Title

Trade Pests and the People: Epistemologies, Governance, and Encounters in Conflicts over the Eradication of California's Agroeconomic Threats

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Trade Pests and the People:
Epistemologies, Governance, and Encounters in Conflicts over the Eradication of California's Agroeconomic Threats

By

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DISSERTATION

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SEDELL ABSTRACT

This dissertation takes a political ecology approach to track how eradication—the removal of all species of a targeted population in a contiguous area—has become embedded in regulatory responses to introduced insect species; in turn, it shows how eradication as a trade concept—and the freedom from pests it implies—shapes epistemologies of determining pest absence and presence, governance across diverse landscapes, and human encounters with pest control methods. In order to protect the top agricultural export economy in the United States, state and federal agricultural regulatory agencies enact projects to eradicate introduced insect species from California's cities, suburbs, wild spaces, and croplands. While most of these eradication projects go unnoticed by the general public, some have generated significant public conflict. Such conflicts open the black box on the practices and implications of regulating across diverse constituents and landscapes specifically to protect California's position in domestic and international agricultural commodity markets. To analyze how eradication has been practiced in the United States, when it generates conflict, and how conflicts play out epistemologically and spatially, the dissertation employs descriptive statistics, historiography, and a phenomenological framework. To describe how eradication has been defined and practiced over time, the dissertation uses data from the Global Eradication Database, an open source project. To illustrate the phenomenon of the extremely controversial eradication project, the dissertation draws on interviews, archival material, and regulatory documents related to projects to eradicate: (1) the Mediterranean fruit fly (*Ceratitis capitata*) by spraying malathion from helicopters in Los Angeles (1981-1996), (2) the light brown apple moth (*Epiphyas postvittana*) by spraying a pheromone slurry from airplanes over Santa Cruz and Monterey (2007-2010), and (3) Japanese beetle (*Popillia japonica*) by spraying a trio of conventional pesticides in yards of a Sacramento suburb (2011-2016). Three key findings emerge from the dissertation. First, the variability of how eradication has been defined and practiced contributes to public controversy. Second, in order to move agricultural commodities out of infested areas as quickly as possible, regulatory agencies constrain their assessment of pest absence and presence spatially and temporally. Third, while eradication projects are designed to mitigate increased pesticide exposures in industrial agricultural areas (and the structural violence associated with their use), I show that highly controversial eradication projects render the slow violence of California's industrial agricultural regions visible in novel ways by translocating the violence into urban and suburban spaces.

Keywords: Eradication, California, Agriculture, Environmental Accounting, Chaotic Conception, Regimes of Perceptibility, Urban Uncanny, Political Ecology

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DISSERTATION INTRODUCTION

This dissertation examines how public conflict develops over where, how, and why regulatory agencies in the U.S. and California eradicate insect pests that threaten agricultural production and trade. While the first chapter of the dissertation reviews the history of eradication projects in the U.S. (262 projects enacted by state and federal agencies between 1890 and 2016), the second and third focus on three eradication projects that generated significant public controversy, those to eradicate the Mediterranean fruit fly (*Ceratitis capitata)* (1980 to present), light brown apple moth (*Epiphyas postvittana*) (2007-2010), and the Japanese beetle (*Popillia japonica*) (2011-2016). The eradication projects were extraordinary in how "cinematic" (Davies 2019) and "spectacular" (Neimanis 2020) they were: helicopters misting organophosphates over the Los Angeles and San Francisco metro areas (see figure 1); a trio of airplanes misting a pheromone slurry under the cover of night over Santa Cruz and Monterey; contract exterminators accompanied by California Highway Patrol spraying three different types of synthetic pesticides on the grass, shrubs, and trees of Sacramento suburbs. The projects were unusual in both methods and public visibility. Their location, in densely populated areas rather than agricultural areas, intensified their strangeness. Their out-of-ordinariness is exactly what helps to answer my overarching researching question: how does protecting California's position in domestic and international agricultural commodity markets inform the everyday ways that state and federal regulatory agencies know and govern California's diverse landscapes?

To answer this question, I engage with the concept of accounting within the framework of political ecology applied to governing heterogeneous landscapes for the purposes of agricultural export. A multivalent term, accounting encompasses the counting of things, demonstrating responsibility, and sharing stories. These three facets of accounting—counting, responsibility, stories—help us to understand three dimensions—epistemological, governance, and lived experiences, or encounters—of conflict over government eradication projects. They also form the triad of research sub-questions that thread through the dissertation: 1) Epistemologically, how is evidence established and contested that zero insects of a targeted population exist? 2) Governance-wise, to whom are the governments that enact eradication projects accountable (e.g., the general populace, trade partners, export-oriented farms, farmworkers, etc.)? To whom should they be? 3) In terms of lived experiences, what do first-hand encounters with targeted pest populations and eradication methods outside of agricultural production spaces tell us about the spatial configurations of governing agriculture? And what do they tell us about the possibilities of transforming industrial agricultural production?

Figure 1: Aerial spraying of the pesticide malathion over Portola Valley area, San Mateo County, July 20, 1981 (Photograph by Mike Maloney; reprinted with permission from San Francisco Chronicle)

Answering those questions requires attention to the geography of an array of biophysical, economic, and political phenomena: insect pathways, production areas, export routes, and jurisdictions, the spaces governments hold authority to know and act on environmental problems. In other words, this is a political ecology problem.

The field of political ecology investigates the connections between ecological systems and "a broadly defined political economy" (Blaikie & Brookfield 1987, p. 17). The political economy includes economic systems, governance structures, and social formations; the ecology indicates biophysical processes themselves, as well as the ways humans make sense of and intervene in biophysical processes (Robbins 2004; Zimmerer & Bassett 2003). Understanding the dynamics of nature-society relations lies at the heart of geography (Watts 1983), and political ecology deepens studies of nature and society by tracing those dynamics across a variety of scales in order to understand how local phenomena are linked to larger patterns and processes across regions and, indeed, the world (Blaikie 1985; Galt 2014; Sayre 2005; Swyngedouw & Heynen 2003). Political ecology is particularly attuned to how dualisms—like urban-rural, nature-society, science-politics—are produced and policed (cf. Braun 2005; Cantor 2020; Connolly 2019; Galt 2011; Heynen, Kaika & Swyngedouw 2006; Mansfield and Guthman 2013; Ranganathan and Balazs 2015). Political ecology's insistence that phenomena conventionally cast as opposites in the Global North are materially linked, even co-productive of each other, is particularly salient with regards to managing agricultural pests across heterogeneous landscapes.

The eradication projects the U.S. Department of Agriculture (USDA) and California Department of Food and Agriculture (CDFA) enact occur only partially in the agricultural fields the projects are designed to protect. The eradication projects reach across diverse land uses—cropland and orchards, yes, but also downtowns, suburbs, small towns, dedicated open spaces, and anywhere else agricultural pests are introduced and reproduce. The biogeography of economic pests and their management connects "landscapes of production" and "landscapes of consumption" (Neumann 1998) in spatial configurations that all but erase tidy divisions of "production" and "consumption." California's metropolitan areas are not just places where agricultural products move to and through for purchase and export; their biophysical properties make them ideal entry points and reservoirs for many insect populations that threaten the highest-earning agricultural regions in the U.S. Their massive ports, high-traffic airports, and verdant yards, which often feature the same plants grown in state commercially, all encourage pests that move through travel and trade to settle in. In this, California's population centers are biophysical extensions of the state's landscapes of production, despite the mental schema dividing rural from urban that many of us in the U.S. tend to hold. Given that, regulatory agencies tasked with ensuring compliance with international trade agreements on agriculture intervene into these non-agricultural spaces.

First, there is the accounting that comes from actual counting. In the governance of natural resources, agriculture, and other environmental systems, state actors develop methods to quantify and convey complex processes and outcomes in simplified terms (Behrsin 2019; Clifford and Travis 2021; Galt 2014; Ghosh 2019; Scott 1998; more). Ghosh and Wolf (2021) define this collective activity as "environmental accounting," which includes "standardized environmental measurement, quantification, and reporting routines" (1). In sum, environmental accounting takes complicated socio-ecological processes and makes them legible within larger political economies (Robertson 2006).

Chapters 1, History and Typology of Government Eradication Programs in the U.S., 1890- 2016, and 2, No Fly Zone? Spatializing regimes of perceptibility, uncertainty, and the ontological fight over quarantine pests in California, investigate different angles of accounting as counting. Since the late 19th century, the ability to show evidence of pest absence in export shipments and the areas in which commodities are grown has become increasingly enshrined in California and U.S. laws and international agreements. This enshrinement began in 1899, when California passed the U.S.'s first quarantine law, continued through the many iterations of the federal Plant Quarantine and Plant Protection Acts and bloomed with the international sanitary and phytosanitary agreements associated with the General Agreement on Tariffs and Trade (GATT) (1947) and the World Trade Organization (1995).

Eradicating insects for the purposes of exporting agricultural commodities requires systems of accounting. The eradication of insects is, at its core, about a single measurement: zero. However, there is no way to directly measure zero generally (Galt 2014) and certainly not zero insect bodies specifically (Meats 2014; Sedell 2019). So, parameters have to be set as to how to determine a lack of insects. How long are they gone for? How large a space has to be clear to declare the "all clear"? How closely does one have to look to show one can no longer see them? Chapter 1 examines how those parameters have historically varied wildly. Rachel Carson (2002[1962]) described eradication as the final extirpation of an insect from its range. Ridding a pest—agricultural, public health, or otherwise—from everywhere it has been known to exist for all time has rarely been achieved. Yet the success rate rises significantly when regulatory agencies set their sights on smaller, recently introduced populations. But even those quick, targeted eradication efforts raise similar questions about parameters. Chapter 2 explores how eradication projects focused on supposedly newly detected pest populations introduces uncertainty about the properties of the population and their eradicability: whether the state is eradicating a new population each time a fly or moth or beetle appears again in the same place, or whether these insects exist undetected until one again is found in a surveillance apparatus. In order to comply with international trade agreements, governments have to demonstrate their ability to see and eliminate populations of pests that could damage not only their own crops but also those of the importers of their goods, which brings us to accounting as a relational dynamic.

The second facet of accounting threaded through the dissertation centers on accountability. To whom are regulatory agencies accountable? And how do they demonstrate their accountability? There are "reporting regimes" (Ghosh and Wolf 2021), such as the standards and codified avenues for communication with both domestic and international trade partners. Being accountable to regulatory counterparts in Canada or Mexico, as discussed in Chapter 2, involves showing that regulatory agencies know where the insect bodies are and can ensure they will not be crossing the border with any imports. There are also "reporting regimes" for assessing and communicating the environmental and health risks to the general public regarding the means of eradicating economic pests, in particular environmental impact reports as mandated by California's Environmental Quality Act (CEQA). However, many of the eradication projects discussed in this dissertation were enacted under emergency orders, which means CDFA's actions were exempt from CEQA and the level of stakeholder engagement required by the law (14 CCR 15269). In other words, even the most basic of "reporting regimes" was sidestepped under emergency order. While there typically was some form of public notifications—in the form of mailers, presentations, and other "unidirectional communication" (Crowley et al. 2017, 139)—and environmental impact reports were often prepared *post-facto*, real-time accountability to those living within the area targeted for eradication was limited. Chapter 3, Kill in the City to Save the Fields: How the Urban

Uncanny Refracts the Violence of Agrarian California, considers how residents made sense of the impacts to their health and environment in the absence of such reporting structures. It also touches on the structural and historical lack of accountability to those who work in and/or live by agricultural fields, who are impacted by the plant health quarantines associated with eradication projects.

To move agricultural products out of plant health quarantines, the production land itself or individual shipments have to be declared pest-free. To accomplish that, some growers have reported that may employ—or even be required to use—more and more toxic pest control treatments, which could increase pesticide exposures for anyone working on site or residing nearby (cf. Rosendale 2007). This dynamic is explored more in Chapter 2. Since plant health quarantines are actions taken by a regulatory agency for the purposes of environmental protection, they are categorically exempt from CEQA (14 CCR 15308). I found no evidence that the environmental and public health impacts of plant health quarantines have ever been assessed by the state of California, which stands in stark contrast to emergency projects, which often spawned assessments to appease the public. Indeed, CDFA has argued that plant health quarantines both do not merit review nor do they cause any impacts to review, writing in the EIR for the Gypsy Moth (*Lymantria dispar L.*) eradication program, "CDFA finds that quarantine activities are exempt from CEQA since they have been approved and carried out on an ongoing basis prior to the enactment of CEQA. Many years of conducting quarantine activities have not revealed any significant adverse environmental effects" (1991, 46).

When trying to make sense of where and why accounting and accountability work and do not, I turn to the third form of accounts: stories. There are stories from urban residents trying to understand how and why they were pulled into efforts to keep California's agricultural production certified as "free from" pests (ISPM-9; see also Sedell 2019; Hinchliffe et al. 2017) or "uninfested" (National Plant Board 2016). They came to know these projects through their skin and nostrils, through their fear and anger, as described in Chapter 3, and through their own entomological experiments, as explored in Chapter 2. There are also stories from growers and pest control advisors who questioned the environmental accounting of eradication projects throughout.

One of the limitations of this dissertation is that it lacks accounts from two key groups: one group is the farmworkers, who would have been tasked with carrying out pest eliminating duties on farms in plant health quarantines; the other group is representatives of CDFA. Much of the data for this project comes from interviews collected during the USDA-APHIS-commissioned evaluation on the "community perceptions of plant health emergency programs" (Zalom et al. 2013). CDFA workers declined invitations to interview with that project. They also declined my subsequent requests for interviews for this dissertation. To piece together their stories, I have relied on the public record of their statements as well as observations of state meetings—specifically for the Statewide Pest Management Programmatic Environmental Impact Review in 2012 and California Invasive Species Advisory Council meetings between 2014 and 2017—and presentations by CDFA staff at various convenings, including the Entomological Society of America meetings (2014 and 2017) and webinars on pest management. The historical record is rich with the stories of regulators, not so much the farmworkers who are impacted by the regulatory apparatus. This bias of the historical record left silences that I was unable to fill. It may be possible to fill them in the future, but I contend it would require a different research design—one that complements on-going environmental justice organizing—rather than a standalone project that would parachute in to extract data.

My own accounting matters too: I came to this work from a place of antipathy toward invasive species and empathy for regulatory scientists. Coming from a family of conservation scientists, I understood that we need to kill certain species so that others can live. Indeed, that invasive species were something to expel did not just make sense to me; I viewed it as an ecological and moral imperative. In 2010, I carried those beliefs into my research assistant position investigating public outcry over programs to eradicate an invasive moth in California. The light brown apple moth (LBAM) (*Epiphyas postvittana*), a leaf-rolling moth native to Australia with over 250 known hosts including many of the state's export-oriented crops, was detected in Alameda County in 2007. Soon thereafter, LBAM was detected in Monterey and Santa Cruz Counties, where state and federal agricultural agencies proposed eradicating it through mating disruption, specifically by spraying a pheromone slurry from airplanes. Community activists fought back through protests, counter-research, legal filings, and political pressure. As I began reviewing the news coverage on the LBAM controversy, I initially interpreted community concerns in much the same way the state and federal agencies directing the program did: *People just didn't understand how dangerous invasive species can be. The government agencies didn't adequately communicate why the moth needed to be eradicated. People didn't get how benign the methods for eradicating it were. People just wanted the government off their lawns*.

Over the course of two years, I and my team, led by entomologist Frank Zalom, interviewed community members, regulators, growers, and scientists who were connected to either the LBAM eradication program (and its fall-out) and the program to eradicate the European grapevine moth (*Lobesia botrana*), which was enacted in Napa and Sonoma just as the LBAM controversy was reaching its peak. Unlike the LBAM program, the European grapevine moth program enjoyed broad community support. As often happens with research, I started seeing something more complex at play than my initial explanation. The rationale for what gets killed—how and where—so that certain other beings can live is situated in the political economy of California's export-oriented agriculture. The state intervenes to protect the movability and profitability of California's industrial agriculture. While some of the economic pests discussed in the following pages also pose threats to non-commercial landscapes, by definition they chiefly pose an economic threat: to growing marketable commodities and to exporting them, period. Over time, I moved the focus off individual actors and centered instead on the systems of production, regulation, and trade. This refocusing allows for more structural analysis that, while not devoid of individual actors, places them in complex political, ecological, and economic systems to understand how our ways of knowing, governing, and resisting exist in networks of relations that constrain and enable certain possibilities.

Chapter Organization

The chapters of the dissertation are stand-alone articles. As such, they can be read in any order. However, they are organized here according to the types of accounting with which they most engage. As noted above, Chapters 1 and 2 concern how regulatory agencies define and provide evidence of eradication; in other words, how the government counts to zero insects. Chapter 1 tells the story of how elastic the term eradication has functioned historically, while Chapter 2 contrasts how regulatory agents and community activists produce knowledge about constitutes pest presence and absence. Chapters 2 and 3 delve into questions of accountability. Chapter 2 considers the relationship between whom evidence is produced for and what constitutes evidence. Chapter 3 considers the accountability of regulatory agencies to communities in and outside of agricultural production zones. Lastly, Chapter 3 highlights accounts as in shared stories of sensory encounters with projects to eradicate economic pests in non-agronomic spaces.

Chapter 1, History and Typology of Government Eradication Programs in the U.S., 1890-2016, delves into accounting as measurement and its implications for accountability to the general public. Broadly, the article describes the variability in how eradication has been defined and practiced over time and with different arthropod targets. My co-authors and I argue that agricultural agencies that implement eradication projects would do well to recognize the many competing forms of eradication that circulate in the public and how those many histories and definitions impact public perceptions of eradication projects. In doing so, we ask managers to set aside the traditional operating model that assumes that publics are ignorant of the science of the programs—"the public deficit model" (Wynne 1993, 2006)—and instead engage with community members' pre-existing frameworks for making sense of the need for and means of eradicating insect pests. Following Sarah Moore's (2012) approach to understanding the multiple signifiers of "waste," the paper develops a typology to historically track and disambiguate "eradication" using data from the Global Eradication Database (GERDA), an open-source project, and archival sources. The analysis shows how eradication is indeed a "chaotic conception" (Marx 1973[1939]; Sayer 2010), a highly heterogeneous concept. The typology, in turn, provides an opportunity for managers to question the assumption that publics are not simply unfamiliar with eradication--an assumption which lends itself to unidirectional, top-down communication (the so-called "public education approach" (Callon 1999)) and tends to intensify conflict (Crowley et al. 2017). In contrast, the typology might orient managers toward engaging with community members through a more frank discussion process about how governments and the community can respond to insect pests.

Chapter 2, No Fly Zone?, digs into the specifics of how zero is calculated and contested on the ground. The article answers the following research questions: How do regulators determine that a population of introduced economic pests have been eradicated? And how do publics contest their ability to see insect populations, their "regime of perceptibility" (Murphy 2006)? Examining the controversies over programs to eradicate the Mediterranean fruit fly (*Ceratitis capitata)* in the Los Angeles basin (1980 to present), light brown apple moth (*Epiphyas postvittana*) on California's central coast (2007-2010), and the Japanese beetle (*Popillia japonica*) in the Sacramento Area (2011-2016), I describe two competing models for understanding invasive insect populations. Through a comparison of these "regimes of perceptibility," to borrow Michelle Murphy's (2006) term, I demonstrate the importance of temporal and spatial scales in determining pest presence and absence. Further, I argue that the dominant regulatory regime of perceptibility, the Multiple and Recent Incursion (MRI) model, constructs certainty in trade relationships by re-establishing production areas as pest-free through the insistence that the insects are invasive, out of the ordinary, and temporary. The competing regime of perceptibility, the Sub-detectable Established Local Population (SELP) model, challenges the construction of certainty on which the MRI both relies and helps produce. In doing so, I show that the SELP model threatens California's position with agricultural trade partners but also opens up possibilities for new agro-ecological and political arrangements. Chapter 2 originally appeared in a special issue of *Geoforum* on "Geographies of Uncertainty," edited by Nari Senanayake and Brian King (see Senanayake and King 2021).

Chapter 3, Kill in the City to Save The Fields, shifts more centrally to the themes of accountability and accounts. The chapter shows how the systems of accountability that govern export-oriented agriculture in California spread the violence inherent to its operations into non-agricultural spaces. The article follows the most spectacular and controversial eradication projects in the state's history (the Mediterranean fruit fly, 1981-1996; light brown apple moth, 2007-2010; and Japanese beetle, 2011-2016). These eradication programs brought helicopters, airplanes, and contract exterminators into urban and suburban spaces in ways that both alarmed residents and made California's production system suddenly visible in novel ways.

As McWilliams (1939) described, and numerous scholars since have documented, there are several forms of violence at work in California's industrial agriculture: the interpersonal violence of armed strike-busting (Mitchell 2010; Montenegro de Wit et al 2021), to the manner in which labor is organized, and the risk of exposure to harmful chemicals from both occupational use and drift (Guthman 2004; Harrison 2011; Mitchell 2010; Montenegro de Wit et al. 2021; Sackman 2005; Sze 2020; Tsu 2013; Walker 2004). This latter form of violence is built into the system of operations and incrementally harms people over time in what Nixon (2011) calls "slow violence." Even regulatory risk assessments acknowledge the chemical intensiveness and social precariousness of agrarian communities in California's centers of production (Horizon Water and Environment 2014). The eradication projects are supposed to protect urban areas from that very violence as well as prevent the violence of agricultural productions areas from worsening. Yet, I argue instead that these instances of spectacular pest management events, truly "cinematic threats" (Davies 2019, 2) or "fast violence" (Nixon 2011), in non-food producing locations refract the "slow violence" (ibid.) that is routinized in California's agrarian landscapes. I say refract, not reveal or make visible, because the violence of California's industrial landscapes has always already been visible, for those who care to look and to those experiencing it firsthand. "Refract" instead suggests that the light illuminating the violence needs to be bent, bounced through another location in order to become more widely visible. This refraction is made possible by the visceral reaction of urban residents to these high profile eradication projects. In moments of "urban uncanny" (Kaika 2005), their sense of safety and independence is threatened when the state insists that their day-to-day environments become part of the metabolic functioning of industrial farms.

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CHAPTER (ARTICLE) 1

History and Typology of Government Eradication Programs in the U.S., 1890- 2016

Abstract

Public support for projects to eradicate invasive insect populations is key to their success. When the public and the agencies enacting eradication projects do not share a common understanding of what eradication is and how it functions, public support erodes. One barrier to a shared understanding of eradication is the circulation of multiple definitions and practices of eradication over time, targets, and projects. We propose that eradication is a chaotic conception, a fuzzy idea that has multiple interpretations but is used as if it has a singular meaning. Chaotic conceptions are unreliable units of analysis, because the single term naming the conception masks the heterogeneity of all its contents. Chaotic conceptions cease to be chaotic once disambiguated. To disambiguate eradication, we describe how eradication of arthropods in the United States has changed over time, from 1890 to 2016, with regards to how often eradication projects are initiated and last, the control methods used, the spatial extent of projects, and the endemicity of the arthropod populations targeted. Drawing on the Global Eradication Database (GERDa), we analyze 262 U.S.-based eradication projects to: (a) sketch out the historical macrotrends by eras of pest management, and (b) propose a typology of eradication from the standpoint of human communities experiencing government eradication projects. We find that overall eradication projects have become increasingly targeted and employ decreasingly toxic methods, which may be in response to evolving public concerns. However, diverse meanings and practices of eradication continue to circulate within regulatory, scholarly, and, importantly, public communities. By placing the eradication projects within larger contexts, by era and type, we find that public conflict is more likely to arise when eradication projects repeatedly target the same species in the same area and/or utilize elements from previous highly controversial eradication projects. We suggest that agencies would do well to consider public engagement in light of the larger cultural and local frames of reference utilized by human communities impacted by eradication projects.

Keywords

Chaotic conception, eradication, GERDA, invasive species, public deficit model, United States

1. Introduction

In 1914, the State Entomologist of Texas warned that "eradication of an insect, in the sense of destroying all individuals of the species, is an end rarely if ever accomplished by artificial means" (Newell 1914, 92) while also administering a program that did just that with cattle fever tick (*Rhipicephalus annulatus*). In 1958, Popham and Hall contrasted a lay understanding of "eradication"—"to destroy, remove utterly, complete destruction, or removal in general" (335) with the expert use of the term: "to the professional entomologist, 'eradication' means extermination or elimination of an insect population, and the term is generally applied with reference to incipient infestation of an insect new to an area or not widely distributed" (ibid.). The authors then proceed to describe contemporary efforts to eradicate the European Gypsy moth (*Lymantria dispar dispar*) from over 14 million acres across the northeastern U.S., by applying DDT, a full 80 years after the species was introduced (ibid.). The infestation was neither new nor well delimited.

This historical push-pull between a) the consensus that eradication responses should be limited and targeted, and b) the insistence in the potential for eradication be practiced as sweeping, matters today as experts—and increasingly the public—debate the viability, ethics, and logistics of eradication generally and eradication via emerging technologies, such as gene drives, more specifically. The contemporary definition of eradication is the "complete removal of all individuals of a distinct population, not contiguous with other populations" (Simberloff et al. 2013, 58). That definition does not directly address how established (or not) the distinct population is nor does it circumscribe the size of the response to it. Depending on the range of the "distinct population," the eradication project could be tiny, massive, or anywhere in between. Even in instances when academic and regulatory definitions of eradication have been updated, the definitions circulating in the public frequently reference forms of eradication that are less common today, such as the wide-area, chemical-intensive programs described by Rachel Carson in the 1960s.

Scholars across disciplines have noted that public support impacts the success or failure of eradication programs (Crowley et al. 2017; Myers et al. 2000; Santo et al. 2015). Many eradication projects provoke little public attention. The melon fly (*Bactrocera cucurbitae*), for example, was eradicated from Kern County, California, in nine months using traps baited with a male insect attractant, cuelure, and the pesticide, naled (Purcell 2010; Lyle 2011). However, some generate significant resistance from the human communities affected. Those working for eradication campaigns have reacted to public resistance by generally drawing upon the “public [knowledge] deficit model” (Wynne 1993, 2006), which assumes that the public is ignorant of scientific truths—in this case about eradication and its tools—and the solution is for the experts to inform the ignorant public. This framing contributes to experts and lay people talking past one another about eradication programs.

We suspect that public support or rejection is partly shaped by the diverse definitions and practices of eradication that circulate in the U.S. In order to understand why publics react differently, those on the forefront of dealing with invasive insects would do well to take those different understandings seriously. Thus, in this paper we seek to answer the following research questions: How has eradication practice — including rate of initiation, type of control, and duration — changed over time in the United States from 1890 until the present? What are the spatial and temporal extents of insect eradication programs in the United States, and to what extent do these differences allow for conceptualizing distinct types of insect eradication? What characteristics did programs that were known to cause controversy share? We draw conclusions about how an understanding of distinct eradication types allows us to better understand public-expert conflicts.

We propose that “eradication” is a “chaotic conception” (Marx 1993; Sayer 2010): a fuzzy idea that has multiple interpretations but has been used as if it were a singular idea. In order to disambiguate “eradication,” we draw on Sarah Moore’s (2012, 780) work disambiguating “waste,” which plots the many ways in which waste is a lens into a variety of issues: “Understanding when, how, and why waste matters provides a fruitful lens for examining contemporary sociospatial processes.” To accomplish this, we analyzed 262 government-enacted eradication programs targeting 51 insect species in the U.S. between 1890 and 2015, using data from the Global Eradication Database (GERDA) (Kean et al. 2016), an open-source data project, and archival sources. The analysis disambiguates eradication through both historical periodization, which builds on Metcalf (1980) and Dahlsten and Dreistadt's (1991) "eras of pest management," and a typology of eradication efforts, single or multiple eradication efforts targeting the same species.

The periodization and typology developed here shows the wide multiplicity of practices referred to singularly as eradication, and illuminates one important facet of why experts and lay people continue to talk past one another about eradication programs. Eradication means literally different things to different people, but its practice-and how that practice is connected to larger socio-ecologic dynamics--are also perceived differently. The periodization and typology provide a way to contextualize public responses to eradication projects by identifying patterns across time, place, and scale in how eradication has been multiply practiced as well as the dangers of divorcing eradication conceptually from the larger political economic systems that impact how it is practiced.

