and plant–insect interactions.''. *Phytochemistry* 65(3): 293–306.

Adam M. Romero is a Ph.D. Candidate in the Department of Geography at the University of California Berkeley. His doctoral work is about the chemicalization of US agriculture, focusing on the role of industrial waste in agroindustrialization. He is also currently writing a book on the environmental history of cyanide. His office has a species richness >200.