The paper is organized as follows. First, we introduce the two key concepts for our analysis, chaotic conception (Marx 1993; Sayer 2010) and the public deficit model (Wynne 1993), in relation to eradication projects. Second, we describe our methods for collecting, cleaning, historicizing, and typing our data. Third, we outline macro-trends in insect eradication programs in the U.S., specifically the quantity, methods, and duration of eradication efforts over time. Fourth, we employ descriptive statistics paired with historical analysis to develop a typology of U.S. government-led eradication programs. The typologies are plotted along two axes, targetedness and frequency, and thereby grouped into four quadrants, from which we describe four overarching types of eradication: discrete responses, repeat incursion-responses, grand battles, and failed wars. Finally, we suggest that while practices in eradication programs have responded to public criticisms over time by, for example, employing decreasingly toxic methods, there remains opportunities for regulatory agents responsible for such programs to further respond to and dialogue with public concerns.

2. Chaotic Conceptions and the Public Deficit Model

2.1 Chaotic Conceptions and Eradication

First introduced by Marx (1993) and then explicated by Sayer (2010), the term "chaotic conception" describes the limited analytical value of fuzzy terms. As Martin and Sunley (2003, 10) sum it up: "we know what they're called, but defining precisely what they are is much more difficult." Sayer argues that a concept is chaotic if it is comprised of incommensurable things, such as "services" in the "service industry," which includes jobs as disparate as airline attendants, plumbers, computer repair, and accountants. The heterogeneity of everything that goes into the concept makes its use as a starting unit of analysis problematic:

> A system is arbitrarily divided into unrelated parts, which are then associated either because of convenience (e.g. their ease of measurement; availability of data) or because of an apparent shared pattern that merits simple description. The division of a system into parts serves to remove critical chains of causality, which have important explanatory power (Pattison and Lane 2011, 86).

Marx (1993) uses the example of a "population" (of humans), noting that a scholar must dig to understand what a population is made of, classes, which in turn must be broken down into their constituent pieces, "labour, divisions of labor, money, value, etc." (100). The concept, in Marx's formulation, is only chaotic when analysis flows from or rests on the concept. A concept ceases to be chaotic when the term under question is the outcome of an analysis into all the many pieces that comprise it.

In recent scholarship, scholars have deployed the notion of "chaotic conceptions" along two lines of inquiry, both of which are relevant to how eradication is defined and practiced. The first uses "chaotic conception" simply to describe a fuzzy term. Editorials in academic journals note that terms like "globalization" (Sites 2000), "neoliberalism" (Barnett 2008), or the "Urban Age" (Brenner and Schmid 2015) have become muddied or overused such that they no longer hold as much analytical value. The second is as a fuzzy term that actively undermines the analysis of which it is a part. Scholars from diverse fields have used the term to discuss the drawbacks of utilizing concepts such as “firms” (Perrons 2004) and “clusters” (Martin and Sunley 2003) in economic geography, “Adverse Childhood Events” (White et al. 2019) in child development and psychology, “well-being” (Jenkins 2016) in global economic studies, or even the established concept of “scale” (Miller 2009) in human geography. Their interpretation adheres closely to Sayer’s description of conceptions being chaotic because of the diversity of objects and experiences they encompass.

Eradication functions as a chaotic conception on all three counts. First, eradication as a fuzzy idea that has been defined and practiced differently over time, across diverse landscapes and spatial units, and with changing parameters for the circumstances under which it is possible. The results by era and type illustrate the many definitions and practices that developed in certain historical moments but continues to co-exist in both regulatory practice and the public imaginary. Second, despite the heterogeneity of eradication programs, eradication programs have been used to illustrate diverse (and sometimes contradictory) phenomena as: a government intervention to prevent overuse of pesticides (Anderson 2005; Walsh 2009), governments poisoning their own populace (Carson [1962] 2002; Kahn et al 1990; Murphy 1992), a driver of environmental decline (DeBach & Rose 1977), government overreach (Kahn et al. 1990), a sink for excess chemical stores (Russell 2001), a moral imperative to protect health (Stepan 2011), a result of troubling ethics (Rabb 1978), a regulatory necessity (Ebbels 2003), and an indicator of climate change (Marston et al. 2019) and increasing bioinvasions (Mack et al. 2000; Suckling et al. 2019). That final point, using eradication projects as evidence of increasing bioinvasions, is specifically discussed and teased apart in the Discussion section, where, by following Marx’s example of rendering concepts no longer chaotic but by both breaking them down in constituent parts but also contextualizing them in larger political economic structures.

By differentiating eradication programs by historical era and type, this paper both builds on previous work disambiguating “eradication” (cf. Popham and Hall 1958; Dahlsten and Garcia 1989; Myers et al. 1998, 2000; Perkins 1982; Simberloff 2009, 2014; Stepan 2011) and shows how competing definitions (and practices) of eradication continue to circulate, impacting public understanding and support for eradication programs. To describe the link between eradication as chaotic conception and eradication as catalyst for public controversies, we turn to the literature on public engagement with science.

2.2 Public Deficit Model

In their review, “Conflict in invasive species management,” Crowley et al. (2017) observe that social conflicts over invasive species management occur frequently. They identify nine “factors affecting conflict development” (ibid., 139), two of which are particularly salient to our analysis: 1) a top-down approach that assumes an un- and/or ill-informed public, what science and technology scholars refer to as the “public deficit model” (Wynne 1993; see also Wynne 2006; Irwin 2014),[1] and 2) legacies of conflict or failure.

The notion that techno-scientific information flows in one direction, from experts to laypeople, undergirds much environmental risk assessment (Cook et al. 2019), including regulatory responses to biological invasions (Crowley et al. 2017). As Crowley et al. (2017) explain,

> the general pattern is that (ecological or environmental) experts define the problem, evaluate evidence and management options, and advise decision makers, who must then persuade ‘the public’ (ie anyone who is neither an expert nor decision maker) to accept their decision, its justification, and its supporting evidence. However, this approach is poorly equipped to recognize and address difference in social values and risk perceptions. It can also trigger and rapidly polarize management conflicts (137).

The public deficit model assumes that if environmental regulators and their proxies communicate the facts well enough, then the public will follow along. When publics do not, then regulators often locate the fault in the unwillingness of laypeople to listen or trust them rather than reflecting on their own strategies

[1] The public deficit model predates the “public education model” (Callon 1999) referenced by Crowley et al. (2017) and has been more widely theorized. The public education model focuses on the method of remedying the ignorance of laypeople, through data dumping. By contrast, the public deficit model considers the processes that render lay knowledge unreliable in the first place, how epistemological conflict between lay and expert communities occurs, and the implications for democracy in how epistemological conflicts are resolved.

(Horst, Davies and Irwin 2017). Indeed, "the public is still routinely seen as a problem in science governance issues" (Stilgoe and Guston 2017, 862), and increased interaction with communities may even "exacerbate this imagined pathology" (ibid.). In other words, the notion that laypeople bring their own value systems, risk assessments, and epistemological frameworks for making sense of biological invasions and regulatory responses to contain them is seen as a problem to overcome rather than an opportunity for increased engagement. However, understanding how laypeople have built frameworks for making sense of eradication efforts is critical for managers, which bring us to another of Crowley et al.'s (2017) factors that affect conflict development: legacies of conflict or failure.

Laypeople in communities impacted by arthropod eradication programs have developed their own reference points to understand their local socio-ecological systems and how eradication will fit into that. Common referents include local histories of eradication programs, where the same species may have been targeted multiple times and/or different programs with similar methods have been employed (California Department of Food and Agriculture 1992, 1994; Division of Parks, the Commonwealth of Massachusetts 1981; Zalom et al. 2013). Also, the enduring legacy of Rachel Carson's discussion of USDA programs to eradicate the European gypsy moth (*Solenopsis invicta*) and imported fire ants (*Solenopsis richteri*) continues to inform public imaginaries of what eradication is.

Our analysis is particularly helpful for addressing why publics continue to characterize eradication programs in Carsonian terms (i.e., wide area, highly toxic, indiscriminate programs) despite trends toward eradication becoming the opposite (i.e., more targeted and less toxic), a paradox that continues to confound some regulatory agents who enact contemporary eradication programs (cf. Kawamura 2008). Laypeople pull from personal experiences as well as different definitions of eradication that have circulated across different time periods and types of targets. To understand how so many different versions of eradication have come to circulate, we analyzed U.S. changes in how eradication has been defined and practiced both historically and with respect to different kinds of insect populations. That process is described below.

3. Methods

3.1 Overview

The descriptive statistics in the macrotrends and typologies used in this paper derive from all entries on eradication programs initiated in the U.S. to eradicate arthropods in the Global Eradication Database, GERDA, an open source project assembled to document eradication programs around the world (Kean et al. 2015). The data subset was downloaded in Excel format, and subsequently cleaned and updated. The limits of the dataset are myriad. As an open-source project, the GERDA database contains only what contributors have volunteered. As such, there are missing programs, incomplete records, and sometimes programs that have been combined or separated in ways that other scholars might disagree with. The most common items, addressed in our data cleaning process, included: inaccurate or missing start and end dates, unknown program outcomes, and incomplete and/or inconsistent spatial data. We describe our process for addressing these immediately below. Despite its limitations, the dataset is one of the most complete records of eradication programs enacted historically, and we take it to be a representative sample of the historical record for the analysis here.

Before describing our data cleaning protocol, it is worth noting that eradication programs may lack an official end date for several reasons. A program may lack an end date because it is still in-progress or the outcome remains unknown. A program may also have no end date because it changed or was rolled into another program instead of concluding. While there are formal processes for declaring eradication in some instances, they are not universal or consistently applied across time, locations, or agencies involved. For example, the USDA released a proclamation on October 19, 2018 that the pink bollworm (*Pectinophora gossypiella*) had been eradicated from the continental U.S. after 100 years of effort (Perdue 2018). In comparison, the USDA functionally declares eradications of introduced populations of Tephritid fruit flies by lifting quarantines; regulatory letters released upon removal of quarantines sometimes include a specific reference to "eradication" (cf. El-Lissy 2019) or they may simply describe how long it has been since the target fruit fly was last detected (cf. Bech 2013).[2] In instances where a program has failed to eradicate, an end date may be even harder to determine. For highly publicized programs, agencies may share with the press and/or update their public-facing websites that they are now seeking to *control,* as opposed to *eradicate*, a target population, as occurred with the light brown apple moth in California (Jones 2010) and emerald ash borer across the Midwest and Great Lakes region.

3.2 Data Cleaning Process

Keeping the murkiness of dates and outcomes in mind, our team did identify instances in which programs had indeed concluded and the entry simply needed to be updated. To correct and add missing dates, the authors followed a protocol with the following steps: 1) consulting the references within the individual GERDA entry, 2) cross-checking the program on the North American Plant Protection Organization's Phytosanitary Alert System (www.pestalerts.org) and the National Plant Board's archive of letters to State Plant Regulatory Officials (https://nationalplantboard.org/laws-and-regulations/spro-letters/), 3) searching websites of federal, state, and/or county agencies responsible for enacting eradication program, and 4) searching and reviewing secondary literature through Web of Science. In adding end dates, we also updated the outcomes in instances in which the program had ended since the last update to GERDA.

Missing, incomplete, and/or unformatted spatial data, including location and maximum treatment area, was scrubbed and updated as possible. Location data varied considerably and included entries with neighborhoods, town names, county names, parks, states, and the entire U.S. Additionally, few entries had maximum treatment area listed, and ascertaining that information through subsequent research was not successful. Therefore, for the purposes of our analysis, we added: 1) the latitude and longitude of the centroid of the location listed for the program, and 2) a jurisdiction category to indicate the scale at which the program was enacted: 1) municipality, national or state park, or smaller unit, 2) county or multiple

[2] The Deputy Administrator of USDA Animal and Plant Health Services, Plant Protection and Quarantine, communicates alerts on phytosanitary issues and changes to phytosanitary regulations via SPRO letters. The letters are published and archived on the website of the National Plant Board (https://nationalplantboard.org/laws-and-regulations/spro-letters)

municipalities, 3) state or multiple counties, and 4) multi-state or entire U.S. The scale of the jurisdiction serves as a proxy for maximum spatial extent.

Our dataset only includes eradication programs targeting arthropods. As such, we removed programs that targeted nematodes, molluscs, bacteria/phytoplasma, fungi/oomycetes, viruses/viroids, protists/algae, and other organisms. Six observations of arthropod eradications were removed because either the entries in GERDA did not contain references and subsequent research could not ascertain whether or not an eradication project had taken place or because the references themselves did not indicate that an eradication project had occurred. There are 262 observations included in the dataset for the macrotrends and in the typology.

3.3 Historicizing Data

To historicize the GERDA data, which extends from 1890 to 2016, we turned to eras of pest management as described in entomology and environmental history. In 1980, Metcalf suggested that the modern era of pest control in the U.S. could be divided into three eras: the "Era of Optimism 1946-1962," marked by the introduction of DDT and general enthusiasm for new classes of pesticides, "the Era of Doubt 1962-1976," ushered in by Rachel Carson and growing concern over both the toxicity of pesticides but also their declining effectiveness due to developing insect resistance, and the "Era of Integrated Pest Management," which began in 1976 and introduced a new paradigm for managing insect pests with fewer chemicals. Dahlsten and Dreistadt (1991) built on Metcalf's periodization and suggested that since 1986, we were in the "Era of Sustainability," because of the "broad concern for sustaining productivity and life on the planet" (291). We bookend Metcalf and Dahlsten and Dreistadt's eras with a pre-modern era and a contemporary era. The Era of "Ecological Independence" (1890-1945) comes from Pauly's (2000) description of the time period in which the U.S. established phytosanitary laws, which also established federal authority to enact eradication programs.[3] We term the contemporary era, the Era of Trade (1995-

[3] Pauly (2000) derives the term "ecological independence" from Alfred Crosby's (1986) term "ecological imperialism," which describes how European colonizers modified local ecological systems to reflect their own aesthetic values and economic interests

present), which begins with the establishment of the World Trade Organization (WTO) and the enactment of the Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS agreement"), which dictate the terms of eradication for a majority of contemporary eradication projects.

In our analysis of the GERDA data, we have modified Metcalf's original dating slightly in order to divide data by whole years. Thus, the periods as we refer to them are:

- Era of Ecological Independence, 1800-1945
- Era of Optimism, 1946-1962
- Era of Doubt, 1963-1975
- Era of Integrated Pest Management, 1976-1985
- Era of Sustainability, 1986-1994
- 1995 - present Era of Trade, 1995 - present .

3.4 Development of Typology

We then went through a process for categorizing each eradication program (or groups of programs) targeting a particular insect into a four-part typology. To develop the typology, all projects aimed at eradicating a target species were grouped together. Hereafter, we refer to these groupings as "efforts," which may include a single eradication project or multiple projects (up to a maximum of 80 for *Lymantria dispar dispar*). It was an iterative process of: 1) visual analysis of program duration and frequency in *D3*, a data visualization and exploration library, 2) visual analysis in *Excel*, *R*, and *D3* of each of the four types vis-à-vis the variables of program count, duration, location(s), start date(s), target taxon, and outcome, and 3) review of contemporary and historical discourse related to target taxon in regulatory documents, primary sources (including historical documents accessed through the National Agricultural Library, the National Archives and Records Administration, UC Davis' Shields Library),

by, for example, introducing rabbits and camels to Australia (Ritvo 2014) or extirpating cougars in Canada (Collard 2012). Pauly (2000, 73) notes that the focus of settler colonialism on managing the flow of species in and out of new territories increased after 1890, resulting in greater international trade of biological material as well as fear of "foreign pests and parasites:" "In particular, leaders of USDA biological science worked systematically to manage species and varieties whose presence or absence could affect the well-being of American citizens." The term "independence" highlights how the framing and systems developed to protect plant health in this era were about protecting national interests from foreign elements.

secondary literature, media coverage, and professional meetings (from the first authors' observations at the Entomological Society of America meetings in 2014 and 2017 and the California Invasive Species Council between 2016 and 2018).

We decided to group projects to eradicate a single species into "efforts" for two reasons. First, most species have been targeted only a handful of times, often close together. Second, and more importantly, even if a species has been targeted for eradication with different control methods, over different lengths of time, and/or the specific populations of the species have been established or recently introduced (all of which is true, for example, of the most frequently eradicated species in the U.S., the European gypsy moth), the eradication projects are linked in the public imaginary. Public comments on environmental impact reports for European gypsy moth eradication projects in Massachusetts and California in the 1990s, for example, reference the USDA's massive, chemical-intensive 1956-1960 European gypsy moth eradication program (California Department of Food and Agriculture 1992; Division of Parks, the Commonwealth of Massachusetts 1981) and lawsuits have frequently followed European gypsy moth eradication projects across the Western U.S. (Scribner 1989).

The typology schema, described in more detail below, runs along two axes that represent a composite of several variables. Efforts aimed at eradicating a target species were assessed as a group for: 1) how targeted or broad they were and 2) how frequently they were enacted.

We refer to how targeted or broad efforts to eradicate the same species have been as "targetedness." Targetedness considers how long the average eradication program for that insect was (the duration) and the spatial scale (by jurisdiction) at which the program(s) were enacted. When known, targetedness also includes the general consensus of how established the target population(s) was/were prior to enacting the eradication program(s). A group was classified as "targeted" if it met three criteria: it lasted six or fewer years in duration, the majority of programs were enacted at the municipal/park or county level, and the populations targeted were recently introduced to the area. This fits contemporary definitions of eradication in regulatory statutes and invasion biology: the removal of all individuals of a distinct *alien* population, which is not contiguous with other populations (Simberloff et al. 2013; Pysek &

Richardson 2010). Broad programs, by contrast, lasted seven or more years; included programs enacted at the state; regional, or national level; and/or targeted endemic or naturalized species.

Frequency considers how many times a species has been targeted for eradication from the U.S. and how clustered the eradication programs have been over time. How many times a species has been targeted for eradication was determined by counting the final number of entries for that insect in our dataset. Spatial clusters were determined by plotting the latitude-longitude centroids of the programs in D3. High-frequency programs generally were enacted four or more times over the entire study period and occurred in one or more clusters. Low-frequency programs were enacted three or fewer times and in one or no spatial cluster.

Fifty-one efforts, which included 262 individual eradication projects targeting 51 species, were then classified and plotted into four quadrants (types) based on their targetedness and frequency rankings. We then paired descriptive statistics with secondary sources and archival material to describe each subset within each quadrant.

4. Results

Results are presented in two major sections. The first describes the macrotrends of eradication projects targeting arthropods in the U.S. between 1890 and 2016. We describe changes in: 1) the rate of initiating eradication projects, 2) the control methods used, and 3) the relative targetedness of programs (based on duration, spatial extent, and how established the target population was). This section ends with a brief consideration of trends by era. The second section develops a typology of eradication efforts, targeting 51 species across 262 programs in the U.S. The section describes each of the types through descriptive statistics from GERDA and situates them within the larger discourse of eradication in the U.S. The macrotrends section uses each individual eradication project as the unit of analysis. The typologies section refers to efforts as the unit of analysis.

4.1 Macrotrends

Our analysis of the GERDA data shows that, since 1890, eradication programs have become more numerous, employ a greater diversity of control methods, and are more likely to be shorter (in years enacted) and smaller (in terms of both average max area treated and by size of jurisdiction).

4.1.1 Rate of Initiating of Eradication Programs In the U.S. the rate at which eradication programs have been initiated was low and sporadic through the Era of Ecological Independence (1890 - 1945). The rate increases in the 1950s (during the Era of Optimism, 1946-1962), continues to rise through the 1970s (during both the Eras of Doubt and Integrated Pest Management), peaking in 1981, drops off (during the Era of Sustainability) then increases again starting in the mid-nineties, which corresponds with the Era of Trade (which beings in 1995), peaking again in the early 2000s (Figure 1). These findings are similar to what Suckling et al.'s (2019) analysis of the GERDA data found for rate of initiating eradication projects worldwide, where they identified changes in rate at two break points: 1956 and 1995.

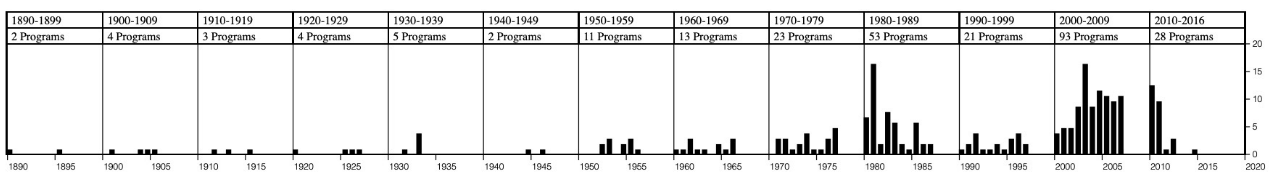

Figure 1: Histogram of start dates for eradication programs in the U.S. (designed by Michael Weinberg)

4.1.2 Diversifying Eradication Methods Since the first eradication program, in 1890, new methods of control have been developed and employed in eradication programs. Figure 2 shows the portfolio of control methods used in eradication programs by era and year. It is worth noting the diminishing share of pesticides in the portfolios over time, especially in the most recent programs, in the Era of Trade. The spike in pesticide usage during the Era of Integrated Pest Management is noteworthy and may indicate a schism between research and regulatory approaches to pest management during that time (with research in IPM focused on alternatives to pesticides, as described by Metcalf (1980), while regulatory agencies enacting eradication projects were slower to seek and adopt alternatives). Trends among other control methods also merit attention. Removal of host material, for example, was a significant method deployed in the earliest eradication programs, during the Era of Ecological Independence. In the decades after the introduction of organochlorine and organophosphate pesticides, the Eras of Optimism and Doubt, host removal was not attempted. However, host removal has expanded considerably over the past three eras. Similarly, movement control and quarantines were employed in 11% of eradication programs in the Era of Ecological Independence, minimally in the Eras of Optimism, Doubt, IPM, and Sustainability, and then jumped up to being employed in 23% of eradication programs in the Era of Trade.

In the 1890s two eradication programs were undertaken, to eradicate the European gypsy moth (*Lymantria dispar dispar*) and the brown-tail moth (*Euproctis chrysorrhoea*). Both relied on the hand removal of insects. The brown-tail moth program additionally employed the removal of host material, and the European gypsy moth program used Paris Green, a copper-arsenical insecticide (Spear 2005). This mix of removal of host material, hand removal, and early pesticides (inorganic compounds primarily based on arsenic or cyanide) persisted in eradication projects through the 1930s, which targeted veterinary, horticultural, and forest insect pests. Movement control (via quarantines) was introduced in the 1910s, which corresponds to the enactment of the federal Plant Quarantine Act in 1912, and bait sprays in the 1920s, a mixture that combined an attractant and insecticide, such as sugar syrup with lead arsenate (Bottle 1929).

By the 1940s, the start of the Era of Optimism, pesticides dominated the portfolio and host removal dropped away completely. With the exception of the eradication program to eradicate the New World screwworm (*Cochliomyia hominivorax*), all programs initiated in the 1950s for which there is control method data relied on synthetic pesticides to the exclusion of all other methods. The screwworm eradication project started in 1958 was the first eradication program in the U.S. to employ sterile insect technique (SIT). SIT involves rearing, sterilizing, and then releasing millions of the target insect; populations drop as wild insects breed with the sterile insects and fail to produce offspring (Bushland, Lindquist, & Knipling 1955). From 1958 onward, SIT has been a consistent part of the overall portfolio of eradication programs, with its use increasing considerably in the past 20 years.

Conventional pesticides, unsurprisingly, dominate eradication programs in the 1960s but start to decline in the 1970s onward (as the Era of Optimism gave way to the Era of Doubt). Several key alternative methods were introduced in the 1970s, following the establishment of the Environmental Protection Agency, landmark national and state environmental and health protections laws, and the rise of the environmental movement (marking the beginning of the Era of Integrated Pest Management). These methods included biopesticides, which Kean et al. (2016) define as pesticides based on "naturally occurring substances" or "microorganisms that control pests" such as *Bacillus thuringiensis*, pheromones for lures and mating disruption, and mass trapping. Quarantines also re-appear and persist through today. The 1980s sees a continuation and growth of these new methods plus the addition of natural enemies and, notably, the return to removing host material (which corresponds to the Era of Sustainability). The 1990s continues this mix, with a substantially greater share of biopesticides. The mix persists into the 2000s, corresponding with the Era of Trade, with even greater reliance on the removal of host material, lures, and quarantines. All in all, the trends show a responsiveness to popular pressure and regulatory shifts toward minimizing conventional pesticide use, taking advantage of less- or non-toxic technological developments, and even the return of one low-technology control method, removal of host material.

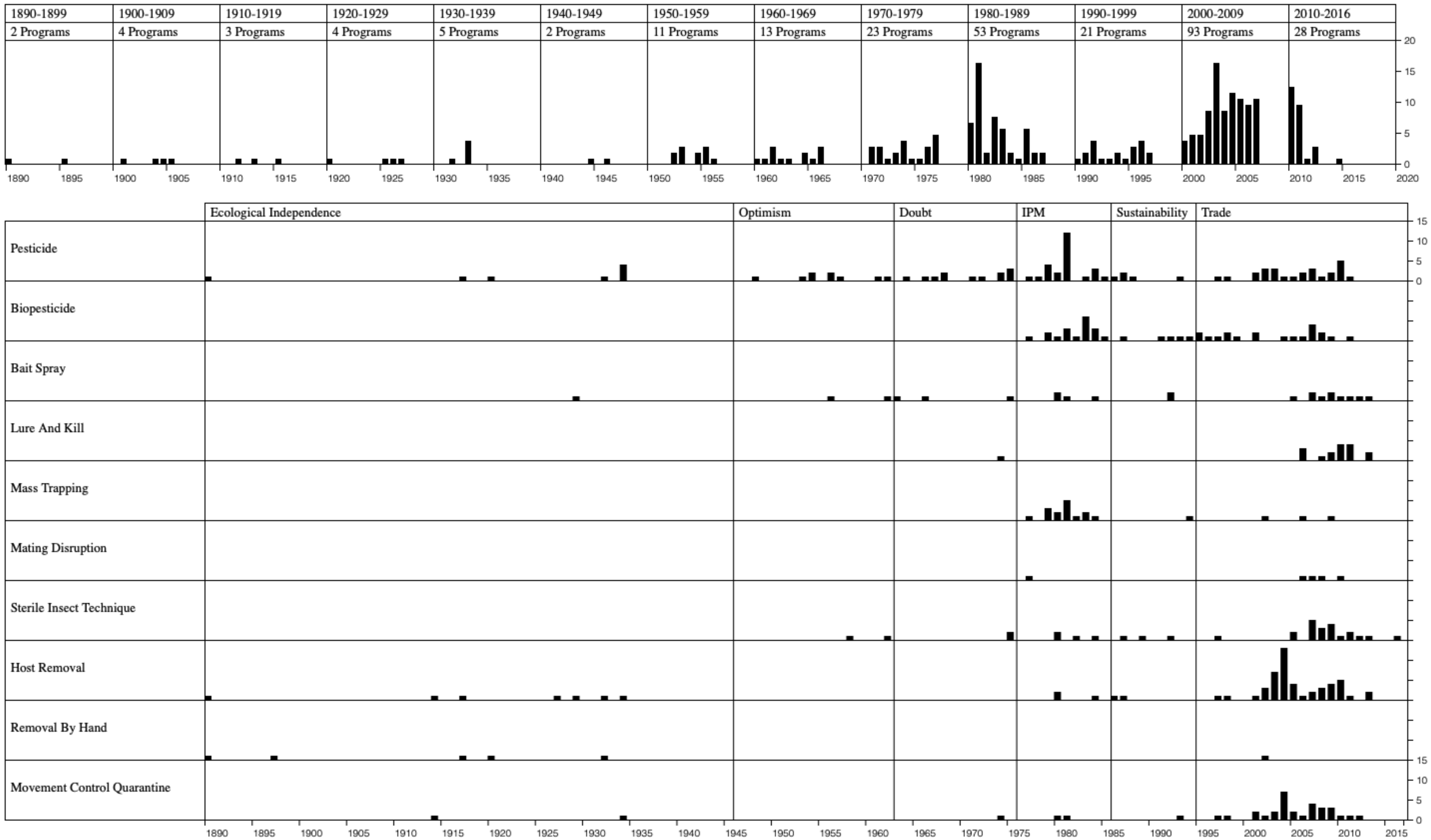

Figure 2: Control methods used in individual eradication projects by era and year the project was initiated. Most projects employed one or more control methods. (Designed by Michael Weinberg)

4.1.3 Increasingly Targeted (Duration, Spatial Extent, Establishment Status) Between 1890 and 2016, the duration and size of eradication programs has decreased. Early eradication programs tended to last several years, and in some cases, decades. How long eradication programs last, their duration, has decreased over time. Eradication programs started in the Era of Ecological Independence, 1890-1945, averaged 19.88 years; in the Era of Optimism, 1946-1962, 8.11 years; in the Era of Doubt, 1963-1975, 4.05 years; the Era of IPM, 1976-1985, 2.52 years; the Era of Sustainability, 1986-1994, 2.35 years, and the present era, the Era of Trade, 1995 to present, 2.04 years.

The jurisdiction data by era shows the trend toward smaller programs, the number of eradication projects targeting the entire U.S. or multistate region declines from seven in the Era of Ecological Independence to just one in the Era of IPM and all subsequent eras. Meanwhile, 101 of the 132 eradication projects enacted in the Era of Trade target municipalities or parks. But we can also look at the maximum area treated directly when aggregated by era. Only 123 of the 262 observations in the dataset included information on the maximum area treated.[4] The average maximum area (in hectares) treated by era were: 72,581,209 in the Era of Ecological Independence, 276,043 in the Era of Optimism, 140,338 in the Era of Doubt, 13,108 in the Era of IPM, 21,004 in the Era of Sustainability, and 3,061 in the Era of Trade. Taken together, the trends in duration and size of eradication programs indicate a general trend toward ever-increasing targetedness.

Although the GERDA dataset does not contain comprehensive information on the establishment status of targeted populations, some general trends emerge. Programs initiated before 1945 often targeted nuisance insects that were either introduced but already established, such as the European gypsy moth and brown tail moth, or endemic to the region, such as a variety of veterinary pests, including horse mange mite, sheep scab mite, and cattle tick. By comparison, 40 of the 85 eradication programs enacted between 2006 and 2016 targeted newly detected tephritid fruit fly populations, all of which triggered quarantines and pest alerts to international trade partners.

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[4] 5 out of 18 programs in the Era of Ecological Independence; 5 out of 18 in the Era of Optimism; 7 out of 21 in the Era of Doubt; 37 out of 52 in the Era of IPM; 7 out of 20 in the Era of Sustainability; and 62 out of 139 in the Era of Trade

Taken together, the macrotrends in practice reflect changing notions of eradication, from a large push to exterminate injurious insects, both endemic and introduced, from the U.S.—an idea that peaked in the early 20th century—to targeted removal of small and recently introduced populations. Along with becoming increasingly targeted, eradication programs in the U.S. have also employed a greater mix of control methods. The use of conventional pesticides in eradication programs has decreased while the use of sterile insect technique, movement control/quarantine, host removal, and methods incorporating pheromones (mating disruption, lure and kill, and mass trapping) have become more common.

4.2 A Typology of Eradication

Here we turn to the spatial and temporal extents of insect eradication programs in the United States, and the extent to which these differences allow for conceptualizing distinct types of insect eradication. We develop a typology of four kinds of programs.

The typology runs along two axes, "targetedness" and "frequency" (see figure 3). The midline describes the middle of the continuum for each axis. Table 1 describes the elements in the axes: targetedness is defined by a combination of duration of programs (in years), spatial extent (determined by the political jurisdiction of program), and, when known, how established the target population was prior to being targeted for eradication. Frequency refers to the number of times an insect pest has been targeted for eradication across the U.S. between 1890 and 2015 and how closely spaced those individual projects were. A species may be targeted with greater frequency due to invasion of areas adjacent to previous eradication projects (Myers et al. 1998), reinvasion (Myers et al. 1998, 2000; Banks et al. 2018), fluctuating populations or cryptic invasions, which may go undetected for long periods of time, (Carey 1991; Papadopoulos, Plant & Carey 2013), proximity to major pathways, such as airports (Leibhold et al. 2006), and/or renewed political will (and associated funding and technology) to eliminate long-standing pests, such as the boll weevil (*Anthonomus grandis*). The uncertainty and contestation over the drivers of frequent programs are discussed in greater detail in the following sections.

	Low	**Midline**	**High**
Targetedness			
- Duration (years)	8+ years	7 years	1-6 years
- Spatial Extent	Multi-State, National	State	Municipalities, Parks, and Counties
- Establishment Status	Widespread, multiple generations		
Frequency			
- Total discrete programs targeting species in US	1-2	3	4+
- Clustering	Single points		Multiple proximate points

Table 1: Continuum and parameters for targetedness and frequency in typologies

As noted above, we did not include program outcomes, i.e., whether or not the eradication was achieved, in the typology. We excluded outcome, because a) the standards for declaring eradication a success have varied over time and b) many official successes have been contested. In sum, if eradication is a chaotic conception, as we argue, then the outcome is similarly chaotic. We discuss these trends further in the Discussion.

Classifying eradication programs along these two axes allows for a four-part typology, as seen in Figure 3 (below). The four types include: Type 1. Discrete Responses; Type II. Repeat Responses; Type III. Failed Wars, and Type IV. Grand Battles. Table 3 shows some basic descriptive statistics for the different types of eradication campaigns. Below we examine each type in turn.

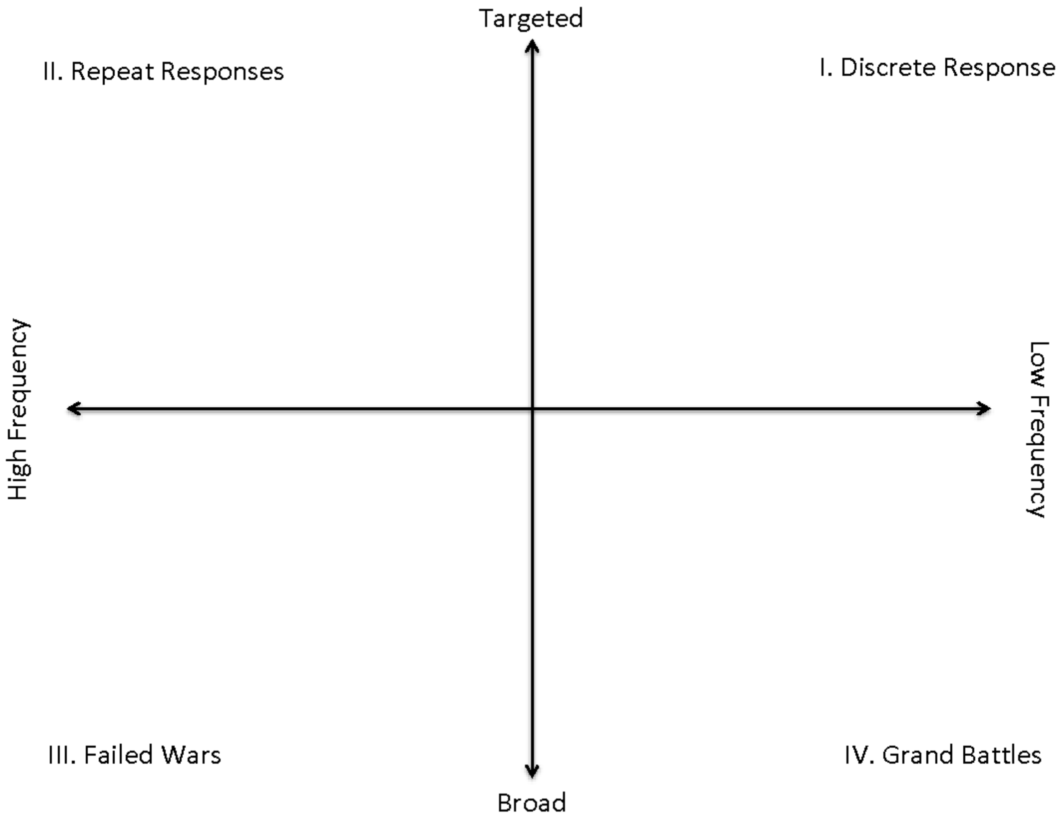

Figure 3: Overview of axes and quadrants

[see/insert QuadrantSummaryStats.csv]

Table 2: Descriptive Statistics of the Four Eradication Types

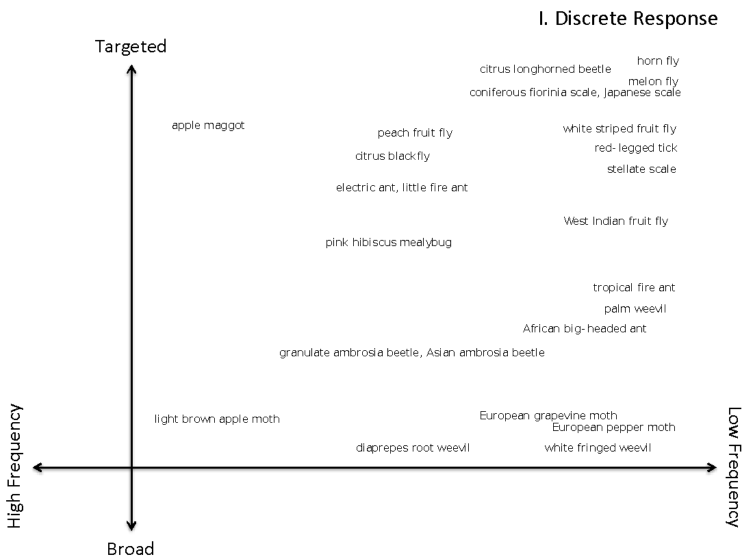

Figure 4: Type I

4.2.1 Type I: Discrete Response Type 1. Discrete Response includes programs that are highly targeted and low frequency. It consists of 25 programs targeting 20 species, with programs lasting an average of 2.6 years. Discrete responses target insect pests that are newly detected over small geographic areas (68% targeted a municipality or park; 8% a county; 24% targeted a portion or entire single state). None have been enacted at a range larger than a single state. As Myers et al. (2000) note, "The rapid discovery of a newly introduced species might allow its elimination on a relatively small scale and with greater probability of success owing to its less widespread distribution" (316). Discrete responses are surgical strikes excising an ecological anomaly before it has a chance to establish.

Figure 4 shows all of the insect pests targeted by discrete responses, according to the targetedness and frequency. Target insect pests in the far, upper-right-hand corner have been targeted over the shortest time periods, smallest geographical area (municipalities and parks), and only one time. Target insect pests lower in the quadrant have been targeted for longer periods of time and/or larger geographic areas. As they reach the central axis points, they become more likely to migrate into another type due to frequency of eradication efforts — such as the programs to eradicate the apple maggot (*Rhagoletis pomonella*) and light brown apple moth (*Epiphyas postvittana* — or the broadness of eradication effort — such as the one targeting the European grapevine moth (*Lobesia botrana*), which expanded in both duration and spatial extent.

Figure 5: Clustering Map of Type I: Discrete Responses

Discrete responses have distinct spatial distributions. Figure 5 shows a map of clustering for discrete responses, and is dominated by programs in states with very high volumes of Under the banner of "eradication," governments (and a handful of philanthropies) have sought to remove insect pests, through a wide variety of programs. Programs may be distinguished by the species targeted—endemic or newly introduced—the geographic scale—from a few city blocks to the entire world—and the duration— ranging from weeks to eternity. Scholars within entomology and public health have long noted the plasticity and limits of "eradication" (cf. Popham and Hall 1958; Dahlsten & Garcia 1989). Debates over the meaning, viability, practice, and ethics of insect eradication in the U.S. arose concurrent with the earliest programs and have persisted to today (cf. Newell 1914; Popham and Hall 1958; Knipling 1978; Rabb 1978; Dahlsten and Garcia 1989; Myers et al. 2000; Pluess et al. 2012; Tobin et al. 2014; Liebhold et al. 2016; Suckling et al. 2019). Throughout, there has been a general consensus that insect eradication programs should be spatially bounded and target recently introduced species. This understanding animates how most contemporary programs are operationalized. However, the history of eradication in the U.S. is marked by periods of paradoxical definitions and practices of eradication, where the word is defined among experts as something quite specific and, inferentially, small or targeted, yet the programs enacted and described by those same experts were anything but. agricultural trade — California, Texas, and Florida — alongside an orchard growing region in Oregon and a grouping in the New York Metro Area (see figure 5).

Largely framed in terms of preventing the establishment of invasive species, discrete responses can effectively prevent damage both from pests and the portfolio of chemicals that would be required to contain the pests were they to become established. Suckling et al.'s (2019) argument that eradication is a tool to prevent collapse of food systems, public health, and ecosystems typifies this framing: "Failure to exclude or eradicate major pests has long term consequences for pest management as pest numbers accumulate on crops and ultimately threaten food security and natural ecosystem integrity, while driving up reliance on conventional broad-spectrum pesticide use" (p. 6). That said, the portfolio of pest management methods for type I is diverse but still relies heavily on conventional pesticides (14 of 34 eradication projects or 41%). The remaining control methods include (in descending order): movement control/quarantine (21%), host removal (15%), lure and kill (9%), mating disruption (9%), SIT (6%), mass trapping (3%), removal by hand (3%). Note that many projects employ several control methods and that no data on control methods exist for 14 of the Type 1 projects.

4.2.2 Type II: Repeat Responses Repeat Incursions/Perennial Emergency (Type II) includes eradication programs that are enacted as a series of discrete responses. Highly targeted, they seek to eliminate recurring infestations from the same or nearby locales of the same species.

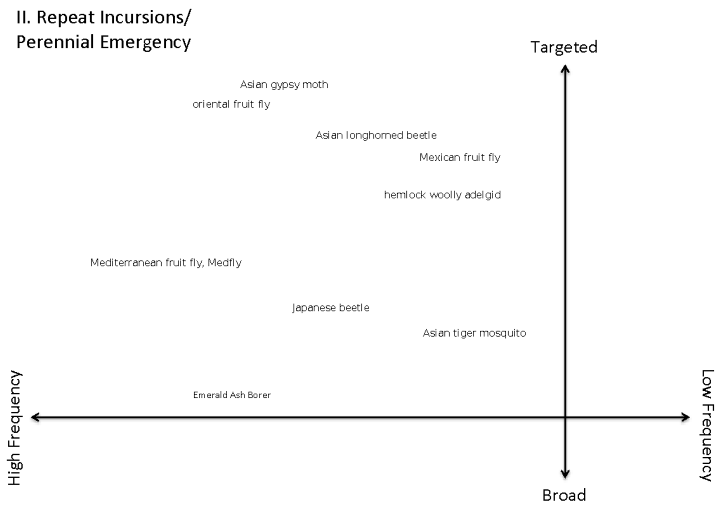

Figure 6: Type II Responses

Type II includes 118 distinct programs to eradicate eight target species. With the exception of the programs to eradicate the Emerald Ash Borer (EAB) (*Agrilus planipennis*), the programs are highly targeted with 75% occurring within a municipality or park and 11% within counties. Twelve percent target multiple counties or states, and less one percent (indeed only one project) targeted a regional/national scale. Type II targets tend to cluster near major international transit hubs along the coasts and Great Lakes. The clustering highlights how a majority of the Type II efforts are to control pests that pose economic threats; seven of the nine species must be reported to international and/or domestic trade partners if detected in the U.S. or specific regions of the U.S.[5] The clusters of projects to eradicate tephritid fruit fly— including the Mediterranean fruit fly (*Ceratitis capitata*), the oriental fruit fly (OFF) (*Bactrocera dorsalis*), and Mexican fruit fly (*Anastrepha ludens*) — are evident in the cluster map below, especially in Southern California. The FAO (2017) notes that:

> Tephritid fruit flies cause major losses in fruit and vegetables, and are often the target of intensive insecticide applications to protect

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[5] Asian gypsy moth, Asian longhorn beetle, Emerald Ash Borer, Mediterranean fruit fly, Mexican fruit fly, and oriental fruit fly must be reported to international trade partners under WTO agreements; detections of the Japanese beetle in "uninfested" states in the U.S. must be reported to domestic trade partners under the National Japanese Beetle Harmonization Plan. By contrast, regulatory agencies pursue eradication against the hemlock woolly adelgid for conservation purposes (Reardon and Onken 2011) and the Asian tiger mosquito for public health purposes.

> commercial production. In addition, few pests have a greater impact on world trade in agricultural products than tephritid fruit flies. Their economic consequences are so great that countries free of the major tephritids (Chile, Japan, New Zealand and USA) prohibit the import of fresh produce from countries where these pests are endemic and have active detection and emergency response programmes in place to maintain their fruit fly free status.

Eradicating incursions of tephritid fruit flies is imperative for the U.S. to maintain its pest-free status, and privileged position within the international market of fresh fruit and vegetables. Projects to eradicate EAB account for many of the clusters in the Upper Midwest (see more on EAB below). The national project to eradicate EAB is visualized as the large dot in the centroid of the continental U.S (Figure 7).

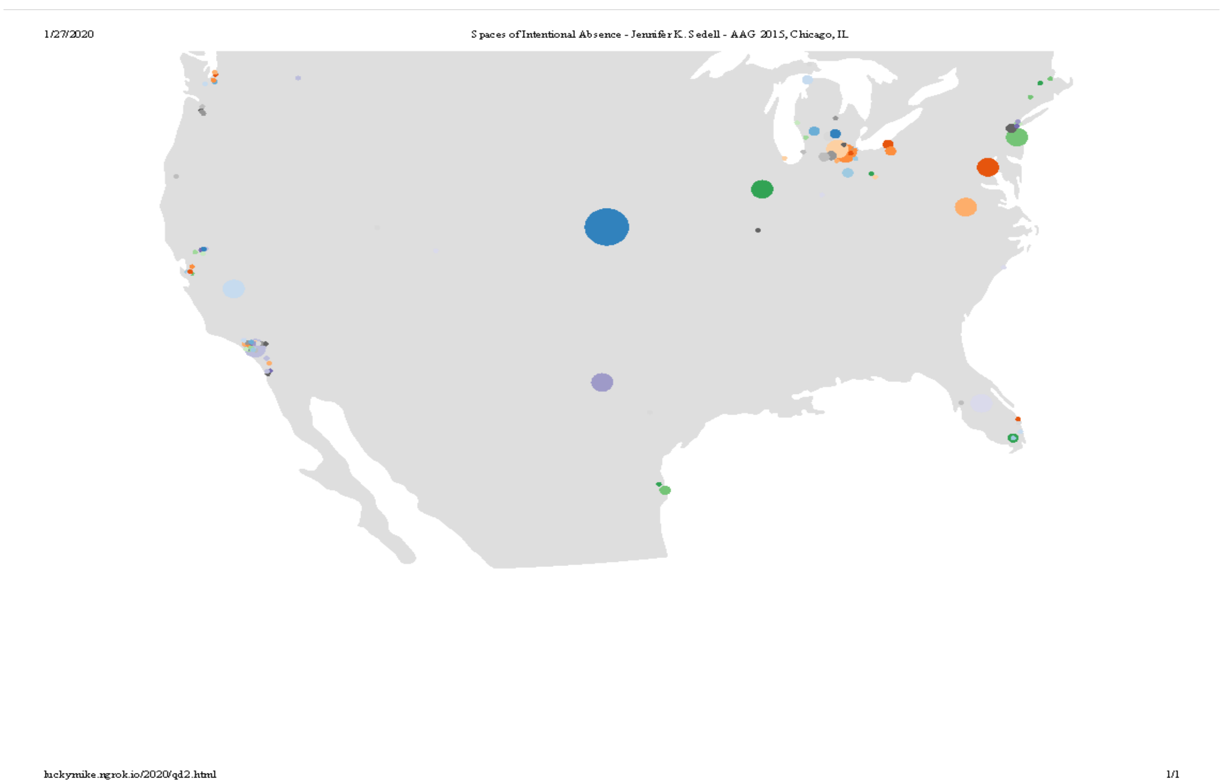

Figure 7: Type II Clustering

Eradication projects within type II efforts boast the greatest mix of control methods (by percentage, in descending order): host removal (36%), movement control/quarantine (22%), SIT (20%), conventional pesticides (19%), bait spray (19%), biopesticides (12%), lure and kill (12%), mass trapping (3%), mating disruption (1%), removal by hand (1%). Many projects employ more than one control method. No data were available on control methods for 20 projects. Overall, Type II efforts utilize fewer conventional pesticide treatments than Type I efforts. This finding is noteworthy given that some of the most high-profile eradication projects included in Type II efforts are famous for their use of conventional insecticides in urban areas, including spraying malathion from helicopters over California cities in the 1980s to eradicate the Mediterranean fruit fly and spraying a triumvirate of conventional pesticides to eradicate the Japanese beetle in Sacramento in the 2010s.

The frequency with which Type II species have been eradicated has raised questions about what eradication means and how it is practiced. Within academic and regulatory circles, there is an active debate over whether populations of tephritid fruit flies in California are established and persist at sub-detectable levels or have been repeatedly introduced and eradicated. All 32 programs listed to eradicate the Mediterranean fruit fly, of which eight are in the LA Basin, five in the Santa Clara Valley, and four in the San Diego metro area, in GERDA are classified as "eradicated" or "likely eradicated." Similarly, all 18 programs to eradicate OFF are all listed as "eradicated" or "likely eradicated." The six programs to eradicate the Mexican fruit fly are all listed as "eradicated" or "likely eradicated."

The programs to eradicate the EAB fall into Type II but follow a slightly different pattern. Whereas most other target species in this quadrant have been repeatedly targeted in clusters over time, 23 programs to eradicate the EAB were rolled out across Indiana, Michigan, Ohio, and Maryland between 2003 and 2005. All 23 are listed as "failed," and 22 were abandoned within two years. Therefore there were a large number of regionally coordinated, locally enacted programs to eradicate the EAB. The EAB eradication effort is situated closest to "broad" along the targetedness axis and shares some characteristics with Type III efforts, namely that the geographic areas over which regulatory agencies attempted to eradicate EAB was so large and EAB populations were ultimately determined to be established.

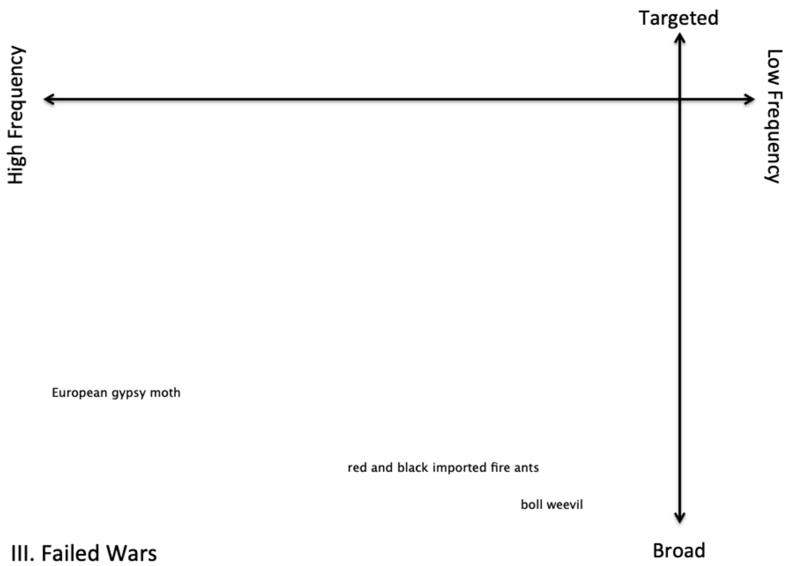

Figure 8: Type III

4.2.3 Type III. Failed Wars Type III eradication programs targeted established populations over wide areas over several years at a time, over multiple efforts. According to the GERDA database, there were four programs to eradicate the boll weevil (*Anthonomous grands*), which lasted an average of 12.67 years each (one is listed as in progress). Three of the four programs were multi-state or national; the fourth was in a single state. There were seven programs to eradicate imported fire ants (*Solenopsis invicta* and *Solenopsis richteri*), which lasted an average of 12.95 years. Two of the seven programs were national in scope. The majority of the programs in the quadrant, however, include those targeting the European gypsy moth (*Lymantria dispar dispar*). The European gypsy moth has been targeted for eradication 70 times in the U.S. Programs have lasted between a few months and 15 years, averaging 3.2 years. The scale of the programs is similarly variable: one multi-state program, seven state-wide, 20 county and multi-municipalities, and 42 single municipalities or parks. The map of programs (figure 9) features large markers in the middle of the country, the northeast, mid-Atlantic states, and the southeastern U.S. These are centroids of national and regional programs. The smaller dots showcase the more targeted programs, primarily for the European gypsy moth, that have occurred throughout the Great Lakes and Pacific Coast.

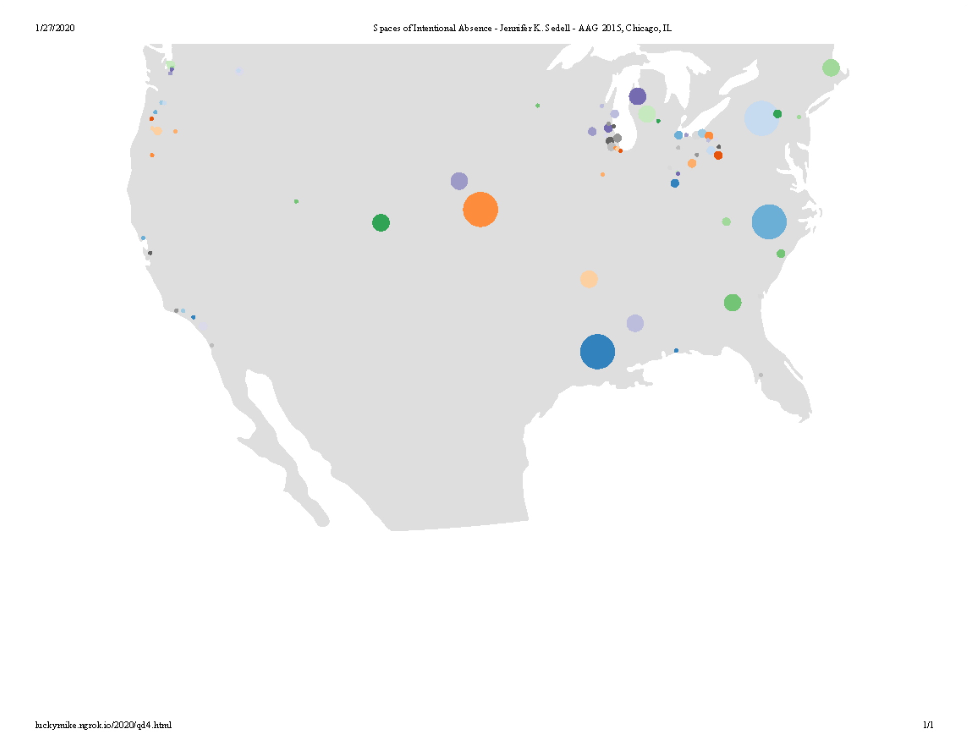

Figure 9: Type III Clustering

The pest control methods for Type III programs are diverse, mainly owing to changing methods to eradicate the European gypsy moth. A little over half have utilized conventional pesticides (52%), including two of the four targeting the boll weevil, five of the seven targeting importing fire ants, and 35 of the 70 targeting the European gypsy moth. Other methods have included: biopesticides (33%), mass trapping (17%), host removal (12%), removal by hand (3%), SIT (3%), movement restrictions/quarantines (2%), and mating disruption (1%).

In *Silent Spring*, Rachel Carson (1962) brought attention to the USDA's national and multi-state projects to eradicate the European gypsy moth and imported fire ants utilizing organochloride pesticides during the Era of Optimism. Her critique not only introduced the public to impacts of new classes of pesticides, but also to the concept of eradication itself. "'Eradication,'" she argued, "means the complete and final extinction or extermination of a species throughout its range. Yet as successive programs have failed, the Department [of Agriculture] has found it necessary to speak of second or third 'eradications' of the same species in the same area" (1962, p. 157). The failure of these famous programs not only refers to the outcome of the eradication efforts, but also ecosystem externality failure (the damage to the ecosystems into which the USDA intervened) and failure of securing public support.

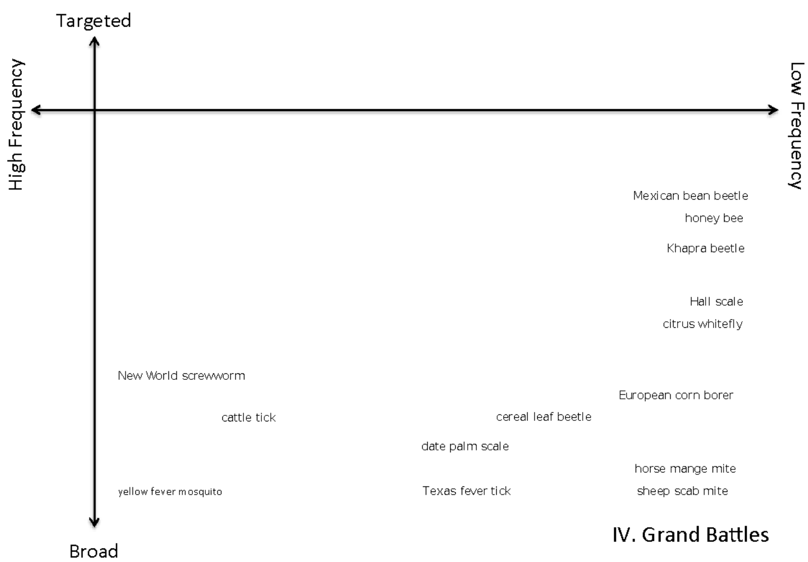

Figure 10: Type IV

4.2.4 Quadrant IV: Grand Battles Type IV includes some of the most widely-cited successful eradication programs in the U.S., including cattle tick (*Rhipicephalus microplus)*, Texas fever tick (*Rhipicephalus annulatus*), and the New World screwworm. The programs were massive and generally long, typically extending across multiple states (38% were enacted across multiple states or nationally; 43% targeted an entire state) and lasted between four and 65 years (average duration was 17.9 years). 21 programs are classified as Type IV; 14% included conventional pesticides, 14% SIT, 10% host removal, 5% movement control/quarantine, 5% removal by hand, 5% natural enemies. No data on control methods is available for 12 of the 21 individual projects included in the efforts.

Type IV programs, particularly the projects targeting veterinary pests, have served as touchstones for advocates of , eradication policies and informed the public imagination of what successful eradication looks like (cf. Knipling 1978). However, Type IV also includes programs targeting horticultural pests with variable results. Despite the mixed outcomes of the programs in this quadrant, they are linked by a shared framing and approach: a sustained effort to achieve complete removal of a species from the territory over which the U.S. government has jurisdiction, and, once achieved, or determined to be unachievable, further efforts were ceased as reflected in their low frequency numbers.

Several programs to eradicate veterinary pests were initiated in the early 1900s and persisted for decades, including efforts to eradicate the sheep scab mites (*Psoroptes ovis)* (1905-1970), horse mange mite (*Sarcoptes scabiei equi)* (1901-1935), cattle tick (*Rhipicephalus microplus)* (1912-1943), and Texas fever tick (*Rhipicephalus annulatus*) (1906-1943). The methods of eradication evolved over the century as old chemicals were phased out and new ones became available. Texas fever tick, for example, was treated by dipping animals in Texas black oil, soap and water up until 1910 when the formulation was replaced by an arsenic dip and then later by DDT (Graham and Hourrigan 1977). Additionally, ticks were removed by hand early on and quarantines applied to cattle from impacted areas. However, the persistence paid off. The Texas cattle tick program was hailed as "largest and most successful eradication program ever undertaken" (Knipling 1978, 47). The toxicity of the program's methods were justified because the program's "success has alleviated the need for environmentally hazardous dips and sprays on millions of cattle during the intervening years" (ibid.).

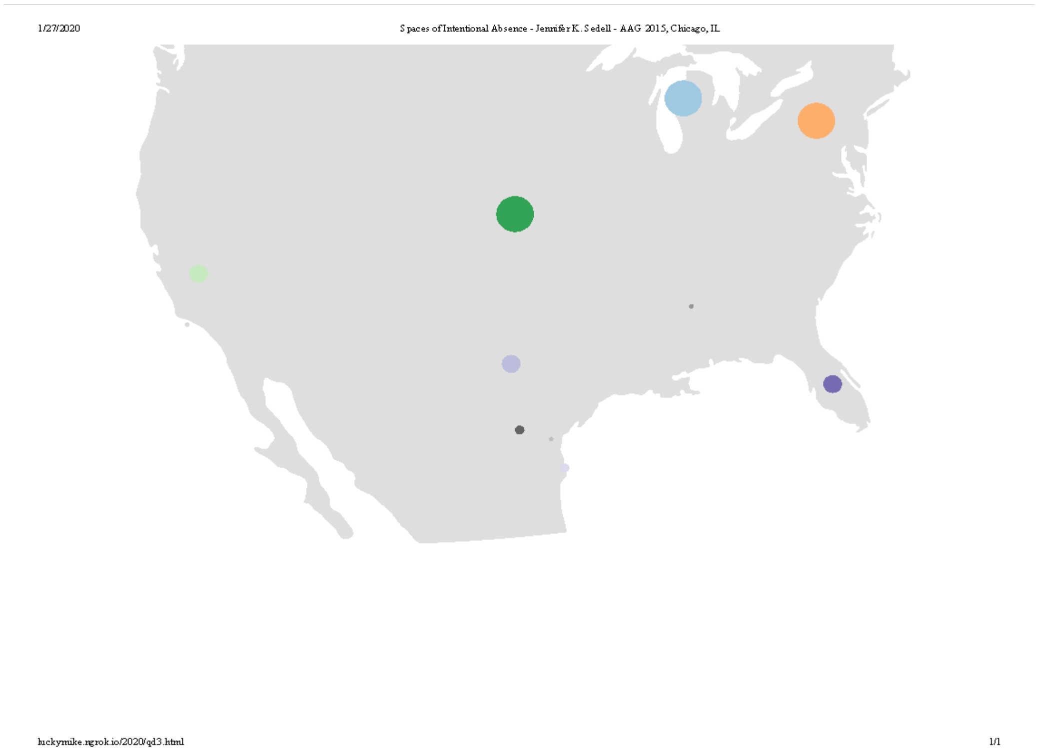

Figure 16: Type IV Clustering

Contemporaneous programs to eradicate pests impacting horticultural production were not, however, as successful. Sixty-two years of throwing the newest chemicals and technologies at the citrus whitefly (*Dialeurodes citri*) (1906-1968), for example, never succeeded. In their review of efforts to eradicate citrus whitefly in California, Rose and DeBach (1981) catalogue varied methods, including host removal, cyanide fumigation, DDT, carbaryl, malathion, and, for the last few years, natural enemies. In GERDA, these various approaches are all collected under a single umbrella eradication project, and the historical record is unclear as to whether the regulatory agencies defined the eradication attempt as a single, on-going project or a series of discrete attempts. Ultimately, Rose and DeBach concluded the citrus whitefly is established in California.

There is also the curious case of the brown-tail moth (*Euproctis chrysorrhoea*), which was discovered in 1897 in Somerville, Massachusetts, and quickly spread across the Eastern U.S. and parts of Canada (Collins 2021; Elkinton et al. 2006; Spear 2005). Regulatory agencies had been waging a battle against *Lymantria dispar dispar* in Massachusetts, and the New England region more broadly, since 1890 and were deeply concerned about another forest pest (Howard & Fiske [1911] 1977; Spear 2005), especially one that can also cause nasty skin rashes on humans (Blair 1979). Initial eradication activities failed; these included “the mechanical removal of overwintering larvae and the introduction of several specialist and generalist parasitoids” (Elkinton et al. 2008, 1429). However, the browntail moth ceased to be a major regulatory concern because its range unexpectedly collapsed (ibid.). Starting in 1915, the browntail moth’s range in North America started to contract, and by the 1960s the range was restricted to two isolated coastal regions (ibid.). While the cause of the collapse is still not entirely understood, it appears that the USDA’s introduction of the tachinid parasite, *Compsilura concinnata*,[6] to control both *Lymantria dispar dispar* and the browntail moth in 1906, played a major role (Elkinton et al. 2006, 2008). So while complete eradication was not achieved (and GERDA marks the program as a failure), ultimately, something very close to eradication was.

5. Discussion: Eradication as a Chaotic Conception and Catalyst for Public Conflict

In this section, we return to the three threads of eradication as chaotic conception: 1) eradication as a generally fuzzy concept, 2) eradication as a fuzzy concept that undermines analysis, and 3) the practice of eradication as chaotic intervention into systems. The discussion of eradication as a fuzzy concept focuses on what ultimately defines eradication: its outcome. Eradication becomes eradication when it achieves its aim of “complete removal of a population” (Simberloff et al. 2013). Therefore, the discussion starts with how a “successful” eradication is defined. Next, the discussion points to how the eras and types help us to understand the limits of using not only eradication outcomes as units of analysis but also eradication attempts. The point here is not to discredit biological and regulatory work that relies on eradication as a unit of analysis (for describing biological invasions and lifting quarantines, respectively), but instead to situate such analyses in broader historical and political-economic contexts.

[6] Howard and Fiske’s ([1911] 1977) original description of how Compsilura concinnata attacks the moths is quite vivid: “Its eggs hatch in the uterus of the mother, and the tiny maggots are deposited beneath the skin of the host caterpillar by means of a sharp, curved, ‘larvipositar’” (219).

Those contexts matter to lay people who encounter eradication projects and attempt to understand them. Lastly, the section concludes with a discussion of the implications of the chaotic nature of eradication for public controversies. It suggests that attention to era and type helps to understand why certain eradication projects become controversial. However, just as the eras are not totalizing in their explanations of how and why eradication was practiced at different points historically, the typology is not predictive of conflict. Instead, it shows patterns that come to matter once a eradication project does generate conflict.

5.1 Fuzzy Concept: Eradication Outcomes as Chaotic

The typology and periodization do not include the outcome of eradication programs as a variable. This is in part because the outcome of eradication is itself chaotic: it is murky to determine, the standards and means of declaring success vary, and how the success is interpreted across stakeholders also varies. Outcome as an output of the typologies and periodization by era is also not terrifically informative. The likelihood that a program will be marked as a success does not vary much across types. Seventy-two percent of Types I and II, 75% of Type III and 77% of Type IV are listed as "eradicated" or "likely eradicated.[7] Success varies more by era.[8] Sixty-one percent of eradication programs in the Eras of Ecological Independence and Optimism, 76% in the Era of Doubt, 88% in the Era of IPM, 85% in the Era of Sustainability, and 65% in the Era of Trade are marked as succeeding.[9]

Let's start with methodological problem of determining when an eradication has ended successfully in the regulatory record. Take, for example, a program generally recognized as successful: the European grapevine moth eradication program in California. USDA-APHIS and their state

7 Type I: 25 programs, 18 eradicated or likely eradicate (72%), four failed or likely failed (16%), three unknown; Type II: 132 programs, 94 eradicated or likely eradicated (72%), 27 failed or likely failed (20%), three unknown, eight in progress; Type III: 81 programs, 61 eradicated or likely eradicated (75%), 17 failed or likely failed (21%), one unknown, two in progress; Type IV: 22 programs, 17 eradicated or likely eradicated (77%), five failed or likely failed

8 Ecological Independence: 18 programs, 11 eradicated or likely eradicated (61%), seven failed (39%); Optimism: 18 programs, 11 eradicated or likely eradicated (61%), seven failed (39%); Doubt: 21 programs, 16 eradicated or likely eradicate (76%), five failed (24%); IPM: 52 programs, 46 eradicated or likely eradicated (88%), six failed (12%); Sustainability: twenty programs, 17 eradicated or likely eradicated (85%), 0 failures, 2 unknowns, 1 in-progress; Trade: 139 programs, ninety eradicated or likely eradicated (65%), 30 failed or likely failed (22%) (23 of which are EAB), seven unknown (5%), twelve in progress (8%)

9 Of the 30 programs that failed in the Era of Trade, 23 targeted EAB and were abandoned en masse in 2005.

counterparts established a quarantine for the European grapevine moth in 2010 that included all or portions of seven counties (Bech 2010). Four more counties were added to the quarantine over the next two years. Subsequently, the moth was declared eradicated from four counties in February 2012, one more in August 2012, four more in December 2012, portions of the remaining two counties in August 2014 (El-Lissy 2014), and eradication was declared across the entire state in August 2016 (El-Lissy 2016). So, one program has five eradication announcements: four of which are small-scale eradication declarations and one of which communicates a finality over a much larger region. The GERDA database lists a single in-progress project that presumably ends with 2016 eradication declaration, thereby erasing the multiple previous successful eradications, a move that in and of itself suggests eradication is still intended as a final, rather than progressive, state.

The standards and means of declaring the outcome of eradication programs varies considerably by target and era. For contemporary programs, eradication may be declared in some cases after monitoring for three years, such as for the Asian long-horned beetle (*Anoplophora glabripennis*) (2013 SPRO letter), or for the time equivalent to three generations, which may be a matter of months (June 24, 2009 OFF SPRO letter). In 1966, the USDA declared that, "the screwworm has been eradicated from the United States" (Agricultural Research Brochure), which echoes Rachel Carson's (1962) definition of eradication, "the complete and final extinction or extermination of a species throughout its range" (157). The language of a "complete and final extinction" re-surfaces in 2018 with the pink bollworm eradication. Then U.S. Secretary of Agriculture, Sonny Perdue, released a "proclamation" that "the pink bollworm is officially eradicated from cotton-producing areas of the continental United States."

The point here is that even in the regulatory record, where there is presumably the greatest shared understanding of what eradication means, the term is still used to describe different efforts and different outcomes. Eradication may be success over small portions of a larger effort to eradicate an insect pest from a larger area (such as with the European grapevine moth). Eradication may be brief interventions, the success of which is determined by varying phytosanitary standards in trade agreements (such as Asian long-horned beetle or OFF). Eradication may be a long-fought war to extirpate an insect enemy once and for all (such as the New World screwworm or pink bollworm).

This record, in all its variations, circulates beyond regulatory circles. Academic and applied researchers interpret the record and draw new conclusions, adding and complicating what eradication means, how to achieve it, and, of course, how to determine it. Media outlets engage with both the regulatory and academic records. Community stakeholders, some of whom may be litigating proposed or recent projects but most of whom are simply trying to make sense of proposed eradication projects, take up all the many records and interpretations in circulation, adding their own experiences and knowledge into the mix.

5.2 Fuzzy Unit of Analysis: Measuring the Population or the Response?

The increasing rate at which eradication projects have been pursued has been offered as evidence that biological invasions are increasing globally (Suckling et al. 2019). We do not dispute the role that increased global trade has had in increasing biological invasions. However, the argument does not account for how the responses to those biological invasions are part and parcel of the global political economic structures that encourage international trade in the first place; nor does it contend with how international sanitary and phytosanitary measures, which are designed to prevent pests from moving with traded goods, impact regulatory agencies' decisions to eradicate, as opposed to manage certain pest populations.

In their analysis of the GERDA data, Suckling et al. (2019, 2) show that the rate of eradication projects were initiated globally increased around 1956 (with a 95% confidence limit of 1947-1957) and 1995 (with a 95% confidence limit of 1994-1998). Their explanation for the first increase follows the same logic that Metcalf (1980) and other scholars (cf. Carson 1962; Russell 1996, 2001; Kinkela 2011; Stepan 2011) have noted about pest management post-World War II (the Era of Optimism): there was "increased availability of broad-spectrum insecticides offering new options for incursion responses" (Suckling et al. 2019, 5). Additionally, they note the successful eradication of screwworm from the island of Curaçao, which functioned as a proof of concept for eradication via sterile insect technique specifically and broad eradication efforts in general (Perkins 1982, 1989). They also point tso "containerized shipping and rapid rise in trade" (Suckling et al. 2019, 5) as reasons for the sudden uptick in eradication projects. The "rapid rise in trade" is not explicated. Regarding the 1995 breakpoint, the authors suggest that the increased rate of eradication, which is used as a proxy for increased biological invasions, "could relate to the effect of the internet with increased timeliness and detail of information" (ibid.). It is unclear if the authors are referring to the sharing of information on biological invasions, eradication attempts, control methods, or something else. No other explanation is suggested.

We propose that looking at the history of international trade agreements would help explain these moments in which eradication was pursued more frequently. However, investigating trade agreements and their impacts also complicates the use of eradication projects as proxies for biological invasions.

First, let's look at the generically framed "rapid rise in trade" (Suckling et al. 2019) between 1947 and 1957, as well as how trade might also matter to the 1994-1998 timeframe. The General Agreement on Tariffs and Trade (GATT) was established in 1947 to encourage free trade among its 151 member states (Heather and Hallman 2008). The first and third articles of the GATT prevent member countries from favoring products from domestic over international suppliers (GATT 1947, Part 5). The World Trade Organization (WTO) was established in 1995. Like the GATT that preceded it, the purpose of the WTO is to increase and facilitate international trade of goods. According to the WTO, world trade volume increased 3983% between 1950 and 2020; world merchandise trade volume increased "steeply" since 1995 (WTO 2021). Lastly, the U.S. Canada, and Mexico liberalized trade between them through the North American Free Trade Agreement, which came into force in 1994. Increases in trade don't occur in a vacuum. Multinational agreements post-World War II era and the mid-1990's specifically encouraged more trade. And more trade, of course, means more opportunities for pests to circulate as well (Banks et al. 2015; MacLeod et al. 2010; Perrings et al. 2010).

Second, members of the GATT, and later the WTO, also understood that trading can increase introductions of plant health pests and diseases, and therefore established several agreements, conventions, and systems to prevent their spread. It is worth noting when these agreements and conventions went into force, and how that may have impacted the rate of initiating eradication projects. The International Plant Protection Convention (IPPC), which is administered by the United Nations Food and Agriculture Organization (FAO), went into effect in 1951 (and was revised in 1977 and 1997). The Uruguay Round of GATT negotiations (1986-1994) included an Agreement on the Application of Sanitary and Phytosanitary Measures ("SPS Agreement").[10] Ebbels (2003) explains how the IPPC and the SPS Agreement are linked: "The IPPC governs the development and adoption of the International Standards for Phytosanitary Measures (ISPMs), which are referred to by the WTO-SPS and satisfy its criteria for international standards, but are established under the terms of the IPPC" (29). Under the IPPC, member countries may establish that they are pest free areas (ISPM No. 4, 1996 as cited by Ebbels 2010, 128). To retain that status, such as the U.S. has done with respect to tephritid fruit flies (as mentioned above), member parties must continue to provide survey data that they are "free from" pests of international concern and demonstrate that they have identified and removed any populations detected within their borders. Thus in order to retain the powerful label of "pest free," regulatory agents in the U.S. (and other member countries with similar status) have to demonstrate to their trade partners that the population is eradicated--not just managed--eradicated. Moreover, the standards for determining a successful eradication are the results of satisficing between internationally accepted surveillance practices and preventing hardships for growers and exporters: "the temporal threshold for declaring eradication is generally set as early as can be scientifically justified" (Sedell 2019; see also Meats 2014). This informs some of the critique of type II and II efforts, which repeat often. Critics--both lay and expert--certain eradication projects have problems at both the outset and the end: populations are already established and thus ineradicable to begin with, and subsequent eradication actions don't actually stamp out the population, they tamp them down just enough to elide surveillance systems long enough to count officially as "eradication" (Sedell 2019). All told, the rate that eradication projects are initiated may not

[10] There is also the Convention on Biological Diversity, administered by the United Nations Environment Programme, which entered into force in late 1993.

be related strictly to trade volume but also to the structures designed to protect against the problems trade introduces. The intolerance of any pest presence, which tends to favor eradication, is baked into both the drivers and guardrails of international trade.

Third, we turn to reporting systems (the sharing of information insinuated in the phrasing , “the effect of the internet” (Suckling et al. 2019, 5)) and how those might also impact the numbers of eradication projects initiated. The IPPC mandates member countries post notifications when pests not known to occur in the country are detected along with a plan of action for dealing with them through Regional and National Plant Protection Organizations. The record of pest alerts makes establishing the record of eradication projects much more accessible. The North American Plant Protection Organization, for example, has made their pest alerts available online since 2000. Methodologically then, you have a kind of data dump from 2000 onward, which may impact how many eradication projects are counted.

In summary, we caution that eradication functions as a chaotic conception that actively undermines the analysis of biological invasions, because: 1) eradication as a general category does not differentiate between the eradication of native, introduced, or re-introduced species; 2) the resulting analysis obscures the role that deliberate policy choices to liberalize international trade played in intensifying biological invasions; 3) the analysis fails to account for how eradication is incentivized and determined under international phytosanitary agreements and the potential impacts thereof on when and how eradication is initiated and declared successful, and 4) the recorded number of eradication projects may be related to data availability, which is influenced by reporting systems mandated by international trade agreements.

5.3 Implications for Public Controversies over Eradication Efforts

While some eradication efforts have generated substantial public controversy, it is worth noting that the majority of programs to eradicate arthropods described here did not generate public controversies. While a very small number operate with outright public support, most contemporary eradication programs operate with little public attention. Additionally, there is an overarching trend of eradication programs, as noted in the macro-trends, to employ pest control methods with fewer human health and ecological impacts. In environmental impact reports, articles, press releases, and oral histories, regulators, advisors, and researchers all report actively working to reduce impacts on non-target species, especially human beings, with the assumption that that goal is consistent with the public will. So, while there are myriad reasons for the larger trends, it is fair to say that the actors who develop and operate eradication programs have, over time, responded to public pushback on the technologies of eradication, especially chemicals. That said, some arthropod eradication programs do generate conflict.

In instances in which controversies do flare up, there has been a tendency to bemoan laypeople's lack of knowledge regarding the reduced risks associated with the eradication programs of today. The following statement regarding the light brown apple moth eradication program (California, 2007-2010) is fairly typical:

> A misinformed or ill-informed public may fail to recognize the difference between chemical insecticide treatments and semiochemical-based eradication treatments, such as mating disruption and mass trapping, which have little to no effect on human health or on nontarget species. […] In most cases when public opposition thwarted eradication programs, the public lacked information about why eradication was proposed, which tactics would be employed, and how the program would likely affect their lives or communities. In the absence of public outreach, residents are likely to be suspicious, and some will be sympathetic to conspiracy theories and other radical arguments (Liebhold et al. 2016, 344).

The public deficit model assumes that fact-dumping will rectify public relations issues (Cook and Zurita 2019; Crowley et al. 2017). However, the model in general, as science and technology studies scholars have noted, tends to exacerbate not calm conflict (Crowley et al. 2017; Horst, Davies and Irwin 2017; Stilgoe and Guston 2017). The model is especially concerning in Types I and II eradication projects—and indeed many in the Era of Trade--since these types are mostly triggered by emergency declarations. When acting under emergency orders, agencies responsible for public outreach and fact-sharing are typically exempted from state and federal environmental regulations mandating public outreach. That is not to say that agencies do not conduct public outreach, but the quality varies significantly and may be significantly constrained by the emergency timetable. This is especially important to note, because these are often the eradication projects that incite public pushback.

Public controversies over eradication programs appear to cluster around certain types. High profile controversial programs often target the same taxa repeatedly, placing them in Types II and III. This is consistent with Crowley et al.'s (2017) review indicating that conflict follows and/or intensifies as a result of "legacies of conflict or failure" (136). Repeated spraying, for example, of urban areas to eradicate gypsy moths, Mediterranean fruit flies, and Japanese beetles, has generated significant pushback (Myers et al. 2000; Sedell 2019). These legacies connect back to the varying standards for declaring eradication. Community stakeholders, for example, may find repeating programs targeting the same species (especially in nearby locations) as evidence of historical failure to eradicate in the "complete and final" (Carson 1962, 157) sense of the word. Indeed, repeated eradication efforts may engender and/or increase public distrust. Some community members interpret repeated attempts to eradicate--especially when each project is declared a success--as evidence that regulatory agencies are unable or unwilling to concede certain pests are already established, thus ineradicable (Sedell 2019). This interpretation is informed by lively debates within scholarly entomology circles over how to determine the presence and absence of pest populations targeted for eradication (Carey 1991, 1996, 2010; Carey and Harder 2013; Carey et al. 2017a, 2017b; Gutierrez et al. 2014; Liebhold et al. 2010; McInnis et al. 2017; Papadopoulos et al. 2013; Shelley et al. 2017).

Public controversies also are more likely when aspects of the programs harken back to the Era of Optimism. Aspects include: 1) the pest control method itself, such as the use of broad-spectrum pesticides, 2) technology, such as the use of aircraft, and/or 3) target pests for which large-scale programs were enacted during the Era of Optimism, such as the European gypsy moth, regardless of control method.

6. Conclusion

In summary, from 1890 (the year of the first documented eradication effort led by a regulatory agents) to now, eradication projects in the U.S. have been initiated more frequently, last less time, and employ increasingly diverse control methods. The diversification of control methods, and when they were introduced, reflects advancements in pest management broadly, and entomology specifically. However, the uptake of diverse methods by regulatory agencies suggests that agents and their technical advisors may be responding to public concerns over certain approaches to eradicating pest populations.

The typology helps us to better understand conflict between expert and lay communities by identifying how eradication projects known to generate controversy fit into larger patterns. Eradication projects that are known to cause conflict often: 1) target the same species in the same general area repeatedly, so are more likely to fit type I or type II, and/or 2) harken back to the Era of Optimism, through the pest control methods, such as the use of broad-spectrum pesticides, the use of aircraft in residential areas, and/or target pests for which large-scale programs were enacted during the Era of Optimism, such as the European gypsy moth, regardless of control method.

Assessed collectively over time, eradication projects in the U.S. have generally progressed from broad to increasingly targeted, in terms of spatial extent, duration, and how recently a pest population was detected. However, within every era, there has been variation: eradication projects functioned as strategic strikes against recent introductions alongside projects that have doggedly pursued long-standing pest populations, both native and introduced. In definition and practice, eradication persists as a chaotic conception. This has led to lay people's personal experiences with eradication projects and their encounters of eradication through media and scholarly work being widely divergent as well. Lay communities experience and react to eradication projects from their own multiple reference points. Theorizing types of eradication through the typology allows us to take stock of collections of eradication efforts rather than just one-off projects. We can situate projects known to cause controversy within broader timeframes but as inherently connected to each other, not just through the biology or biogeography of the targets but as moments of social reference that exist within larger political economic structures.

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CHAPTER (ARTICLE) 2
No Fly Zone? Spatializing Regimes of Perceptibility, Uncertainty, and the Ontological Fight over Quarantine Pests in California

Abstract
For nearly 40 years, California has been periodically gripped by controversies over government efforts to protect agricultural trade by eradicating invasive insects in cities. The analysis focuses on one thread that has linked and stabilized these controversies: disagreement over whether or not the local population of invasive insects is already established and thus ineradicable. Examining the controversies over programs to eradicate the Mediterranean fruit fly in the Los Angeles basin (1980 to present), light brown apple moth on California's north coast (2007-2010) and the Japanese beetle in the Sacramento Area (2011-2016), I describe two competing models for understanding invasive insect populations. Through a comparison of these regimes of perceptibility, to borrow Michelle Murphy's term, I demonstrate the importance of temporal and spatial scales in determining pest presence and absence. Further, I argue that the dominant regulatory regime of perceptibility, the Multiple and Recent Incursion (MRI) model, constructs certainty in trade relationships by re-establishing production areas as pest-free through the insistence that the insects are invasive, out of the ordinary, and temporary. The competing regime of perceptibility, the Sub-Detectable Established Local Population (SELP) model, challenges the construction of certainty on which the MRI both relies and helps produce. In doing so, I show that the SELP model threatens California's position with trade partners but also opens up possibilities for new agro-ecological and political arrangements.

Keywords
quarantine pests, invasive species management, eradication, agricultural trade, California

1. Introduction

Since its first appearance in California in 1975, the Mediterranean fruit fly (*Ceratitis capitata*) has been officially eradicated 61 times in California (Papadopoulos, Plant & Carey 2013b; author's analysis of [database]Kean et al. 2015).[1] The United States Department of Agriculture (USDA) and California Department of Food and Agriculture (CDFA) initiated the programs in response to what they described as an onslaught of independent incursions of the fruit-destroying flies. To say their response generated public pushback would be an extreme understatement. In the 1980s and 90s, helicopters sprayed a broad spectrum pesticide, malathion, over Los Angeles and the Southern San Francisco Bay while agricultural agents destroyed fruit in yards and inspected cars leaving quarantined areas. Residents and local officials fiercely protested these federally-mandated, California state-enacted eradication programs, which collectively were shorthanded as "MedFly." They accused the government of "poisoning them from the skies" and curtailing their rights as citizens. When an entomologist from the University of California, Davis, Dr. James Carey, disputed the evidence agricultural agencies used to substantiate the program, his analysis was quickly enrolled in calls to terminate eradication efforts. His counterclaims to the regulatory justifications for eradicating the Mediterranean fruit fly would form the backbone of contestations over programs to eradicate invasive insects in California for decades to come.

Originally published in 1991, and subsequently updated in 2013, Carey's research disputed claims made by state and federal agricultural agents that the Mediterranean fruit fly was repeatedly introduced into California through air travel and trade and, in turn, repeatedly eradicated by pesticides, fruit removal, and, later, releases of sterile flies. Instead, he argued that the fly was likely already established but at numbers so low they were undetectable through normal regulatory monitoring. When their numbers built up enough to be detected, they were knocked *down* but not *out* by emergency efforts to eradicate them. While the fly primarily impacts the agricultural economy—damaging fruit and triggering quarantines throughout the world—urban residential areas serve as reservoirs. Therefore,

[1] A broad definition of eradication in invasion science is "the removal of every potentially reproducing individual of a species or the reduction of their population density below sustainable levels" (Myers et al. 2000).

eradication programs repeatedly target non-agricultural spaces, igniting pushback from urban and suburban communities. For those fighting the Mediterranean fruit fly eradication programs, Carey's hypothesis provided a scientific platform for dissent: if the cities (and, presumably, surrounding agricultural areas) were already living with the pest, why risk harm to people, landscapes, and animals to get rid of it?

Challenging eradication programs that impact urban areas by arguing that a pest is already established and thus ineradicable has persisted and spread beyond the MedFly controversy. As state and federal agents eradicate new invasive insects that impact the agricultural economy but thrive in California cities, concerned residents, growers, and local officials have modified Carey's theory on the Mediterranean fruit fly to make sense of and resist other programs that bring pest-killing chemicals into non-agricultural spaces. During controversies over programs to eradicate the light brown apple moth (*Epiphyas postvittana*), dubbed "LBAM," on the north-central coast and the Japanese beetle (*Popillia japonica*) in the Sacramento area, concerned stakeholders actively sought out Carey and worked with him to develop counter-explanations for the age and extent of the pest populations. Over time, concerned residents and other stakeholders have forwarded an analysis arguing that local pest populations were already established prior to emergency efforts to eradicate them. The groups explain that the populations escaped detection, because, in the cases of Mediterranean fruit fly and Japanese beetle, the populations have been at low but fluctuating numbers over decades, or, in the case of LBAM, the population was not detected previously because the monitoring systems were inadequate. Pitting the state model of *multiple and recent incursions* (MRI) against a model of *subdetectable established local populations* (SELP) has become a key thread through controversies over invasive insects in California.

Responding to Christian Kull's (2018) call to engage in a critical invasion science that investigates how knowledge of invasive species is framed at "a particular temporal, spatial, or organizational scale" (p. 263), the analysis foregrounds geographical elements of competing ways of making sense of and responding to populations of invasive insects that pose a threat to agriculture from urban areas. Specifically, I examine how the dominant model for understanding and responding to invasive insects, the MRI, functions within a "regime of perceptibility" (Murphy 2006) that becomes visible only when challenged at different spatial and temporal scales. As Christophers (2017, 260) explains, "a regime of perceptibility encompasses the data we look at, the lens through which we consider those data, and the types of question we ask of the data we see." Regimes of perceptibility are never pan-optic: they focus on the signals that contemporary technological tools can perceive within larger social, political, and economic assemblages. In doing so, they also inevitably generate blindspots, causing certain phenomena to "disappear" (Murphy 2006). In the case of the dominant regulatory model, challengers contend that entire established insect populations have been disappeared, making efforts to eradicate—instead of manage—them moot.

The terms SELP and MRI derive from my geographical analysis and are not entomological or regulatory concepts. In entomology and agricultural regulatory circles, the theory that the Mediterranean fruit fly and other tephritid fruit flies are established at subdetectable levels in California is commonly referred to as "The Carey Hypothesis." The moniker was coined by Roy Cunningham, Chair of the CDFA Medfly Science Advisory Panel, on which Dr. Carey also served in the 1990s. It is, in general, used only in critiques of Carey and his associates' work (cf. McInnis et al 2017; Shelly et al. 2017). I have elected to use terms that: (a) are descriptive of the competing scientific analyses themselves rather than the names most attached to them and (b) can be more readily applied in public discussions beyond the fruit fly debates. Further, I do not assert whether the SELP or the MRI is right. Instead, I ask what work the SELP hypothesis *does*. I argue that uncertainty generated by the SELP hypothesis opens up a previously closed problem. It re-arranges the rules governing what we can and cannot see. In doing so, it challenges a carefully constructed regime of perceptibility, which, in turn, threatens the certainty of pest-free guarantees upon which agro-environmental commodity markets rely. It also invites us to reconsider the terms under which we live with our unchosen companions.

I begin by reviewing the concept of "regimes of perceptibility" and exploring how attention to spatial and temporal metrics helps extend Murphy's theory. I then situate the research in relation to Kull's call for "critical invasion science." This is followed by a brief description of the methodology of the research and the rationale for examining multiple eradication programs together. From there, my analysis proceeds in four parts. First, I describe the practices and rationale of building the MRI, a regime of perceptibility that can measure "zero." Second, I contrast the SELP and the MRI models to understand how the two approaches differentially materialize the pest populations using the same data. Third, I examine how the SELP was adopted and adapted through on-the-ground experiments during the LBAM eradication program. Fourth, I demonstrate that the resiliency of the MRI model results from its ability to construct certainty in agricultural trade through political and knowledge management.

Overall, the analysis describes how controversies over eradication programs in California have stabilized. Regulators continue to assert that the Mediterranean fruit fly and LBAM controversies were the result of "bad communication," public misunderstanding of science, and/or a widespread fear of being sprayed by their government from the air (interviews Y16, Y17, C24; Carey & Harder 2014; Liebhold 2014). However, these explanations fail to explain how a differential understanding of pest populations has taken hold and continues to bolster publics concerned with eradication practices. Indeed, concerned stakeholders assert they want "better science" and "better government" (interview C47), not a total ceasefire. In order to begin building bridges toward more sustainable governance of invasive species, I offer a detailed view into how each side of the ontological fight over invasive pests builds and fortifies their positions.

2. Reading Regimes of Perceptibility and Metrics through Critical Invasion Science

2.1 Regimes of Perceptibility

Michelle Murphy (2006) posits that "regimes of perceptibility" cause certain objects to become knowable and actionable while simultaneously disappearing others. Her research focused on whether and how it was possible to detect—and, therefore, address—chemical exposures from multiple and unknown source points, a notoriously difficult proposition (Brown et al. 2011). Regimes for making indoor chemical exposures perceivable include the devices used to collect data, the systems deployed to analyze the data, the social structures of society at large and workplaces in particular, as well as the political economy of science and science-informed policies (Murphy 2006). Built on these assemblages of social and technological features, regimes of perceptibility define how and if a problem exists, dictating the terms of any possible intervention: "Regimes of perceptibility populate our world with some objects and not others, and they allow certain actions to be performed on those objects" (ibid., 24).[2]

Regimes of perceptibility can also help explain blindspots common across a profession or discipline. As Murphy argues, regimes arise through the congealing of epistemological practices and traditions within a field. Over time, regimes naturalize ways of measuring, describing, and addressing problems: experts within the regime would argue that this is simply how it's done, and, moreover, that their approach works. Yet the very way they come to understand the problem causes certain objects to fall out of view. In her own work, Murphy explores how not only multiple chemical exposures but also race are rendered imperceptible within the US Environmental Protection Agency.

My specifically geographical read of regimes of perceptibility focuses on the spatial and temporal dimensions of how invasive insects are rendered perceivable and imperceivable. These geographic elements consider: (a) the locational definition of invasive insects, (b) the temporal scale over which their presence and absence in that place is determined, and (c) the spatial "tool of government" (Foucault 1990; Li 2007) used to manage infestations, the quarantine. Invasive species are, by definition, out of place. While no special technologies may be required to see individual insects—unlike chemical exposures, you can confirm the ontological existence of the flies, moths, and beetles discussed here with your own eyes—seeing that insects are in the wrong location does. Further, determining whether or not those insects have existed long enough in a location to be considered recently introduced or already established, let alone to forecast how that population will grow, requires a system for perceiving and analyzing their populations. Technologies and metrics mediate our understanding of the existence and absence of insects in particular places at particular times; they inform an epistemology of invasive insects. However, the

[2] While Murphy's usage of "our world" suggests a collapsing of epistemology and ontology, she holds to the history of science notion of "historical ontology" (2006, 7): while things may happen in the world without our ability to perceive them, knowledge changes over time and what we hold to be "true" at any given moment is historically specific and confined.

larger political economic context within which the technologies are deployed, specifically trade relations and international phytosanitary measures, demand ontological claims of presence and absence: insects caught and not caught in monitoring traps. In response, a regime of perceiving invasive insects in the U.S. has developed, which detects pests in specific spatial and temporal ways, circumscribing the means to which we can respond to them. In order to act on invasive insects, the regime relies on the third geographic element listed above: the quarantine.

2.2 Quarantines and the Spatial Metrics of Managing Invasive Insects

States acquire and codify their authority through the production of environmental knowledge (Mitchell 2002; Jasanoff 2004; Kosek 2006; Winickoff and Bushey 2010; Peet, Robbins and Watts 2011); the quarantine highlights the spatiality of those processes (Foucault 2012; Hincliffe et al. 2017). Foucault (2012) described how the enactment of quarantines help lay the foundation of governments that rule by setting terms for living rather than through their authority to kill. During the plague, residents of European towns were governed by keeping them in place and making them visible. The presumed vectors of disease, people, were made to stand in the window and be counted. The dead were tallied and transported only by those authorized to circulate. The system functioned by stopping movement and making subjects perceivable. To this day, the general principle of the quarantine persists: stop circulation, make diseased subjects visible, and contain the infestation in place.

Quarantines to protect plant health create unique, temporary, and elastic spatial units of government control and measurements. Regulations hinge on how and what moves across quarantine borders, and emergency rules exempt many normal government processes within its bounds (APHIS 2009; Ahuja 2017; Hinchliffe et al. 2017). Additionally, the quarantine defines the spatial unit of analysis for pest populations. The quarantine's borders are determined by equations related to the distance from the original discovery of invasive insects and may change as more insects are detected. Density and, ultimately, absence of pest populations are determined via the quarantine area. Overall, quarantines exemplify how the metrics of governance and state authority are co-produced (Jasanoff 2004).

2.3 Contribution to Critical Invasion Science

Invasive species are generally understood to be a species that has not historically existed in a particular place, has the potential to spread and establish populations in the new place, and could negatively impact the local ecology, economy, and/or public health (Simberloff et al. 2013). The field of invasion science draws together multiple disciplines under one umbrella to understand the dynamics of biological invasions, generally with the normative goal of preventing such invasions (Kull 2018). Kull's call to develop a "critical invasion science" asks scholars to more deeply consider the ongoing entanglements and historical situatedness of invasive species and human responses to them.

Critical scholars in the social sciences and humanities have investigated invasive species from many angles. Some point to instances in which failure to control invasive species exacerbated socio-economic disparities (Bassett and Zuéli 2003). Many more problematize and historicize responses to invasive species by investigating the xenophobia inherent in the language (Subramaniam 2005), the nativist and xenophobic origins of plant health laws (Pauly 2000; Nash 2006; Shinozuka 2009, 2013; Biermann 2016), the conditions of "living with" invasive species (Atchison 2015; Gibbs, Atchison and Macfarlane 2015) and "living without" (Phillips 2013), the symbiotic relationship between agricultural chemical manufacturing and invasive species management (Perkins 1982; Russell 2001; Robbins 2004; Kinkela 2011), and further marginalization of communities dependent on invasive species (Kull & Tassin 2013). Threading through this diverse body of scholarship is the insistence that local experiences of and responses to invasive species are situated within longer histories and larger socio-economic contexts.

Scholars engaged in what might be termed "critical entomology" seek to understand how the dynamics of studying and managing insects are situated within larger techno-social assemblages (cf. Robbins 2004; Mavhunga & Spierenburg 2007; Robbins, Farnsworth, & Jones III 2007; Biehler 2009, 2013; Kosek 2010; Raffles 2010; Mavhunga 2011; Kelly & Lezaun 2013; Peloquin 2013; Shinozuka 2013; Carter 2014; Nading 2014; Romero 2015). However, few have engaged with the driver for the lion's share of government responses to invasive insect species: to protect the agricultural economy.

Catherine Phillips (2013) analysis of the Australian Fruit Fly Free Zone stands as the notable exception. Phillips observes that invasive fruit flies, “are relatively ignored creatures, until they become risks—to good-quality fruit, maintaining markets, biosecurity budgets, private property rights” (1683). Critically, she points to the messiness of biosecuring production areas from invasive insects, especially as practiced on the ground, and refuses to simplify her analysis to a call to live with invasive insects, noting that pest exclusions may have some merit, especially pragmatically. Indeed, meeting international trade agreements while protecting the livelihoods of those in the fruit growing regions, Phillips argues, leave few practical alternatives.

While governments manage invasive species for a variety of reasons, they pursue eradication for the express reason of protecting and facilitating trade at significantly higher rates than for maintaining public or ecological health (author’s analysis from data available through [database]Kean et al. 2015).[3] Invasive species that could cause economic injury are called “quarantine pests,” a “pest of potential economic importance to the area endangered [which] are not yet present, or present but not widely distributed” (FAO 2016, ISPM 5-19). Quarantine pests in California link the state’s $50 billion dollars a year agricultural industry (CDFA 2018) and its cities in unexpected configurations. Salomon Cavin and Kull (2017) note a trend in invasion science toward incorporating urban ecosystems into analysis of invasions. However, teasing apart the linkages between urban environments, political economic pressures, pest materialities, and community reactions is beyond the scope of most invasion science research. Here, I connect them from the integrative perspective of geography.

3. Methodology and Connected Cases

The research presented here triangulates between: a) archival sources, b) entomology research presented in peer reviewed journals and academic conferences, and c) 68 interviews with scientists (*n* =

[3] In author’s analysis of eradication program data available in GERDA, four of 250 programs targeted public health pests, two different types of invasive mosquitoes. In the U.S., most public health campaigns involving insect populations focus on management, not eradication, hence mosquito management districts (see Robbins et al. 2007 for a discussion thereof).

10), regulators (n = 6), community members (n = 26) and growers (n = 26) impacted by eradication programs in California. The majority of interviews were conducted as part of an evaluation of "public perceptions of emergency plant health programs" (redacted for review) for the United States Department of Agriculture – Animal and Plant Health Inspection Services (USDA-APHIS) between 2011 and 2013. The interviews for this project focused significantly on the LBAM eradication program. The author conducted additional interviews and observations at professional entomological and invasive science meetings between 2014 and 2017. Archival sources include regulatory documents from the California Department of Food and Agriculture (CDFA); USDA-APHIS; the National Archives – Records of the Bureau of Entomology and Plant Quarantine, and articles in local newspapers.

The analysis focuses on the SELP hypothesis and associated counter-claims as a connecting theme through the two controversial eradication programs—for the Mediterranean fruit fly, 1980-present, and LBAM, 2007-2010—with brief mentions of a third—for the Japanese beetle, 2011-2016. In doing so, the analysis does not treat the three eradication programs and their associated controversies as distinct case studies, but rather as different facets of a shared history. The choice to consider the programs collectively derives directly from the linkages made by research participants and data sources. The Mediterranean fruit fly programs were frequently cited during interviews and news coverage regarding both LBAM and the Japanese beetle. LBAM, in turn, was cited by residents concerned with the Japanese beetle eradication program. Regulators anticipated in 2012 that the LBAM experience could negatively impact public perceptions of future eradication programs, and, indeed, by 2015, responses to the Japanese beetle program confirmed those concerns. Additionally, self-described activists shared scientific papers and political strategies they acquired during the LBAM program protests with residents fighting the Japanese beetle eradication program. Understanding the heat and expansion of the controversies over eradication programs in California requires an analysis engaged with historical and local complexities. By studying the programs and their controversies together over time, the construction and persistence of the two regimes of perceptibility comes into view.

[Insert Table 1: Overview of connected case studies]

4. Analysis

4.1 Building a Regime of (Im-)Perceptibility for Quarantine Pests

How, where, and when invasive insects officially exist (and don't) depends on a regime of perceiving quarantine pests. Regimes of perceptibility make certain objects knowable and inadvertently disappear others (resulting in systemic blindspots). They also intentionally endeavor to demonstrate the absence of still other objects. We cannot calculate absence in the most absolute sense; as Galt (2009, 475) notes: "absence of evidence cannot be taken as evidence of […] absence." However, many systems substantiate claims of absence by setting certain thresholds for detection and evidence. Within agri-food systems, for example, thresholds are set to detect bacteria (Hinchliffe et al. 2017) or traces of pesticides (Galt 2008) on fresh produce. The concept of regimes of perceptibility helps us connect how those thresholds are determined with why and how they are enforced. In the case of quarantine pests, demonstrating absence is incentivized through international sanitary and phytosanitary measures (ISPM) and are made possible through a system of technologies and metrics designed to calculate absence.

Moving agricultural commodities under today's phytosanitary regulations requires that trading parties demonstrate that either the commodities themselves or the area from which the commodities originate are "free from" pests. As Hinchliffe et al. (2017) summarize, "freedom *to* trade requires freedom *from* pathogens" (42; italics original). The ISPM define the health of agricultural commodities in terms of absence of pathogens (ibid.). For raw agricultural commodities, we also add the absence of weeds and pests. The notion of health defined in the negative—in which the key marker of healthfulness is the absence of the unwanted (Belasco 2007; Hincliffe et al. 2017)—derives from germ theory and became engrained in large-scale public, animal, and plant health campaigns to sanitize entire landscapes in the late 1800s and early 1900s (Biermann 2016; Nash 2006, 2008; Pauly 2000; Shinozuka 2009). While the practice of insect eradication has changed over time (Perkins 1989), a negative definition of plant health has persisted along with the notion that large areas can be maintained as "pest-free." By defining health in terms of absence, rather than any positive attributes, the system requires a means of measuring zero, which informs, in turn, how quarantine pests are controlled.

There are two general approaches to controlling quarantine pests. The first is to *manage* the pest population in the area. If the insect has already become established, growers and government agents work in various arrangements to control insect populations in production areas (Lodge et al. 2006; Simberloff 2009). At the time of export, government agents inspect shipments; agents and/or growers may also treat raw agricultural commodities post-harvest. In management, the freedom from pests is established for a specific shipment. The second approach is to *eradicate* the pests, eventually (re-)establishing the area of production as "free from" the pests (FAO 2016, ISPM-9). Eradication, in most regulatory entomological circles, is understood to be the "complete removal of all individuals of a distinct population, not contiguous with other populations" (Simberloff et al. 2013). While U.S. eradication programs have, at times, covered enormous areas and even targeted endemic species (Dahlsten & Garcia 1989; Perkins 1989), most eradication programs today target recently introduced, discrete populations. Eradication is the excision of a new anomaly.

The choice between the two approaches, management or eradication, is largely dictated by whether or not a local population is considered established (Pluess et al. 2012). Indeed, "early detection" of an incipient population is considered one of two critical variables for an eradication program to be successful; the other variable is public support (Myers et al. 2000; Berenbaum et al. 2009). In short, if a population is established, then it should be managed. If the population is recently introduced, then it should be eradicated. The idea being that removing an invasion, and returning to a "pest-free" baseline, is both ecologically and economically preferable to dealing with an infestation long-term. Indeed, many argue that quickly taking out a new incursion is less chemically intensive than on-going area-wide management schemes and allows exporting areas to maintain the preferred status of "freedom from" pests with trade partners (Myers et al. 1998; Liebhold & Tobin 2008; Kawamura 2008; Shelly et al. 2017).

While the USDA and CDFA employ a number of technologies to detect quarantine pests—including genetic analysis of trapped and intercepted insects—their assertions of pest presence and absence are determined by the actual collection of insects in monitoring devices, baited traps. Quarantines appear and disappear by the counting of dead insects, not by simulated forecasts, therefore the means of acquiring countable dead bodies matters a great deal. As one regulator noted,

> we just need to make sure that we keep California free of these pests, and free is defined as what is caught in the traps (interview Y16).

Trap construction and baits vary by quarantine pest, ranging from those that look like plastic buckets to small paper trifolds. The traps hang from trees and fence posts at set distances, creating a grid, or "array" (Meats 2014). The density and location of the grid varies depending on if a pest is anticipated to be, or has already been, detected. *"Sentinel trapping"* (ibid.) or "origin surveys" (CDFA 2014) are used to monitor for insects that are not known to occur in an area but threaten to. The traps are spaced widely and designed to detect the introduction of invasive species before an infestation can develop. *Detection trapping* is used to determine if a pest that is suspected of being introduced has indeed been introduced or, worse, has become established. *Delimitation trapping* is deployed when an introduction has been confirmed but the spatial extent has not yet been determined. The density of the detection and delimitation trapping grids is specific to the pest under surveillance and varies depending on the phase of regulatory response to an incursion (see table 2). During active eradication programs, traps are spaced closely together in order to identify and target hot spots as well as demonstrate reduction in pest numbers. After eradication has been declared, a smaller number of traps are left in place for continued monitoring (Jang et al. 2014).

The trigger for establishing a quarantine is determined by counting a certain number of insects within a certain distance of each other over the duration of the insect's life cycle. While the specific metrics of detection in an area varies, they frequently encompass some version of two adult insects or "evidence of a reproducing population," such as larvae or "mated" female (see Table 2). The metrics for determining establishment are not as clear-cut. Under the ISPM, "establishment" means that a pest population is expected to "perpetuate" into the "foreseeable future" (FAO 2016 ISPM-5, 32). In practice, establishment is often only asserted after attempts at eradication have failed, as happened with LBAM after five years (Rogers 2012).

[Insert Table 2: Metrics for determining quarantine pest presence and absence in California]

The evidence that a population has dropped to zero is even harder to ascertain, as stakeholders on all sides of the controversies over eradication programs attest (Shelly et al. 2017; Carey et al. 2017a,b). Under the ISPM, scientists and regulators have come to agree on thresholds at which they find it reasonable to assume that a pest population has ceased to exist (see Table 2). The goal of ISPM is to support the circulation of goods and capital while stopping the circulation of pests (MacLeod et al. 2010), therefore meeting the ISPM guidelines should not cause undue hardships for growers and exporting regions (Meats 2014). As a result, the temporal threshold for declaring eradication is generally set as early as can be scientifically justified (ibid.).

The traps allow governments to perceive the presence and, critically, the absence of invasive insects. Traps are deployed and monitored by the appropriate local agricultural governmental authority. The data collected in them is the only sanctioned way of knowing an invasive insect exists in a particular place for any length of time. Their importance cannot be overstated. The freedom to trade goods is predicated on the absence of pests, which can only be demonstrated through trapping. Therefore, the sooner the traps catch nothing, the sooner trade as usual can resume. There is a built-in incentive to achieving zero, but the zero must be carefully constructed. The SELP model threatens the zero that eradication programs seek to assert.

4.2 Perceiving the Imperceivable: the SELP vs. MRI Models

This section compares the MRI and SELP models through research and debates over the Mediterranean fruit fly and other fruit flies in the Los Angeles Basin. Whether or not there have been repeated outbreaks or a low level established population has animated heated debates within entomology and set the course of subsequent controversies.

Murphy (2006, 111) explains the imperceptibility induced by regimes of perceptibility through the metaphor of white noise:

> Focusing on a single signal entails a learned inattention to other noise. These suspensions of perception, moreover, result not just in passive disengagements but also the production of historically specific terrains of invisibility.

Under the MRI model, state and federal regulators receive, interpret, and disseminate data in narrow slices of time and space. Recent finds are divorced from the past and spatially isolated. They are the "single signal" that demands an emergency response. When the signal and, thus, the emergency cease, they leave a presumed silence, void of the target insects. By contrast, the SELP hypothesis (re-)introduces background noise. Detections of invasive insects are connected over time and placed in relationship to each other such that the history of invasive populations in an area emerges as linked and dynamic. Placed in this larger timescale, the cessation of the single signal—detections in traps—does not indicate that the population has been eradicated, only that it has been quieted for a time.

The MRI model for explaining the repeated outbreaks of the Mediterranean fruit fly in the Los Angeles Basin begins with an introduction, very likely from one of the local airports (Liebhold et al. 2006). Given the favorable climate and abundance of host plants, the fly quickly colonizes the new area (ibid.). The population grows exponentially, at which point, regulatory monitoring picks up on the incipient population, which triggers an emergency plant health response. The grid of detection traps thickens and delimitation trapping begins to identify the outer edges of the incursion. Federal agents declare a quarantine while state agents determine the boundaries within the state. Using a variety of techniques—which, over time, have included aerial and ground applications of synthetic pesticides, host removal, and sterile insect technique—the state and local agricultural officials, with financial and intellectual backing from the USDA, eradicate the new population. When a new outbreak is detected, it is attributed to a new incursion, approached as a distinct population, and subsequently eradicated.

By contrast, the SELP hypothesis links supposedly discrete invasion events over time and space to suggest that the population has existed and/or persisted beyond what regulatory monitoring can perceive. During his time on the statewide Mediterranean fruit fly Board and then in subsequent publications, Carey forwarded an analysis of the Mediterranean fruit fly in the Los Angeles Basin and San Jose Valley that differed from that of other Board members and agricultural agents (Carey, 1991, 1992, 1996; Papadopolous, Plant and Carey, 2013). Carey and collaborating researchers proposed that a new population of Mediterranean fruit flies establishes itself in California more slowly than the USDA suggests. The numbers of the population fluctuate seasonally over several years before building up to numbers great enough to be picked up by the traps (see Figure 1). At that point, eradication efforts knock back the population to sub-detectable levels. However, crucially, the population remains and continues to build up until the numbers once again hit the threshold for becoming visible.

[Insert Figure 1: "USDA" vs Carey's models (Carey 1991)]

Carey's formulations draw on the same datasets state and federal agricultural agents use to establish and lift quarantines: insect finds in traps (Papadopolous, Plant and Carey, 2013; Carey, Papadopoulos and Plant, 2017a). However, Carey and his colleagues reinterpret the data on longer timescales and with greater emphasis on where the flies are detected. They plot historical finds together on the same map, highlighting hotspots of repeated outbreaks. Finer grain maps show how finds from different years group together. Timelines chart genetic clusters, linking outbreaks. By zooming out temporally and zooming in spatially, the reinterpretation offers an altogether different view of the population. Instead of the discrete, recently introduced, and containable population of invasive flies agricultural agents see, Carey and his associates see a dynamic population, long established, their numbers fluctuating over time and space.

Just as the SELP hypothesis generates uncertainty over insect establishment, it also opens the question about determining eradication. In regulatory communications, ecological and economic descriptors of eradication are used interchangeably, for example "lifting regulations" and re-establishing "pest freedom" status are functionally synonymous with "eradication." Papadopolous, Plant and Carey (2013, p. 8) note that, "CDFA and USDA declared 100% success for each of the several hundred eradication programmes that were launched against fruit flies in California." Each one met the legal criteria of eradication set by the USDA and the Commission on Phytosanitary Measures. As the authors explain, “these legal criteria are required for regulatory compliance to enable growers to ship their produce,” however, “the more stringent ecological requirements for eradication declaration were not met in the majority of cases” (ibid.).[4] This point was picked up by critics of the LBAM program, who interpreted regulatory successes as evidence of systemic failure:

> We met with [then Secretary of Agriculture for California] A.G. Kawamura at one point, and he handed us quite proudly this list of the 274 eradication programs that CDFA has carried out since 1982, I believe. And they are for the same nine insects year after year after year. And so, my first question was, "What are you eradicating?" If it is coming back every year, this […] is just a chronic chemical-control program. This is not eradication. Eradication is when you get rid of it. It's like, "No, no, no - every year we get rid of it" And, so - then, "why does it come back every year?", "Oh well, it's re-introduced by careless people and their suitcases" (Interview C34).

The quote above captures a fundamentally different reading of quarantine pest populations and government responses to them. From the MRI perspective, quarantine pests are ever on the move, invading new spaces, and subsequently being removed from them. In this, the MRI fundamentally relies on the notion that the pests are invasive, that they disrupt the status quo temporarily and that their extermination returns an area to normal conditions. From the SELP perspective, the ceaseless motion makes little sense: quarantine pests can also stay put, dormant or at low numbers, quietly buzzing like white noise. The quote also shows how the SELP critique of eradication developed by Carey and associates over the Mediterranean fruit fly began to translate over to subsequent eradication programs. And as concerned community members and a select group of growers sought recourse to the eradication programs that impacted their communities, they turned increasingly to his ideas in order to make sense of population establishment.

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[4] While the authors do not provide an explanation of the “stringent ecological requirements,” they do point to historian Nancy Ley Stepan’s (2011) work on disease eradication, where she defines the term in the book’s subtitle, “ridding the world of diseases forever.”

4.3 Grounding and Growing the SELP Model

In this section, I turn to how the SELP has been adopted from the fruit fly debates and modified by those resisting the LBAM program. In particular, those who have supported and grown the SELP hypothesis—as a justification to end or, rather, as the argument to have never initiated the eradication program—focused on the metrics upon which the MRI relies. Critical residents, growers, and scientists called into question the trapping efforts that define "infestation," "eradication," and "establishment." Conducting their own field and archival research, these collectives forwarded questions focused on the efficacy of the traps to collect data—Are the lures appropriate? How are they spaced?—as well as how the data in the traps is analyzed—At what grain, and spatial and temporal extents?

Challenging eradication programs with the argument that an invasive insect is already established and, thus, not eradicable did not originate with Dr. Carey. In the first program to eradicate the Mediterranean fruit fly in the U.S., Florida citrus farmers argued that they had seen "skipping maggots" (Perry, Marsh and Dickson 1930) – the key identifier at the time for Mediterranean fruit flies – for years before the government took notice. In arguing that the fly was already established, the farmers sought to end government agents from spraying lead arsenate, which damaged fruit and poisoned pets and people (Whorton 1974). In the mid-twentieth century, Rachel Carson (1962) famously criticized the USDA programs to eradicate the Gypsy Moth and Fire Ants. She argued that,

> Eradication means the complete and final extinction or extermination of a species throughout its range. Yet as successive programs have failed, the Department of Agriculture has found it necessary to speak of second or third 'eradications' of the same species from the same area (157).

Without intending to, Carey's Mediterranean fruit fly hypothesis built on these historical critiques. It bolstered first-hand knowledge of those living closest to the pest. And it supported Carson's observation that the USDA gets trapped in cycles of eradications, which, in turn, expose ecosystems and humans to excess loads of pesticides. These critiques have resonated with residents, growers, and scientists concerned with programs to eradicate LBAM and the Japanese beetle in California, who have used their proximity to the pests and long view on USDA (and CDFA) interventions to shape their challenges.

Prior to state agricultural agents announcing they would aerially apply pheromones across Monterey and Santa Cruz Counties to combat LBAM, they enacted a quarantine and protocols that concerned many local growers, especially organic growers and small nursery owners. Nursery operations within 1.5 miles of an LBAM detection had a short list of options in order to ship their "nursery stock, cut flowers, […] greenery of any plants" (Dunkle 2007, 4) or, with few exceptions, any "fruits and vegetables and bulk fresh herbs and spices" (ibid., 5). Either the operation could apply chlorpyrifos, an organophosphate linked to neural toxicity and development disabilities (Keigwin 2013), or hold their often-perishable plant commodities for two weeks (Pittman 2007). In interviews, several growers described the situation as a decision between spraying a known "bad actor pesticide" (Kegley et al. 2000) or risk losing their business. In an editorial to the San Francisco Chronicle, a nursery owner from Watsonville charged that the eradication effort was driven by "political precedent that was created many years ago" rather than necessity as: (a) the damage by the pests was no greater or qualitatively different from that of native leaf rolling moths, which growers already successfully controlled, and (b) because "it is very reasonable to assume that, for this insect to be so widespread in Santa Cruz County, it has been here for several years" (Rosendale 2007, B-5). The statement invokes the history of the Mediterranean fruit fly eradications and points to how Carey's fruit fly hypothesis would be transformed for LBAM: the moths were subdetectable because the government wasn't looking for them.

LBAM was first discovered in California outside of the official monitoring grid. A retired entomologist in Berkeley maintained a trap to monitor for alien moth species in his backyard as part of an ongoing citizen science project (Brown et al. 2010). Unlike the Mediterranean fruit fly and the Japanese beetle monitoring programs, LBAM boasted no government-maintained sentinel or detection trapping programs at the time of discovery. A previous survey conducted in the summer of 2005 had failed to register any LBAMs (ibid.). Therefore, while the insect was listed as an "Insect Not Known to Occur in the United States" that could threaten U.S. agriculture, it did not warrant a pre-emptive trapping program.

The lack of a prior trapping program for LBAM opened questions about the age, range, and density of the population. When CDFA initiated trapping in 2007, they discovered a fairly widespread population, stretching in patches from Northern Monterey to Solano Counties. By 2008, populations had also been detected in South Monterey County all the way up to Sonoma and Napa Counties, and the populations at the center of the quarantined areas were much thicker than before. Simultaneous to increasing detection and delimitation trapping, CDFA was enacting an emergency response predicated on the assumption that the population was not yet established. Furthermore, CDFA argued the emergency response was justified by the rapid expansion of LBAM populations. For many, this raised a classic geography question: is a phenomena, in this case an insect population, expanding or does in only appear to be because of how it is measured? As one grower observed:

> They started putting out more traps. And then they tried to say that more traps meant, "We are finding it spreading." It's like, "No, you haven't even done the background trapping yet!" You don't know if it is zero already. Then they started quarantining counties. […] Not realizing that the insect might already be at sub-detection levels already—Jim Carey's whole point. How can you count from zero when you haven't established a zero? (Interview C30).

The challenge was further substantiated by a National Academy of Sciences report reviewing the authority of USDA to classify the LBAM as an actionable pest.

> The increase in mean moths per trap per month may partly reflect the increasing number of traps and the increasing geographic area of their placement, inasmuch as both can increase the probability of inclusion of localized high-density populations (Berenbaum et al. 2009, p. 6).

In addition to the spacing and timing of the trapping programs, critics also raised questions about the effectiveness of the traps themselves. In interviews, organic growers and nursery owners described conducting their own experiments to understand the moth and its monitoring. After agricultural agents had positively identified LBAMs on a bush at one nursery, a worker tested the distance at which the official baited traps could attract the moths (interview C30). He slowly moved the traps toward the infested bush, and the moths continued to ignore them. When he surrounded the bush, placing the traps within a foot of it, a moth finally flew in. The detection trapping density at the time was 100 traps per square mile, or one trap per 278,874 square feet. The delimitation trapping density was 25 traps per square mile.

Unlike the Mediterranean fruit fly populations in California, which Carey and associates argue are subdetectable because they fluctuate above and below monitoring thresholds, LBAM populations were argued to be subdetectable because the monitoring itself was dynamic and inconsistent. The nature of the blindspots differ but result in much the same outcome: regulatory agencies cannot perceive that populations are already established and, therefore, not eradicable.

4.4 Regimes of Perceptibility and the Construction of Certainty

The MRI model, driven by the notion that invasive insects are repeatedly introduced and successfully eradicated, has withstood the criticisms of those who embrace the SELP model for decades. In general, the MRI remains remarkably resilient. This resiliency is directly tied to its ability to construct a particular kind of certainty: certainty in trade. Yet that certainty is tenuous and under constant construction, through the apparatuses that provide evidence of pest presence and absence, but also through management of the scientific debate and policy negotiations.

Under the ISPM, exporters seek to re-establish "freedom from pests" and normal trade conditions as soon as possible. Demonstrating that a pest population is temporary and out of the ordinary is critical to reaching that goal. The MRI regime functions by doing just that: showing that status quo conditions have been only momentarily interrupted by an incursion and there is no ongoing infestation. In sum, the species is out of place—invasive—but only for a limited time. To work, however, the evidence cannot be up for dispute. Parties to the ISPM are barred from enacting "barriers to trade" (Perrings et al. 2010, 49) and must ground any refusal to accept raw agricultural commodities in science, broadly defined.

Uncertainty in the science, therefore, opens the door to justifiable sanctions. The audience for the demonstration of scientific certainty is the importing trade partners.

In their critique of Carey's analysis of the fruit fly populations in California, Shelly et al. (2017) argue, "the continuation of trade is surely a recognition of pest-free areas" (229). Trade partners have not rejected commodities due to infestations on imports, which validates the system. Put another way, circulation of capital is itself proof of freedom from pests. As long as commodities and money move across borders, the dominant regulatory model of seeing and acting upon quarantine pests works. An entomologist—who distances themselves from the debates—echoed this line of reasoning, but opened up the possibility that circulation of capital may not actually provide evidence of absence:

> I know the argument that James Carey makes, and he has evidence to that effect. And maybe it is correct. … But, I think that you can argue that even if it has not been eradicated, it has been suppressed. And is that suppression cost effective? And my answer would be yes (interview D55).

The observation suggests that complete absence of pests may not actually be necessary to meet trade standards. California may already be living with certain quarantine pests in configurations that change over time, but the populations are maintained at tolerable levels, and, critically, California produce is still shipping.

Indeed, from the standpoint of simply trying to maintain the movement of goods and capital—the key concerns of the MRI—the ontological particulars of a pest *population* may not actually matter. Traps without individual pest bodies are what ensures certainty. However, *debate* over the ontological existence or absence of the pest population does matter. As one regulator noted:

> If you haven't caught anything in the traps, then you are free of [the pest]. Did we get the population down to zero? How would you ever know? I don't how you could prove the point either way. […] But to have the debate about, 'is this a resident population and you have never eradicated it?' puts doubt in the minds of our trading partners; [it] affects our exports (interview Y16).

The quote points to both the danger of the SELP model and the importance of knowledge management in the construction and reproduction of certainty in the MRI model. Debate over the reliability of detection processes threatens California's export agricultural industry by giving trade partners cover to enact their own quarantines. If sanctions materialize, political interventions may be necessary to re-establish certainty.

A ban enacted by Mexico against Santa Cruz and Monterey County strawberries (Bookwalter 2008) illustrates the point. U.S. quarantine protocols applied to fruits and vegetables grown for export within a 1.5 mile radius of LBAM finds in California, yet Mexican authorities rejected any produce within a 1.9 mile radius of an LBAM detection (ibid.), suggesting a concern over the efficacy of the trapping grid. Further, strawberries had been ruled out as a host plant, raising even more questions about the scientific integrity of the ban. Two days after Mexico announced its ban, California's Secretary of Agriculture, A.G. Kawamura, made an appeal to the public to drum up support for the unpopular program: "these trading partners rightly know they do not want the pest, and they are acting to protect their own crops and environments" (2008). However, the trade restriction was lifted in less than ten days, just in time for the local strawberry harvest, valued at over $150 million a year: "Negotiations between the two countries resulted in a removal of the ban" (Ragan 2008). An update to the U.S. federal domestic quarantine order for LBAM shows that the 1.5 mile radius had not changed (Eggert 2008). The incident highlights how the technological and scientific components of the MRI cannot ensure the certainty of commodity chains alone. Certainty must be bolstered against and through the intervention of trans-border politics.

This is not to say that politics alone can guarantee freedom from pests or even convince trade partners, but rather to suggest that negotiations and other political maneuvers are part and parcel of the entire regime of perceptibility. Concerns about the efficacy of the trapping grid, for example, might also be overcome by pointing to additional data points. An interlocutor privy to a separate set of negotiations with Canada over strawberries and LBAM pointed to an exhaustive analysis conducted by California's Strawberry Commission of county inspection records as key to reaching a successful agreement (interview C48). The new data, which showed only one LBAM had been intercepted on California strawberry exports over five years, mattered, but it could only come to matter by being articulated in a political setting. Evidence and politics are ever entangled in the effort to show pest presence and absence.

These negotiations also show the importance of qualifying pests as shared external threats to trading partners, in other words, invasive. While invasive and endemic pests both have the potential to do damage, they co-construct different regimes of perceptibility and regulatory responses. The MRI only makes sense in the context of invasions: new populations come in, get taken out, and everything goes back to normal. The certainty of "pest-free" status remains intact. Accepting the SELP would mean living with a plain old pest, one that has overcome their status as exceptional and temporary and instead are part of the new normal. Under current trade agreements and arrangements, that new normal would be management, which MRI proponents warn includes heavier pesticide loads to ensure pest-free exports as well as greater trade restrictions (Shelly et al. 2017).

Proponents of the SELP have divergent views what how and why to accept that certain invasive insects are established. Carey and associates share their critics' concern about ensuring pest-free commodities and offer different prescriptions in each of the cases addressed. For LBAM, they supported those who petitioned to reclassify LBAM as a lower risk pest, citing concerns over the state's original assessments of the insect's economic and ecological risk (Harder and Carey 2010). For the Japanese beetle, Carey recommended swapping out the conventional pesticides being sprayed in backyards with tools from organic farming, such as *Bacillus Thuringensis* (Ortiz 2015). For several invasive fruit flies in the Los Angeles basin, they advocate for a system to achieve a more permanent definition of eradication over several years (Carey et al. 2017). While these solutions challenge CDFA and USDA's approach toward understanding and acting on invasive insects, they do not question the value of protecting California's export-oriented agriculture. By contrast, several community activists who embrace the SELP do.

Drawing on diversified farming practices, such as permaculture and agroecology, these community activists point to the vulnerability—or "invasibility" (Richardson and Pyšek 2006)—of California's export-oriented agricultural lands, locating the problem not with the insects but in production systems that lack resilience to biological invasions.

> Monoculture […] creates chemical dependence, and ecological imbalances, and guarantees that these invasions, these infestations, happen. And, so I think that these so called infestations are actually a symptom of industry invasion (interview C29).

For them, questioning the MRI is not simply a means of challenging the necessity of any single eradication program, but a means to re-evaluating an entire agro-environmental system that is supported by the MRI and the brand of certainty it constructs. Accepting the SELP would be one step toward radically re-organizing California's agriculture. Differently perceiving the age and location of pest populations would be the beginning of transforming our relationships to pest populations and how California produces food.

5. Conclusion

The analysis extends Murphy's regimes of perceptibility by drawing out the primacy of spatial and temporal dimensions. Regimes of perceptibility develop in tandem with the technological, social, political, and economic capacities that circumscribe knowledge in a field. But they are not simply snapshots of a single place or time. Regimes of perceptibility operate across time and space and may only become visible themselves when analyzed along those axes. The USDA and CDFA bolster their regime of perceptibility, the MRI, by investigating and demonstrating the presence and absence of invasive insects in narrow snapshots. This focus on short timelines and contained spaces serves the purposes of meeting the ISPM and continuing the circulation of capital. The SELP challenges the certainty of pest absence precisely by challenging the temporal and spatial boundaries of the MRI, but all the SELP can do is challenge. Neither regime can be scientifically verified in the absolute. Thus, they fill the void where epistemological possibility—the boundaries of the knowable—end. Similar to regulators who test for pesticide residues (Galt 2011; 2009), agricultural regulatory actors must act on what they assume to be happening beyond what they can they can prove absolutely.

Maintaining that an insect population is invasive (and temporary) instead of established makes governing in the face of that uncertainty neater. In the insistence that an insect is not known to occur here, the pest-less past promises a pest-less future, free of both trade sanctions and the uncertain terrain of learning to live with unwanted companions. The ontological fight over quarantine pests in California shows the value of interrogating the "here" in the "not known to occur here" formulation, especially over time. Kull (2018) directs those in invasion science to "question scale and its impact" (2018, 263), noting that invasion science tends to focus on "biological species […] rather than particular populations of particular species in particular places" (ibid.). Contrasting the MRI and SELP shows how the scale of analysis of particular populations dramatically shifts landscapes of infestation, opening up divergent political, economic, ecological, and chemical futures.

It is tempting to seek an ultimate answer to whether these invasive insect populations are "really" established or recently introduced. The MRI and SELP rely mostly on trapping data, but also draw on and intersect with other ways of knowing quarantine pest populations, including modeling and genetic testing. Genetic testing is of particular interest in the debates, and research on Mediterranean fruit fly populations in the Los Angeles basin has been deployed to shore up claims of both new incursions and established populations (Carey et al. 2017; McInnis et al. 2017). The additional data is marshaled as evidence of absence and presence in the predetermined scripts of the MRI and SELP respectively. Read together, they describe a challenging landscape to parse, much less govern: cities full of quarantine pests with uncertain entrances and stoppages, where new introductions live and die alongside aging ones. Proof of absence, but also presence, remains elusive.

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Table 1: Overview of connected case studies

Quarantine Pest	Location	Years Detected in CA	Years of Eradication Programs	Outcome of Eradication Programs	Risk Assessment	Eradication Methods
Mediterranean fruit fly (*Ceratitis capitata*)	Los Angeles Area	1975, 1980-1982, 1987-1993, 1997, 2001, 2005, 2007, 2010, 2016-2018	1975 - 1976, 1980-1982, 1987-1994, 1997-1998, 2001, 2005-2006, 2007-2008, 2010, 2012-2013[5], 2016-2018[6]	Successful eradication declared after each program.	Over 250 wild and cultivated fruits at risk. "In California, the combined 2011 gross value of the [potential] hosts was over $16.5 billion (USDA NASS 2012)."[7]	Aerial and ground applications of malathion (1975-1992); spinosad; host fruit removal; sterile insect release
	San Jose Area	1980-1981, 1989, 1992-1993, 2003, 2007	1980-1982, 1992, 2005-2006, 2007-2008	Successful eradication declared after each program.		
Light Brown Apple Moth (LBAM) (*Epiphyas postvittana*)	San Francisco Bay Area	2007 - present	2007-2010[8]	Eradication failed, changed to management	Possible to lose $133 million in production and control costs in California for significant host crops and nurseries (2007)[9]	Aerial and ground applications of pheromones to disrupt mating (aerial only 2007 in Monterey and Santa Cruz), ground applications of chlorpyrifos in nurseries
	Santa Cruz and Monterey Counties	2007 - present	2007-2010	Eradication failed, changed to management		
Japanese Beetle (*Popillia japonica*)	Sacramento Area	1961-1962, 1983-1984, 2002, 2006-2007, 2010-2012, 2014-2015	1961- 1962, 1983-1986[10], 2011- 2016	Successful eradication declared after each program.	Over 300 known host plants, including turf and ornamental plants as well as high value commodities, such as grapes, berries and stone fruit[11] "The production value of the susceptible fruits grown in California was more than $6.2 billion in 2007" (CDFA)[12]	Ground applications of cyfluthrin, carbaryl, and imidacloprid in residential yards, schoolyards, and government property lawns

5 From [database]Kean et al. 2015 and ESM Supplement to Papadopolous et al. 2013
6 CDFA PHPPS FruitFly Updates (11/30/2016) and https://www.cdfa.ca.gov/plant/medfly/regulation.html
7 https://www.cdfa.ca.gov/plant/pdep/target_pest_disease_profiles/mediterranean_ff_profile.html
8 https://www.cdfa.ca.gov/plant/regs_lbam_archive.html#LBAM6
9 https://www.cdfa.ca.gov/plant/PDEP/target_pest_disease_profiles/LBAM_PestProfile.html
10 Segawa 1988, https://www.cdfa.ca.gov/plant/jb/
11 https://www.cdfa.ca.gov/plant/pdep/target_pest_disease_profiles/japanese_beetle_profile.html
12 https://www.cdfa.ca.gov/plant/JB/pdfs/JB_Damage-web.pdf

Table 2: Metrics for Determining Quarantine Pest Presence and Absence in California

Quarantine Pest	Trigger for Quarantine	Threshold to Declare Eradication	Sentinel Trapping Density	Detection Trap Density	Delimitation Trap Density
Mediterranean fruit fly (*Ceratitis capitata*)	Two flies within three miles of each other or evidence of a reproducing population (e.g. single mated female at any life stage)	No flies detected within quarantine for equivalent of three life cycles, approximately 18-24 weeks	Five traps per sq. mile[13]	100 traps per sq. mile	100 traps per sq. mile, centered on find, surrounded by four buffer zones with decreasing density of traps
Light Brown Apple Moth (*Epiphyas postvittana*)	Two moths within three miles of each other; one mated female; or, one or more immature LBAMs confirmed through DNA analysis[14]	No moths detected within quarantine for equivalent of three life cycles, approximately one year (although four generations are possible in CA)	One trap per sq. mile, relocated every 6-10 weeks w/in sq. mile (only surveyed once prior to 2007 detections, from May to October 2005)[15]	100 traps per sq. mile within a 0.5 mile radius and 25 traps per sq. mile in an additional 1 mile radius	100 traps per sq. mile within a 0.5 mile radius of a single find and 25 traps per sq. mile in an additional 1 mile radius
Japanese Beetle (*Popillia japonica*)[16]	Two adult beetles within one square mile, evidence of a reproducing population (e.g. larvae), or one beetle trapped in area for two or more successive years	No beetles detected within quarantine area for two subsequent and consecutive years of delimitation level trapping	One trap per sq. mile throughout susceptible residential and rural/residential areas	Two traps per sq. mile throughout the residential and rural/residential areas that are susceptible to Japanese beetle introduction and establishment	49 traps per sq. mile within one sq. mile around the adult find. 25 per sq. mile in contiguous sq. miles. Five per sq. mile for an additional two miles.

Figure 1: "USDA" vs Carey's models (From Carey, J. 1991. Establishment of the Mediterranean fruit fly in California. *Science* 253 (5026):1369-1373. Reprinted with permission from AAAS and author.)

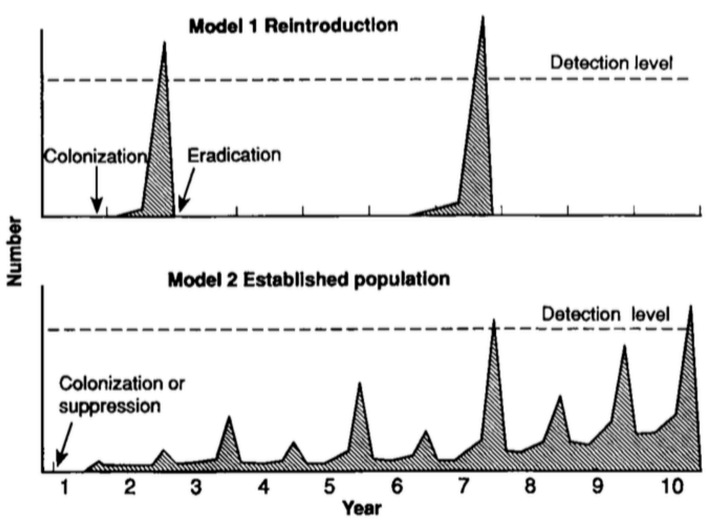

Fig. 1. Diagram illustrating patterns of medfly colonization and growth according to two alternative invasion models.

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13 Meats 2014
14 APHIS Plant Protection and Quarantine, LBAM Regulatory Protocol October 2007
15 Brown et al. 2010
16 All data from the U.S. Domestic Japanese Beetle Harmonization Plan 2016

CHAPTER (ARTICLE) 3

Kill in the City to Save the Fields: How the Urban Uncanny Refracts the Violence of Agrarian California

Abstract

California's industrial agriculture has been operated at scale for the purposes of capitalist accumulation since the state's incorporation into the United States, resulting in a long history of slow and structural violence in agrarian communities. State agents have argued that failure to eradicate agricultural pests in urban areas could result in increased pesticide use and socio-ecological devastation in agricultural production areas; in other words, eradicating pests before they can reach production areas will prevent the intensification of already-present structural violence. However, some such projects have generated significant public conflict. This paper focuses on urban residents' experiences of three particularly controversial projects to eradicate: (1) the Mediterranean fruit fly (*Ceratitis capitata*) by spraying malathion from helicopters in Los Angeles (1981-1996), (2) the light brown apple moth (*Epiphyas postvittana*) by spraying a pheromone slurry from airplanes over Santa Cruz and Monterey (2007-2010), and (3) Japanese beetle (*Popillia japonica*) by spraying a trio of conventional pesticides in yards in a Sacramento suburb (2011-2016). I argue that the fast violence of spectacular pest management events in urban and suburban areas refracts the slow violence that is routinized in California's agrarian landscapes. "Refract" suggests that the light illuminating the violence needs to be bent, bounced through another location in order to become more widely visible. This refraction is made possible by the visceral reaction of urban residents to these high profile eradication projects. To describe urban residents' experience of the phenomenon of spectacular pest eradication projects, I use Kaika's concept of the "urban uncanny," which occurs when the urban metabolism—the in-flow of commodified nature and out-flow of waste that makes urban life possible—breaks down and becomes visible. In moments of "urban uncanny," urban residents' sense of safety and independence is threatened when the state insists that their day-to-day environments are part of the metabolic functioning of industrial farms. Framing urban encounters with agricultural pest eradication methods as "urban uncanny" highlights both how sensory encounters stoke political reactions from bourgeois households to environmental problems as well as why the political

reaction is short-lived: the discomfort is temporary and relieved as soon as the urban-agrarian metabolism disappears from sight again.

Keywords
urban uncanny, urban political ecology, violence, California, industrial agriculture

1. Introduction

The images are spectacular. Helicopters bear down on Los Angeles, fogging out pesticides. A trio of airplanes fly low across Santa Cruz, misting clouds of moth pheromones. A California Highway Patrol car parks on a suburban street outside Sacramento, escorting a team of contract exterminators into the backyard of a reluctant homeowner. For the California residents who experienced the campaigns to eradicate the Mediterranean fruit fly (*Ceratitis capitata*) (1981-1996), light brown apple moth (*Epiphyas postvittana*) (2007-2010), and Japanese beetle (*Popillia japonica*) (2011-2016)—and those who watched through media outlets—the government seemed to be putting on quite a show. Those responsible, regulators with the California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture (USDA), however, framed the programs as something quite different: low-impact, surgical strikes to take out virulent pests before they could upend California's $50 billion a year agricultural industry.

As described by CDFA and USDA agents, the programs were ostensibly designed for the economic and chemical welfare of all Californians. When populations of insects not known to exist in California appear in the state, they can disrupt the production and export of agricultural commodities, threatening the U.S.'s top exporter of agricultural commodities. In the case of the Mediterranean fruit fly and light brown apple moth (LBAM), these disruptions can occur because international trading partners may refuse to import agricultural commodities from infested areas under World Trade Organization (WTO) agreements. Detections of the Japanese beetle threaten California's privileged position within domestic trade relations, i.e. the state's status as "non-infested" under the National Japanese Beetle Harmonization Plan (National Plant Board 2016). Eradicating these pest populations, then, improves or maintains California's economic standing. Moreover, CDFA and USDA representatives have argued, such programs benefit the health of the general population of California—and the occupational health of farm workers in California's industrial agricultural regions specifically—by getting ahead of potential overuse of pesticides that could be required if a species became endemic (cf. Horizon Water and Environment 2014). Regulatory risk assessments predict that eradicating economic insects in metropolitan centers prevents their (re-) introduction to adjacent areas of commercial agriculture, thereby removing the pressure to use more—and more toxic—pesticides to manage them in the field (cf. CDFA 1994).

This article addresses this translocation of pest management from agrarian to urban spaces, and specifically asks: How do visceral encounters with the state's effort to protect California's industrial agricultural in urban and suburban areas—spaces that do not contain landscapes of industrial agricultural—render the violence of California's industrial agricultural systems legible in new ways? In doing so, it responds to calls with urban political ecology (UPE) to seriously consider how areas outside the urban core transform urban centers, rather than assuming socio-economic change—and the capital and power to enact it—derives exclusively from urbanizing forces (Cantor 2020; McKinnon et al. 2019; Tzaninis et al. 2020). The eradication of economic pests from cities in California shows how the "factories in the field" (McWilliams 1939) reach into the cities, not only to enrich (Walker 2004) or feed (Cronon 1991) urbanites, but to protect the social and ecological systems that make California's export-oriented agriculture profitable.

As McWilliams (1939) described, and numerous scholars since have documented, there are several forms of violence at work in California's industrial agriculture: the interpersonal violence of armed strike-busting (Mitchell 2010; Montenegro de Wit et al 2021) to the manner in which labor is organized and the risk of exposure to harmful chemicals from both occupational use and drift (Brown and Getz 2008; Guthman 2004; Harrison 2011; Mitchell 2010; Montenegro de Wit et al. 2021; Sackman 2005; Sze 2020; Tsu 2013; Walker 2004). This latter form of violence is built into the system of operations and incrementally harms people over time in what Nixon (2011) calls "slow violence." Even regulatory risk assessments acknowledge the intensiveness of chemical exposures and social precariousness of agrarian communities in California's centers of production (Horizon Water and Environment 2014).

Pest eradication projects that spread to cities are supposed to protect urban areas from that very violence as well as prevent the violence of agricultural productions areas from worsening. Yet, I argue instead that these instances of spectacular pest management events, truly "cinematic threats" (Davies 2019, 2) or "fast violence" (Nixon 2011), in urban and suburban areas refract the "slow violence" (ibid.) that is routinized in California's agrarian landscapes. I say refract, not reveal or make visible, because the violence of California's industrial landscapes has always already been visible, for those who care to look and to those experiencing it firsthand. "Refract" instead suggests that the light illuminating the violence needs to be bent, bounced through another location in order to become more widely visible. This refraction is made possible by the visceral reaction of urban residents to these high profile eradication projects. In moments of "urban uncanny" (Kaika 2005), their sense of safety and independence is threatened when the state insists that their day-to-day environments are part of the metabolic functioning of industrial farms.

The paper analyzes the state rationale and urban residents' experiences of three pest eradication projects to describe how state and federal agencies have battled "quarantine pests," invasive insects that threaten the agricultural economy by causing damage to crops and/or bans from importers, in California's urban areas. The three projects to were undertaken across the state to eradicate three species: 1) Mediterranean fruit fly (*Ceratitis capitata*) in Santa Clara (1981-1982) and Los Angeles Counties (1987-1994), 2) Light Brown Apple Moth (LBAM; *Epiphyas postvittana*) in Santa Cruz and Monterey Counties (2007-2010), and 3) Japanese beetle (*Popillia japonica*) in Sacramento County (2011-2016). Rather than treat the three projects as discreet—or comparable—cases, I see them as part of a joint history, as one case builds on the next. Their shared history is evidenced by references made by regulators, activists, scientists, and journalists who have covered the programs and the controversies they generate. Indeed, they each are a manifestation of a singular phenomenon, the spectacular pest eradication project.

The paper proceeds by outlining urban metabolism and how economic pests and industrial farming practices circulate between population centers and agricultural landscapes. After describing this urban-agricultural metabolism, I turn to Kaika's (2005) concept of "the urban uncanny" to illuminate how interventions to disrupt these circulations are experienced by the residents of towns, suburbs, and cities where eradication programs are enacted. Next, I shift focus to agrarian California by defining and illustrating the types of violence documented in California's export-oriented agricultural production regions. I then describe the methods and framework for the analysis, including an overview of the three highly controversial eradication projects. From there, the analysis proceeds in two parts. First, I detail how the federal and state agricultural agencies manage their multiple and competing legal mandates to protect California economy, environment, and human health. This section also considers how the agencies ward off the potential harm growers and other non-state actors might enact if left to their own devices to manage newly-introduced species that becomes endemic. In doing so, the regulatory agencies operate in a system in which protecting the position of California's industrial agriculture in domestic and international markets becomes synonymous with protecting the welfare of all Californians. The analysis then shifts perspectives to that of residents in Los Angeles, Santa Cruz, and two suburbs of Sacramento, who detail their often surreal, "uncanny" (Kaika 2005) moments as government agents and contractors exterminating crop pests in non-agronomic places. Framing urban encounters with agricultural pest eradication methods as "urban uncanny" highlights both how sensory encounters stoke political reactions from bourgeois households to environmental problems as well as why the political reaction is short-lived: the discomfort is temporary and relieved as soon as the urban-agrarian metabolism disappears from sight again.

2. Urban Metabolism and the Urban Uncanny

2.1 Urban Metabolism and Ruralization Processes

Urban metabolism is a central organizing concept of UPE (Connolly 2018; Gandy 2004; Heynen, Kaika, and Swyngedouw 2006). There are flows of social and biological phenomena, which in turn enable flows of capital, and make urban life and landscapes possible. Water, electricity, steel, timber, food, and other forms of "good nature" (Kaika 2005) flow in to population centers; waste, pollution, and other forms of "bad nature" (ibid.) flow out; money moves and accumulates along the way. The landscapes that supply and receive goods are transformed through the process. In *Nature's Metropolis*, Cronon (1991) demonstrates how Chicago and its vast hinterland, "the great west," produced one another through the exchange of pigs, wood, railway systems, and more. For Cronon, the flow of goods, services, and people unite spaces conventionally cast as separate: "the urban and rural landscapes […] are not two places but one. They created each other, they transformed each other's environments and economies, and they now depend on each other for their very survival" (1991, 384). Cronon's observation is particularly helpful for understanding the co-production (Jasanoff 2004) of the spaces in which food is produced and consumed in capitalist societies, a relationship I specify as the "urban-agricultural metabolism."

While some UPE scholars have maintained that the urban metabolism is inherently about flows that go toward both urban and rural areas, the field has been critiqued for focusing too closely on what occurs within urban boundaries. Indeed, Angelo and Wachsmuth (2015) urged practitioners of UPE to organize their research around "urbanization as process" rather than "city as site:" to investigate the emergent and changing tangles of socio-environmental processes that make urban areas, however near or far from urban areas they may be, instead of taking the chunk of land marked "urban" as a pre-given and fixed location. Their provocation generated substantial response within UPE research circles—some pushing back against the notion that UPE practitioners had not already been doing just that (Connolly 2019; Tzaninis et al. 2020), some centering the call in new research agendas (Aroboleda 2016). In all, there is a trend toward exploring the manner in which urban natures — water (Kaika 2004, 2005; Gandy 2004), electricity (Silver 2015), technologies (Arboleda 2016), garbage (Behrsin and De Rosa 2020) — reach beyond city limits, into remote mines, water sources, landfills. The process of urbanization transforms edges and hinterlands but also remote satellite locations around the globe (Swyngedouw and Kaika 2014).

Emergent scholarship on processes of "suburbanization" (Keil 2017; Tzaninis 2020) and "ruralization" (Krause 2013; Mercer 2017; Cantor 2020) push against the notion that "processes […]

emanate unidirectionally from cities" (Tzaninis et al. 2020, 1). Indeed, the periphery—whether suburb (Keil 2017), ex-urb (McKinnon et al 2019), or far-flung urban water source (Cantor 2020)—can drive the level of landscape changes UPE previously attributed to urbanization. Cantor's (2020, 5) "typology of urban and rural as place and process" describes examples of ruralization processes at work in the city: landscapes within metro areas become more rural, such as through urban agriculture, green space, and low-density suburban development. My analysis builds on the notion that the rural—specifically the agrarian rural—does indeed cause socio-ecological change in cities, but not to make remake the land in its image. Instead, like many urbanization processes, the ruralization process discussed here—government projects to eradicate economic pests in urban areas—facilitates the circulation and accumulation of capital, but it does so by prioritizing rural, agribusiness interests.

2.2 The Urban Uncanny

In her investigation of urban water provisioning, Kaika (2005) explains how the urban metabolism is designed primarily for the comfort and ease of the modern bourgeois urban household. The private home "of the white Western subject" (52) became a sanctuary away from environmental and social ills. To mask a home's inherent "permeability" (Biehler 2009) to the world outside, all the infrastructure—the pipes, electrical wires, insulation—became hidden from view. Placing infrastructure out of sight created an illusion that daily domestic life was somehow disconnected from locations where the resources they carry are sourced and transformed. When the urban metabolism serves the urban household well, residents experience a feeling of being both comfortable and independent.

The urban uncanny occurs when the flow of "good nature" into the city and the household—such as water, gas, and electricity—and "bad nature" back out—through, for example, waste management—breaks down and becomes visible (Arboleda 2016; Bridge 2009; Kaika 2005). As Kaika (2005) explains, leaking pipes, power outages, garbage accumulation due to strikes,

> Such incidents produce a feeling of uneasiness, discomfort, and anxiety, which threatens to tear down the laboriously built and elaborately maintained security and safety of

> familiar spaces. These occurrences put the normalized character of the control and commodification of nature into question, and threaten the smooth functioning of the domestic sphere. Such an exposure of the limits of domestic bliss and a revelation of its dependency on social relations of production generates a feeling of 'not being at home in one's own home.' This unhomely feeling with the homely was termed by Sigmund Freud as 'the Uncanny' [das Unheimliche] (68).

While Kaika's example uses breakdowns at the household level, Arboleda (2016) suggests it can occur at larger scales, such as when a gas pipe explodes, impacting an entire neighborhood. Provoking the urban uncanny can also be part of a political strategy, such as when garbage workers go on strike (Moore 2008, 2009), leveraging the unpleasant smells and sights of waste to bring attention to the labor required in maintaining the urban metabolism. The urban uncanny is a breakdown of the smooth functioning of domestic, urban life, and it exposes the contours and complexity of urban metabolic circuits.

In emergency pest management programs, the breakdown occurs in both directions of the urban-agricultural metabolism. Moving from urban to rural, the flow of bad nature—in the form of *economic pest organisms*— threatens the good nature of agricultural fields. In the other direction, the bad nature of the *pest management* in industrial agriculture—chemicals and various methods of spraying them—disrupts how city and town dwellers experience their landscapes and air space.

3. The Violence of Agrarian California

Agriculture is—and has always been—big business in California since it was incorporated into the United States. California's total agricultural revenue is now over $50 billion, making it the "leading state in cash farm receipts in 2019 with combined commodities representing over 13 percent of the U.S. Total" (CDFA 2020b). With annual international exports valued at $21.7 billion (CDFA 2020a), California's reports the highest export earnings of all U.S. states (USDA-ERS 2020). The state accounts for 16 percent of total U.S. agricultural exports (CDFA 2020a) and is the top exporter of dairy, vegetables, fruits, and nuts (USDA-ERS 2020). This juggernaut of agricultural output is not spread evenly across the state, but instead concentrated in three key regions: the state's Central Coast; the Imperial Valley at the southern end of the state; and the Central Valley, one of the most productive agricultural regions in the world (Montenegro de Wit et al. 2021).

California agricultural production has, since European settlement, been capitalist (Walker 2004; Romero 2016; Mitchell 2010; Guthman 2004; Harrison 2011; McWiliams 1939), meaning that agricultural activities have been pursued in the state for the purposes of profit, as opposed to subsistence. Moreover, production for profit has been overwhelmingly pursued at scale by large landholders rather than family farms or small holders (Walker 2004; Romero 2016). The exceptional level of production and profit has been made possible by a number of factors: the mild climate, research and support through public universities and cooperative extension, irrigation, intensification of production, and low wages—achieved by cultivating and maintaining the precarious social, political, and economic positions of immigrants in the agricultural workforce (McWilliams 1939; Walker 2004; Harrison 2011; Tsu 2013; Montenegro de Wit et al. 2021; Sackman 2005; Guthman 2004; Mitchell 2010).

Multiple forms of violence embedded in California's industrial agriculture have facilitated its profitability. The World Health Organization defines violence as, "the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment, or deprivation" (2014, 84). Starting from this baseline definition of violence, California's agribusiness history holds many examples, including growers and police shooting workers attempting to unionize or striking to improve wage and conditions in the early 20th century (McWilliams 1939; Mitchell 2010; Montenegro de Wit et al. 2020) and "vigilante committees burning Chinese workers out of camps in the 1870s and 1880s" (Mitchell 2010, 149). Yet violence is not always quite so straight-forward as person-on-person.

Other forms of violence emerge out of the way societies organize themselves politically, economically, and ecologically. Structural violence occurs when groups of people are denied basic needs—such as potable water (Ranganathan 2016), clean air (van Glascoe & Schwartz 2019), food

(Whittle et al. 2015), health (Farmer 2004; Davies et al. 2019), healthcare (Farmer et al. 2006), and housing (Taylor 2013; Goodling 2019)—as a result of the way societies organize political, economic, labor, and educational systems to provide these social goods (Banerjee et al. 2012; Gultang 1969; Davies 2019). In short, as Peña (2011) defines it: structural violence is "the systemic ways in which a given social structure or social institution kills people slowly by preventing them from meeting their basic needs" (207). Peña's definition segues us to another related but distinct form of violence: slow violence. Nixon (2011) argues that it is easy to recognize the violence of abrupt, spectacular events that cause mass injury and casualties, such as airplanes crashing into towers or "avalanches, volcanoes, and tsunamis" (3). However, harmful events that unfold slowly are less likely to be identified as violent even if they ultimately cause injury and casualties at the same or even greater scale. To bring our collective attention to the "long emergencies" (ibid.) of, for example, petro-chemical exposures, sea level rise, or chronic pesticide exposures, Nixon introduces the term "slow violence." As Sze (2020) clarifies, slow violence showcases how "violence has a temporal character, which manifests how the impacts of violence are often rendered invisible for those impacted by it, as well as made difficult to see for those not directly impacted. These impacts often take a long period of time, in contrast to fast violence, which is sudden, obvious, and explosive" (142).

Much of the violence embedded in California's agrarian landscapes and communities is both structural and slow. First, there are a host of occupational hazards that arise out of the organization of labor to produce at the scale and profit margins California maintains. California farms have long relied on the labor of immigrants whose legal protections are limited (McWilliams 1939; Walker 2004; Harrison 2011; Tsu 2013; Montenegro de Wit et al. 2021; Sackman 2005; Guthman 2004; Mitchell 2010; Brown & Getz 2008). Indeed, legal structures, international agreements, and state and federal government actions often codify their precarity making their social exploitation possible (Tsu 2913; Walker 2004; Mitchell 2010; Getz & Brown 2008). Mitchell (2010), drawing heavily from McWilliams (1939), describes the structural violence California's agricultural workers endured in the first half of the twentieth century: "the everyday debilitating violence of appalling work conditions, bad sanitation in the camps and fields, the constant mobility and sleeping rough that marked – and destroyed – so many workers' lives, the respiratory and other diseases that came with migrant work and the preventable injuries and illnesses that defined that work" (150). Eighty years later, the conditions remain remarkably similar (cf. Holmes 2013). The structural violence experienced by California's agricultural workforce is compounded by climate-change events, another form of slow violence, such as extreme heat and wildfire smoke (Castillo et al. 2021). Critically, the risk of occupational exposure to pesticides remains high, despite increased pesticide regulations, use of personal protective gear, and trainings on safe pesticide handling (Harrison 2010).

Second, simply living in and near California's agricultural production zones exposes individuals to the structural and slow violence of contaminated water sources, contaminated soils, and pesticide drift events (Bostic 2021; Luo & Zhang 2009; Harrison 2010; Sze 2020; Pannu 2012: Dobbin 2021; Ranganathan & Balazs 2015). As Harrison (2010) notes: "Although immigrant farmworkers and their family members are certainly not the only California residents exposed to pesticide drift, they are disproportionately exposed to agricultural pesticides at work and by living near agricultural fields" (29). Childhood asthma and other respiratory illnesses are especially common in the Central Valley (van Glascoe & Schwartz 2019). Communities of migrant workers also have limited political representation (Sze 2020; Anderson 2010; Pannu 2012).

Much of the structural and slow violence described so far derives directly from the methods of conventional, industrial agriculture in California. Put another way, a violent relationship with the land and its biota has begotten manifold forms of social harm. The Central Valley contains only "2 percent of the nation's farmland [but uses] 25 percent of its pesticides" (Sze 2020, 52). This concentration of pesticides is symptomatic of "antibiotic approaches" (Guthman 2019) or "total pest management" (Perkins 1982), which defines agricultural health by the absolute absence of pests. The Central Valley has been engineered over time to be a place of health and abundance: water re-routed, marshes drained, fields restructured, and chemicals injected, sprayed, and powdered specifically to limit disease, of plants and humans, and increase agricultural production (Nash 2006). Considerable resources and ingenuity have been put into maximizing California's agricultural output (Henke 2008), from refrigeration (Freidberg

2009) to repurposing oil waste for pest management (Romero 2016) to mechanical tomato harvesters (Schmitz & Seckler 1970), agricultural innovations of the past 150 years have been developed, tested, and/or perfected in California. The resultant landscapes, monocrops of fruits and vegetables, scholars argue are themselves violent (Mitchell 2010). Hetherington (2020), building off Tsing (2017), sums up: "monocrops are emblematic landscapes of late capitalism, spaces of industrial killing that aim to simplify life into its most scalable, commodifiable forms" (20).

Despite the long history of both research on the violence of California's industrial agricultural systems and activism on the ground to address it, especially through labor and environmental justice organizing, the average urban bourgeois household in California does not typically experience the violence or advocate for systemic change; instead choosing to protect their own family members and communities by "shopping their way to safety" (Szasz 2009; see also Harrison 2014). However, visceral experiences of pest eradicating methods through highly controversial agricultural pest eradication projects open the door to raising awareness and engaging in action for structural change.

4. Methods and Overview of Pest Eradication Projects

4.1 Methods

The data for this paper includes public comments, regulatory documents, stories from local and national news outlets, the personal archives of activists, and 65 interviews conducted by the author and M. Lelea for an evaluation of public perceptions of emergency plant health programs commissioned by USDA-APHIS (Zalom et al. 2013).[1] Sedell conducted additional fieldwork between 2014 and 2017, including observations at three Entomological Society of America meetings, regular California Invasive Species Advisory Council meetings, and four additional interviews (two community activists, one

[1] The interviews conducted for Zalom et al. (2013) are anonymized and reported in aggregated form here to protect the identity of participants. At the time of the evaluation (2010-2012), several major lawsuits were pending and tensions generally ran high in the wake of the LBAM eradication program. Participants are grouped into four major identified categories: 1) community members and activists (labeled "C"), 2) growers and pest control advisors (labeled "G"), 3) academic entomologists and scientists (labeled "D"), and 4) staff at county, state, and federal agricultural agencies (labeled "Y"). Because of the aggregations, participants are referenced by their overarching category rather than titles, functions, or locations.

academic, and one former commodity board representative). Residents of Carmichael and Fair Oaks generously shared their personal records documenting their experience with the Japanese beetle eradication project.

While the analysis of the qualitative data draws on three case studies (described more below), it is structured as a phenomenological study (Cresswell 2013). Specifically, the analysis follows shared and/or connected experiences of individuals in relation to a singular phenomenon (ibid.). The phenomenon is spectacular economic pest eradication projects enacted in urban and suburban areas in California. I gather the three cases/projects into a single phenomenon, because the three cases share many attributes, and those who experienced them first-hand both situate their experiences in relation to the other eradication projects and transfer their knowledge and political strategies with residents resisting other eradication projects.

In terms of shared attributes, few emergency plant health projects generate the level of public conflict that the projects discussed here have (Sedell *in progress*), making the cases "extreme" (Miles and Huberman 1994, 28). They are "unusual manifestations" (ibid.; see also Cresswell 2013, 158) of emergency plant health projects. The combination of their spatial configurations, targeted insect populations, methods of eradication, and enactment through emergency orders made them all particularly inflaming. Specifically, these projects all targeted economic-agricultural pests in urban and suburban areas with substances with which residents then had direct visual, tactile, auditory, and/or olfactory encounters. Additionally, because the projects were enacted by emergency declarations, the agencies in charge were exempt from assessing the environmental and health impacts prior to enacting them. This last point speaks directly then to *how* residents resisting the projects forged conceptual and relational connections between the projects. Pushing for accountability under California's Environmental Quality Act (CEQA), which exempts agencies from preparing environmental impact reports for emergency projects, was a shared tactic among those who fought against the aerial release and ground application of malathion to eradicate the Mediterranean fruit fly, the aerial dispersal of pheromones to eradicate LBAM, and the ground application of a trio of insecticides to eradicate the Japanese beetle. Additionally, residents in interviews as well as local media outlets drew comparisons between the three projects, some from personal experience, others from public commentary. Residents resisting the LBAM and Japanese beetle eradication projects eventually also joined forces to resist and litigate CDFA's new framework for responding to introduced pest populations, the Statewide Plant-Pest Programmatic Environmental Impact Report (Horizon Water and Environment 2014; North Coast Rivers Alliance v. California Department of Food and Agriculture 2017).

I initially employed an "open coding approach" (Emerson et al. 2011) to analyzing the qualitative data. In the process, two overarching "analytic codes" (Cope 2010, 283) emerged. The first was phenomenological in that it related to the lived experiences of urban and suburban residents during the three eradication projects. This included both their own descriptions of the experience, personal observations of their neighbors and/or family members' experiences, and media coverage of individuals' reactions to the eradication projects. The second was spatial in that it captured how multiple stakeholders—residents but also CDFA staff and affiliated experts--framed California's Central Valley, urban and suburban areas, and the relationships between them vis-à-vis agricultural pest management. These two analytic codes were then placed in relationship with the theoretical concepts of urban metabolism, urban uncanny, and fast and slow violence to describe how the shared sensory experiences of high profile projects to eradicate economic pests in cities and suburbs makes the ongoing violence in California's industrial agricultural regions visible in new ways.

4.2 Three Pest Eradication Projects

The analysis follows three pest eradication projects: 1) Mediterranean fruit fly (*Ceratitis capitata*) in Santa Clara (1981-1982) and Los Angeles Counties (1987-1994), 2) Light Brown Apple Moth (LBAM; *Epiphyas postvittana*) in Santa Cruz and Monterey Counties (2007-2010), and 3) Japanese beetle (*Popillia japonica*) in Sacramento County (2011-2016). Presented in chronological order, here is an overview of each project.

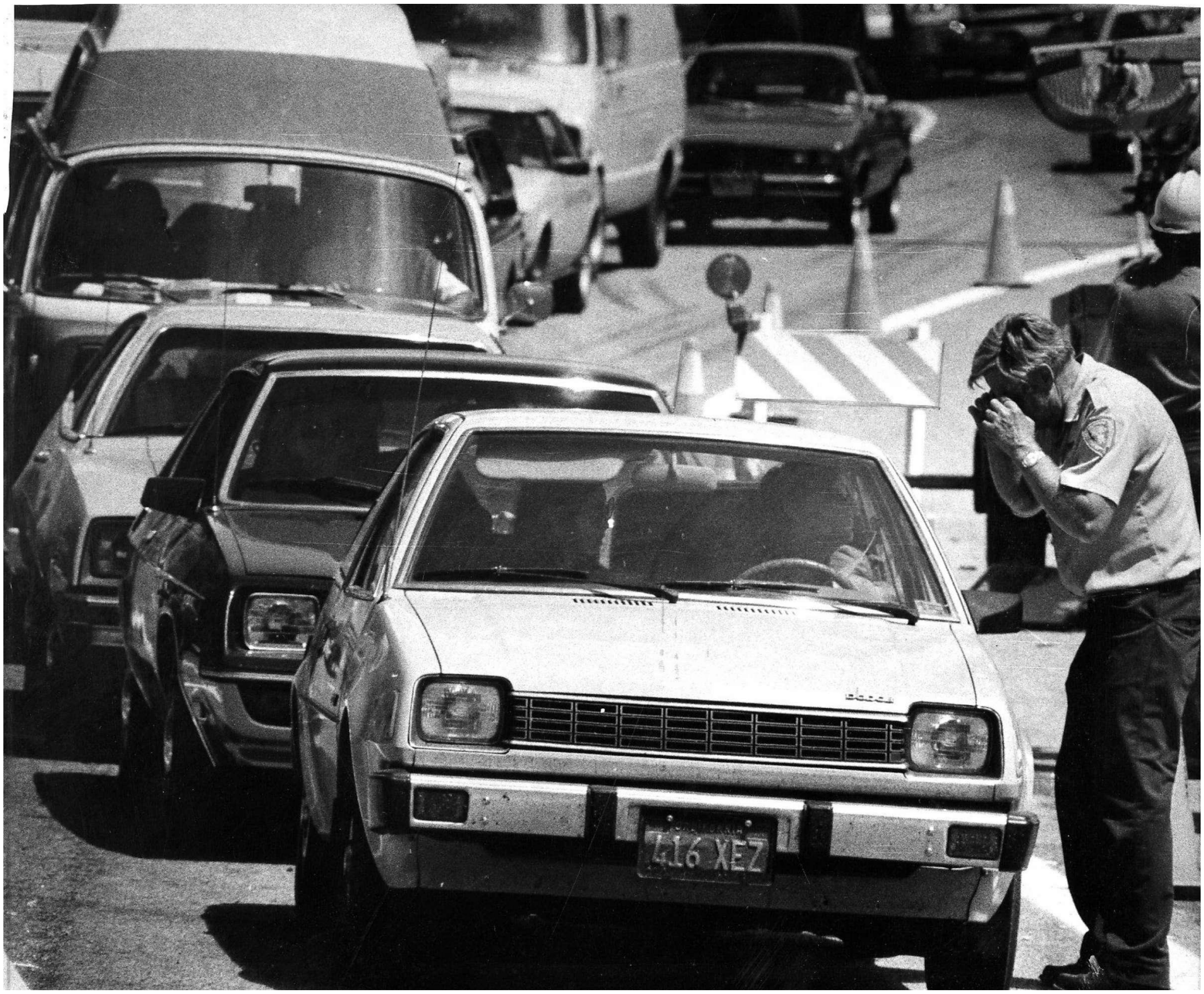

Figure 1: Cars stopped for inspection in Santa Clara County Quarantine for the Mediterranean fruit fly (photo reprinted with permission from the San Francisco Chronicle, 1981)

In 1980, the USDA threatened to quarantine all of California if the state did not initiate efforts to eradicate the Mediterranean fruit fly (*Ceratitis capitata)* (Dahlsten and Garcia 1989), an agricultural pest that attacks over 260 different kinds of host plants but is particularly damaging to citrus (CDFA 1994). Governor Jerry Brown, in his first term, balked but eventually relented and declared an emergency. The resultant emergency plant health programs (1981-1982 in Santa Clara County and 1980-1994 in Los Angeles County), which were jointly operated by CDFA, USDA, and County Agricultural Commissioners, were the most ambitious conducted in the state to date. Quarantines and checkpoints were established in Santa Clara Counties and later Los Angele County; akin to the checkpoints at the state borders, officials would stop motorists to ask about and confiscate fresh produce (see Figure 1). Crews fanned out into yards, fields, and parks to inspect plants for flies, remove infested plants, and apply pesticides. The National Guard was deployed to increase the capacity for home and checkpoint inspections. Malathion, an organophosphate associated with neurotoxic, genotoxic, and carcinogenic effects (Badr 2020), was applied on the ground and, in diluted concentrations, from helicopters across the metro areas. The experience for many residents was, to put it mildly, unsettling. The aerial spray program was ended in 1994, and in 1996 CDFA began a preventative eradication program by releasing sterile flies (CDFA 2018).

In 2007, another plant health emergency put aircraft into the sky when, the light brown apple moth (*Epiphyas postvittana*), was detected in counties across the San Francisco Bay. The tiny, leaf-rolling moth from Australia has over 250 known host plants, including many of California's high-value crops (Knighten and Hawkins 2007). The LBAM eradication program was billed as "the most environmentally friendly eradication program in California's history" by A.G. Kawamura (2007), the CDFA director at the time. Instead of conventional pesticides, airplanes would spray a pheromone slurry to confuse the moths, and prevent individuals from finding mates. The plan was that, after spraying for three nights in a row every five weeks for five years, the moth would be gone, and residents would have only been exposed to "perfume" (interview D57). The emergency plant health program to eradicate LBAM on the Central Coast generated significant public pushback, with many news outlets and concerned community members comparing it to the Mediterranean fruit fly programs. While pheromones are not a conventional insecticide, they are still classified by U.S Environmental Protection Agency (EPA) as a pesticide, a term that indicates, "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest" (Section 2(u) of Federal Insecticide, Fungicide, and Rodenticide Act, US Code 2013 Edition, aka U.S. Code Title 7, Chapter 6, Subchapter II, Sec 136 - Definitions (u) Pesticide). The EPA specifically classifies pheromones as a "biochemical pesticide" (EPA 2021), which indicates that its mode of action to target pests is "nontoxic" (ibid.) and that the substance has history of only "minimal toxicity" (ibid.) to humans and the environment. However, residents raised three human-health concerns regarding the pheromone slurry deployed in the LBAM eradication project: (1) the makers of pheromone slurry would not disclose the inactive ingredients in the slurry, raising questions about possible human and environmental health impacts of the unknown components (Dilworth 2007; Ragan 2007), (2) the droplet size of the aerosolized slurry could be small enough to inhale deeply in the lungs, which could pose a threat to respiratory functioning (Lynberg 2008), and (3) for the many residents in the area with multiple chemical sensitivities disorder, the pheromone itself could impair their daily functioning (as reported in interviews). Only three instances of aerial dispersal of pheromones ultimately occurred, two in Monterey County and one in Santa Cruz County, both in late 2007. In 2008, all plans to aerially disperse pheromones over Monterey and Santa Cruz Counties as well as the nine counties of the San Francisco Bay Area were postponed. In 2010, CDFA ended the program and shifted their strategy to "management"—rather than eradication—of LBAM in the region (Jones 2010).

From 2014 to 2016, CDFA attempted an eradication of the Japanese beetle, which has historically been a turf and ornamental pest but has more recently been cast as a vineyard pest as well (Burfitt 2017), in two suburbs of Sacramento. Instead of spraying by air, the agency contracted a local extermination company to apply three different conventional pesticides (imidacloprid, cyfluthrin, and carbaryl) to the soil, grass, and shrubs of residential areas. If residents refused the spray, exterminators returned, accompanied by California Highway Patrol officers. Community members resisted the eradication efforts and coordinated with community organizers from the LBAM resistance to develop media and legal strategies to stop the program.

5.0 Managing Economic Pests Across California's Urban-Agricultural Metabolism

State agents have frequently dismissed resistance to the three agricultural pest eradication projects in urban and suburban areas as NIMBYism (Not in My Backyard-ism). However, that framing invisibilizes why the eradication projects are occurring in the first place, specifically what they are aimed at protecting--export-oriented agriculture--and in doing so, conflates economic activity with public welfare. The following section outlines these steps in order to both explain how and why these eradication projects occur but also why framing the controversies as NIMBYism works to both dismiss lived experiences of urban residents and turn attention away from systemic change.

5.1 Quarantine Pests, Emergencies, and Quarantines

Tracing economic pests through both their pest pathways and the regulatory responses shows us that as much as agricultural production areas are part of the urban metabolism, urban areas too are part of the agrarian metabolism. In their review of invasion science literature, Soloman Cavin and Kull (2017) found that cities are frequently framed as problems. Urban landscapes invite pests to stay and proliferate, eventually spilling over into wild and agricultural areas beyond city limits. The risk assessment of economic pests in California underscores this point and introduces a specific spatiality to the state's urban-agrarian metabolism.

Invasive species, broadly defined, are not known to historically exist in a particular place *and* have the potential to cause damage to local ecology, public health, and/or economy (Simberloff et al. 2013). Economic pests that may provoke bans from international importers are "quarantine pests" (FAO 2007). As Catherine Phillips (2013: 1683) observes, invasive fruit flies (and other quarantine pests) "are relatively ignored creatures, until they become risks—to good-quality fruit, maintaining markets, biosecurity budgets, private property rights." When a quarantine pest is detected, its presence and the actions being taken to control it must be communicated to trade partners through pest alert systems (Ebbels 2003). In turn, trade partners evaluate the risks and mitigation measures and, in some instances, may refuse to accept certain commodities from infested areas, as happened when Mexico refused California strawberries in early 2008 during the LBAM outbreak (Kawamura 2008; Bookwalter 2008). To prevent such sanctions, state and federal agencies use a variety of tactics, two of which are particularly salient to this analysis: emergency declarations and plant health quarantines.

When a quarantine pest is detected, the secretary of food and agriculture in California issues a "Finding of Emergency," stating that the "situation calls for immediate action to avoid serious harm to the public peace, health, safety, or general welfare" (Government Code Section 11342.545; see also Public

Resource Code Section 21080). The Finding of Emergency outlines the specific threats posed by an introduced species and outlines the ecological and legal imperatives to eradicate it, but does not specify how eradication will occur. After the finding of emergency has been released, the public typically has five days to comment on the document, although in instances in which the threat is considered particularly imminent, CDFA has the authority to begin actions immediately (Government Code Section 11349.6(b). Eradication programs, however, are not solely authorized as emergencies. They also fall under state regulatory agencies mandate to protect the environment (State of California Food and Agricultural Code, principally Sections 5028, 5301, 5302, 5306, 5309, and 5322).

In California, plant health quarantines are enacted by CDFA and enforced largely through county agricultural commissioners. The USDA has the power to quarantine an entire state, as part of their authority to regulate interstate commerce (Plant Protection Act of 2000, Section 415). However, USDA typically works with state agencies to determine smaller quarantines within state borders (APHIS 2009). California is unique in that it also has robust local authority in the county commissioners' offices to inspect fields and shipments and coordinate with growers, pest control advisors, and extension agents. The size of plant health quarantines depends on the locations in which the target insect has been detected alongside a risk assessment of the population and its mobility. In order to move fresh produce, plants, and other host material out of the quarantine for sale extra-locally, the field in which the material was grown or the particular shipment must be certified as "free from" pests (Sedell 2019; see also FAO 2016). Within the quarantine, growers are encouraged (sometimes required) to use certain approaches to managing the target insects. While plant health quarantines often extend across a range of landscapes, including residential areas, they are typically only enforced in production areas.

Eradication programs undertaken under emergency orders and plant health quarantines are exempt from state environmental protection policy, the California Environmental Quality Act (CEQA). Preventing or mitigating an emergency is a statutory exemption to CEQA (California Public Resources Code; Section 21080(b)(4)); the statutory exemption related to emergencies covers actions taken to respond to new pest incursions. Eradication actions taken by regulatory agencies to "protect the environment," which includes plant health quarantines, also fall under categorical exemptions to CEQA (CDFA 2011). In sum, because eradication projects result from both an emergency declaration and a state agency's mandate to "protect the environment" writ large, the state is not required to conduct an assessment of environmental or public health impacts of plant health emergency programs. That said, in highly controversial programs, including all three in this analysis, environmental impact reports were eventually developed after the programs had been initiated, often after they had concluded.[2] In the case of the aerial treatment MedFly programs, the draft programmatic environmental impact report (PEIR) was prepared in 1993, thirteen years after the initial aerial application of malathion; aerial application was already dropped as an option by the time the final PEIR was released in 1994. The final PEIR for LBAM was released in 2010, three years after the program began and the same year that the state announced it was changing its strategy from eradication to management (Jones 2010). The evaluation of the environmental impact of the Japanese beetle eradication project was folded into the litigated Statewide Pest Programmatic Environmental Impact Report (Horizon Water and Environment 2014) as eradication activities were wrapping up.

5.2 "Ensuring the welfare of every citizen"

During plant health emergency responses, county, state, and federal governments hold together—and sometimes conflate—competing mandates to (1) protect the economy by removing risks to trade (quarantine and other economic pests), and (2) minimize the threats to environmental and public health from insecticides, which assessments typically predict will be used in greater quantity and skew toward higher toxicity if infestations are not eliminated through government intervention (cf. Horizon Water and Environment 2014; LBAM PEIR 2010; CDFA 1994).

When assessing the risks posed by economic pests introduced into California's urban areas, state and federal agents paint a dire picture of California's industrial agrarian communities in the Central

[2] The EIRs were developed to cover on-going eradication activities beyond the immediate emergency responses. While it appears that they were prepared in part to address and allay public criticism—and litigation—related to the projects, state agents have not publicly attributed the preparation to EIRs to public pressure.

Valley and argue that failure to act in urban and suburban landscapes will exacerbate already untenable social and ecological conditions. In the programmatic environmental impact report for LBAM, the risks of not taking action explicitly invoke the state's centers of industrial agriculture, the San Joaquin Valley, which forms the southern portion of the Central Valley:

> The No Program Alternative [not having the eradication program] is also infeasible because it would be economically, socially and politically unacceptable to allow LBAM to cause extensive agricultural damage to crops, and economic damage to farmers, at this time. Farmers are already suffering due to an extended period of drought and regulatory restrictions that limit the amount of water available for irrigation. Unemployment in some portions of the San Joaquin Valley – one of California's most heavily agricultural areas – is currently running above 15%, and in some heavily hit areas such as Mendota, Orange Cove, Parlier, and Huron, it is more than 35%. […] As explained in the Agricultural Resources Chapter of the PEIR, the No Program Alternative will cause significant agricultural and economic losses, including job losses. This will, in turn, decrease local tax revenues and further strain the budgets and resources of local agencies in these areas. Further agricultural job losses, and associated secondary impacts, in areas already hard hit by water supply problems and the general economic downturn are economically, socially, and politically infeasible at this time. (LBAM Final PEIR, 2010, p. 18).

In this formulation, CDFA draws attention to features of the structural violence of the California's industrial agricultural regions and argues that it will worsen if LBAM is not eradicated. Other times, the Central Valley is implicitly invoked, as in the case of the possible establishment of invasive tephritid fruit flies, including the Mediterranean fruit fly,

> If the exotic fruit flies were to become permanently established in California the agricultural cultivation of host plants could continue in most areas, but at higher cost ($493 million - $875 million dollars per year), lower yield, and with increased pesticide use (14,000 - 5,500,000 pounds active ingredient per year, depending on the fly involved)

(Exotic Fruit Fly Eradication Program using Aerial Application of Malathion and Bait, Final PEIR, 1994, p. 10).

A map in one of the appendices shows "selected crops susceptible to fruit flies" are heavily clustered across the Central Valley (Figure B-6: Distribution in California of Commercial Plantings of Selected Crops Susceptible to Fruit Flies", Exotic Fruit Fly Eradication Program using Aerial Application of Malathion and Bait, Final PEIR, 1994, B-44).

In these formulations, state intervention is necessary because the pests could decimate crops, but also because if industry was left to its own devices, its response to pest outbreaks would decimate agrarian communities through higher insecticide use. By spreading pest control methods across both urban and agrarian landscapes, regulatory agents spread out the chemical risks of pest management and pre-emptively reduce pesticide loads in the Central Valley. In this way, the state meets both the mandates to protect export-oriented agricultural production *and* the health of communities, all through processes that are exempt from CEQA and therefore public input. Regulatory agents have seemed surprised that this logic of risk-sharing across California's diverse landscapes has not been more widely accepted.

Charles Getz, IV, the Deputy Attorney General for California who defended CDFA in lawsuits stemming from the Mediterranean fruit fly eradication programs, frame the state as arbiter and custodian of citizen exposures to pesticides, a protective government that intervenes in order to ensure the chemical well-being of the greatest number of people. Getz fortifies the position by casting those who object to the eradication programs simply as NIMBYs who care little what pesticides are used in California's foodways so long as they do not drift, soak, or otherwise touch their property. The framing is shared by CDFA, USDA, and affiliated experts associated with the LBAM and Japanese beetle programs. To Getz's point, it is not hard to find evidence to support his claim in these highly controversial programs. One letter to the editor of the Monterey County Herald regarding LBAM asserted that, "If CDFA doesn't want moths on their crops it might be a better idea to spray the heads of lettuce than the heads of people" (2007) as if no people worked in or lived by fields of lettuce. Yet Getz's argument elides who and what exactly is being protected. The Mediterranean fruit fly, LBAM, and the Japanese beetle pose, primarily, an economic threat. Moreover, the state argues that growers' response to that threat may be to intensify chemical use in areas of industrial, export-oriented agriculture. Introduced pests "benefit from many conditions associated with modern agriculture, particularly the use of extensive monocultures and the intensive use of fertilizers" (Legros et al. 2021, 8); thus the practices of California's export-oriented industrial agriculture render it vulnerable, and its own response to such threats may intensify that vulnerability. Overall, the implication then is that in order to "ensure the welfare of every citizen" (Getz 1989, 71) the state must protect its citizenry against the chemical intensity and trespass of industrial agriculture by protecting export-oriented industrial agriculture from its own vulnerabilities and responses to those vulnerabilities.

6.0 Moments of Urban Uncanny

6.1 Los Angeles: Medfly

By the time the USDA strong-armed California into war with the MedFly in 1981, helicopters were already part of the everyday experience of many living in Los Angeles (Davis 2006). The Medfly helicopters extended the aural assault already underway by the Los Angeles Politce Department in "a nocturnal sonic signature that evoked comparisons to war zones" (Kaplan & Miller 2019). It also triggered wartime associations for veterans, as one grower explained, "After the Medfly, there were Vietnam Vets who panicked from the sounds of helicopters, planes passing overhead" (Interview G58). However, unlike the LADP helicopters, the Medfly eradication program helicopters did not just surveil; they sprayed malathion, an organophosphate pesticide. As a class, organophosphates include many nerve agents initially developed in Germany (Russell 2001; Mukherjee & Gupta 2020). Concerned residents picked up on the link, noting that their own government was spraying them with substances developed for use in "chemical warfare" (Letter from Azhar Al-UqDah , Pasadena, CA, to Robin Reynolds, CDFA, July 26, 1993, p. 21 of Aerial EIR, April 1994). Indeed, for those caught in the spray, the experience felt very much like a chemical attack:

When I first came to this country in 1981, I was fourteen. And, I didn't, you know, just

> like any kid—I didn't really read the newspapers. I really did not speak English well enough to read the newspapers at that age either, and really didn't have a clue as to what was happening. And, one day, I was on the street in my neighborhood, and all of a sudden my friends yelled at me and said, 'Run!' I couldn't figure out what was going on. I thought maybe some thugs were on the street –you know—some bullies, or something. And, what it was [was] the helicopter. There was a helicopter spraying my street as we were walking down the street. So, we did our best to outrun the helicopter – got under an awning. You know, when we got out from under the awning, the whole street was just, just, drenched. I almost slipped on the stairs that I had run up to, to get under the awning. And yeah. We dragged the malathion home with us. We breathed it. I was quite sick afterwards. (Community Activist; Interview C29).

Government agents did their best to allay the fears of residents in the Los Angeles and San Jose metropolitan areas. In 1981, B.T. Collins, the Director of the California Conservation Corps, drank malathion in front of a crowd to prove that the substance was safe (Haberman 2014; see Figure 2). His act in and of itself highlights the schism between the risk assessment of regulators and the fear of those about to be sprayed. In both the Medfly and LBAM eradication programs, agricultural regulators in California pushed an argument that the substances to be sprayed are not any of those old, bad nasties — DDT, dieldrin, Agent Orange (an herbicide anyway!), or any of their ilk — but new and *safe* classes of pesticides, diluted for aerial dispersion in ways that make them even more innocuous.

A Toast To Malathion

B.T. Collins, director of the California Conservation Corps, said yesterday he drank a glass of diluted malathion to prove its safety to his dubious teenage troops — and that he feels fine.

The notoriously cocky Collins, who is leading the corps' land war against the Mediterranean fruit fly, said he swilled down a 6-ounce glass of the pesticide solution at a camp rally at Agnews State Hospital Tuesday night, while "giving my typical Martin Bormann speech" to 980 youths.

"The fact is that the stuff is not harmful," the 40-year old CCC director, who lost an arm and a leg in the Vietnam War, said in a telephone interview yesterday. "This was a much greater exposure than anyone will get from the spray."

"I drank it because you don't ask your troops to do anything you wouldn't do," Collins added.

By 4:30 yesterday afternoon, Collins was answering a deluge of phone calls to his Sacramento office with the words, "Yes, I drank malathion, yes I feel fine, this is a tape recording."

Insisting that the substance he drank was actually malathion, Collins said he felt a little queasy after he drank the liquid.

"It tasted horrible, like kerosene," he admitted. "No wonder the Medflies hate it."

Collins is no stranger to drinking either traditional or unorthodox concoctions. During his stint as an Army captain, he said, he downed a bottle of Aquavelva aftershave lotion.

The malathion he said he drank Tuesday night was diluted to the same strength as that sprayed by the helicopters over the Medfly infested regions, Collins said.

UPI Telephoto

State official B. T. Collins joked about the malathion he said he downed in an attempt to prove it harmless

Figure 2: "A Toast to Malathion" Feature of B.T. Collins, director of the California Conservation Corps, publicly consuming malathion (Susan Sward, July 16, 1981; reprinted with permission from the San Francisco Chronicle)

6.2 Santa Cruz and the Greater San Francisco Bay Area: LBAM

In 2012, an agricultural regulator interviewed about the LBAM eradication program referenced the Collins stunt, acknowledging that, "I don't know if anyone would do that [drink malathion] now" before pivoting to a defense of the pheromone slurry applied aerially across Santa Cruz and Monterey in 2007:

> You know the technology has changed and instead of organophosphates, you are using pheromones. You know, synthetic pheromones. And […] the interesting thing: I think is that there was a time when people would have died or rolled over to have those kind of options versus what they had at the time (Interview Y13).

Using pheromones instead of conventional pesticides was a huge leap forward for agencies (Kawamura

2008). The risk posed by pheromones to human or environmental health is generally thought to be quite low (EPA 2021), especially when compared to the organophosphate insecticides, which are potent toxins of the human nervous system. Pheromones are part of the toolkit for organic agriculture.

The fact many anti-spray activists did not recognize the innocuousness of airplanes dispersing a pheromone slurry bewildered regulators. Yet, it arguably should not have given how many community members reported that they and/or their loved ones felt sick afterward. For some it was the smell as one Santa Cruz resident described:

> We heard the planes starting to fly over and they were doing passes back and forth, for a couple of hours and they were really low-flying planes, to hear them really close by, and then the smell of the spray started to come from upstairs, down to where we were at that point, and we could smell the smell of Raid (Interview C27).

For others it was a sudden change in breathing. The San Francisco Chronicle carried a story about how an 11-month-old exhibited breathing problems after the aerial application of pheromones in Monterey, raising questions about the size of the droplets dispensed in the pheromone slurry and if they were small enough to inhale deep into the lungs (Kay 2008). The non-active (sometimes misleadingly called "inert") ingredients of the slurry, which were protected as trade secrets, also concerned community members. And for those who were already sensitive to chemicals, such as the interviewee who smelled Raid, the pheromone mix itself caused dizziness, disorientation, and nausea.

6.3. Sacramento: Japanese Beetle

Establishment of JB [Japanese beetle] in CA vineyards and irrigated croplands could have far-reaching consequences. I understand that as a protected State committed to staying JB free as long as possible, CA must be proactive and aggressive in combatting this pest. The risk of establishment is ongoing and growing, potentially via aircraft and especially through grubs in nursery stock shipped from other states. Blanket or haphazard spraying of suburban residential properties year after year does not resolve that.

Daniel A. Potter, Distinguished Professor of Entomology, University of Kentucky, letter to Karen Ross, Secretary of CDFA, dated Dec. 4, 2015, p. 4

Ground treatment has been a part of almost all plant health emergency responses. During the

Mediterranean fruit fly eradication efforts, for example, ground crews sprayed malathion in yards and other landscapes near detections. However, the intensity and frequency of the pesticide spraying to eradicate the Japanese beetle in Fair Oaks and Carmichael was extraordinary. Even for communities of "lawn people" (Robbins 2007), the pesticide application protocols were disturbing:

> The [2015] CDFA spray season included ten applications of toxic chemicals. Carbaryl was sprayed three times on stone fruit trees. Carbaryl is a known potent neurotoxicant. […] Cyfluthrin was sprayed six times on trees and landscape. This pesticide is an highly active neurotoxicant. […] Also, Imidacloprid was injected into our lawn last summer […] a neonicotinoid insecticide, which can affect the central nervous system of humans, and should not be applied to residential lawns. (Letter from Carmichael resident, Karin Mahnke, to Stephen Brown, CDFA, December 5, 2015)

According to records retained by neighborhood residents, contract exterminators returned to spray one or more chemicals roughly every two weeks from May to August 2015, resulting in six to ten visits per property. One resident described the seemingly endless treatments in embattled terms:

> It was like a war zone. That's all I can tell you. Every day in 2015, if it wasn't you, it was your neighbor. If it wasn't the grass, it was the stone fruit. If it wasn't the stone fruit, it was the other type of fruit trees (Interview C47).

When residents pushed back against the program, CDFA agents requested law enforcement be present at residential sprayings. Residents reported seeing two California Highway Patrol units and an animal control officer on the scene for the spraying of one neighbor's property in June 2015. Later that month, another resident returned home to find:

> Multiple (identical) warrants pasted on front door and garage door, next to my protest sign; my lock on my side gate broken. A notice of insecticide treatment (yellow form) pasted on front door. Dog […] still loose with access to treated backyard when imidacloprid label warning specify [sic] that pets and children should be off turf until chemical dries (Records from a Carmichael resident shared anonymously with author,

dated June 30, 2015).

Dismayed by both the tactics and the chemicals used by CDFA and their contract exterminators, residents — many of whom described themselves as "pro-government" (interview C47) — felt the agency was deliberately antagonizing them, treating residents as the enemy and using the full force of the emergency declaration, CEQA loopholes, and their agency mandate to push through a program, residents argued, that was unsound in terms of social, ecological, and human health impacts. Some CDFA agents recognized the strained relationship with the public. In a presentation at the 2017 Entomological Society of America Meeting, an entomologist for CDFA told the audience: "so that was at least seven visits to properties in each of these years. You can imagine going back to people's houses year after year after year, over and over again, they get sick of you, anybody would" (Leathers, 11/7/2017).

7.0 Discussion: Urban uncanny refracts the violence of California agribusiness

These extraordinary interventions are moments in which the violence of California's agricultural production—normalized in the state's primary agricultural areas—erupt into cities. They are moments of fast violence that, if one pauses to catch it, tell the story of slow violence occurring in rural counterparts. How people absorb the chemical inputs used to mitigate the vulnerability of monocropped industrial farms through their skin, water, and air; how people are denied agency to redress their own vulnerability to those chemical trespasses. Framing the experiences as the urban uncanny brings attention to the strangeness residents experienced upon learning that their bodies, homes, and environs were part of the agrarian metabolism. They allow us to see, quite starkly, the lengths to which the state and federal government will go to make sure that California produce can be exported and profitable.

In these highly controversial agricultural pest eradication projects in California, regulators and their advisors assert that pesticide use would be much higher and more toxic without state intervention. The risk assessments they produce paint a bleak picture of the future of California agriculture: lost crops, massively increased chemical inputs, the end of organic food production, and rejection of produce from domestic and international trade partners. In order to protect humans from the worst of industrial agriculture, the state has to protect industrial agriculture from itself: its vulnerability to pest incursions, and its response to that vulnerability through increased insecticide use. The regulatory agencies do so in service to their competing mandates to prevent damage to agroecological systems while easing the ability to produce and trade agricultural commodities at scale. The result is that they protect, even encourage, systems of production that are particularly susceptible to introduced pests. Hetherington (2020) describes the development of input-intensive, monocropped agricultural systems. Reflecting on how such systems increase crop production and economic growth, but at the cost of complex ecologies, he argues that, "one reason it is so hard to figure out how to respond to agricultural destruction is the same reason that decarbonizing the economy is so difficult: the government systems we rely on to protect people and other living things from the ravages caused by economic growth are impossible to disentangle from the same systems that promote that growth" (7-8).

Bourgeois urban households, for the most part, have benefitted from the abundance of affordable, quality food California's industrial agricultural systems have produced. And when household members have been concerned about the residues of pesticides on their food, in recent decades they have been able to change their exposures through consumer choices (e.g. buying organic produce). The "good nature" (Kaika 2005) of California agriculture flows through the urban metabolism to residents through multiple streams. However, the circulation between core and periphery does not exclusively work to serve urban residents. Sensory encounters with agricultural pest management in unexpected places make the multidirectionality of the circulation visible.

Pragmatically, these moments open a possible bridge to environmental justice. Urban residents got first-hand experience of exposure to pest-killing methods as well as a taste of having their legal protections stripped; the statutory and categorical exemptions to CEQA meant that CDFA did not have to meet the public engagement standards CEQA requires. Urban residents who protested against these eradication projects learned a lot about California's foodways and some are now vocal advocates for systemic changes to the state's industrial systems of agricultural production. Yet, framing their experiences as the "urban uncanny" also suggests why they did not galvanize more public pressure for structural change. After the moment passes, the connections between the urban and agrarian metabolisms disappear from sight again for the bourgeois urban household. To enact long-term, structural change requires staying with the discomfort of the awareness the uncanny brings, which would involve holding the refracted light up long enough to spur widespread action for change.

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DISSERTATION CONCLUSION

Overall, this dissertation considers the many ways that federal and state regulators have sought to ensure the health and profitability of agricultural production by intervening to eliminate injurious insects. The central question guiding the work is: how does protecting California's position in domestic and international agricultural commodity markets inform the everyday ways that state and federal regulatory agencies know and govern California's diverse landscapes? To answer that question, the collection of chapters analyzes "extreme cases" (Creswell 2013, 158) of highly controversial eradication projects to "open the black box" (Guthman 2021; see also Latour 1987) of agri-environmental governance. In particular, it examines the systems of "environmental accounting" (Ghosh and Wolf 2021) conducted to bring target insect populations to zero and how those are shaped by the social groups to which regulators are held accountable. The lens of accounting and the three facets considered here—counting, accountability, and accounts—helps us to understand the implications of prioritizing exportability and profitability in governing a wealthy region in three key ways.

First, regulatory agents protect agricultural production within a legal and economic system that requires they show evidence of absence in order to function. Without substantial changes to international trade agreements and federal and state laws, that will not change. Eradication—as an act, as an outcome, as a signifier of freedom from pests--is baked into every regulatory and legal definition of plant health and how to maintain it. The same rules that Hinchliffe et al. (2017) describe in relation to animal health under the World Trade Organization applies to plant health: "Freedom *to* trade requires freedom *from* pathogens" (42; italics original). On the ground, that leaves growers, pest control advisors, extension agents, county agricultural commissioners, and experts with a very high bar to scale; or rather, as one pest control advisor described it, an impossibly low requirement: "a pest threshold of zero" (interview D54).

Eradication is an artifact of one way of approaching agricultural production, sterile environments in which only the crop to be sold is allowed to live, and to make it live, enormous agricultural inputs are required (Guthman 2019; Perkins 1982). This approach is enshrined in our plant health regulations, laws, and agreements. Alternatives exist. Integrated pest management (IPM), for example, tolerates pests and their damage up to thresholds at which they cause economic damage (Metcalf 1980; Perkins 1982). Agroecology situates production systems within ecological systems to develop “a high-quality matrix” (Perfecto et al. 2009, 35) that encourages growth through diversity. Both IPM and agroecology ask for something that is anathema to the current agri-regulatory systems: to live with pests. As shown in Chapter 1, state and federal regulatory agencies are trying to incorporate less toxic methods in its eradication projects. Those efforts should not be ignored. However, even using less harmful methods to eradicate does not challenge the regulatory and political economic structures that demand eradication in the first place. As entomologist, Frank Zalom, explains: “as long as [regulatory agencies’] goal is eradication, they can’t use an IPM strategy, just some of the IPM tactics that are available. An IPM strategy by its definition ‘management’ implies that some of the pests can be tolerated" (personal communication, 9/2/2021). Until alternative systems—not just individual tactics from them—are reflected in regulations, laws, and agreements, regulators will continue to chase zero.

Second, in order to be accountable to both trade partners and the broader public simultaneously, regulators conflate economic health and general well-being in their defense of eradication projects. In many ways, this finding is unsurprising given that one of the most common metrics of assessing the well-being of a governed populace measures the market value of the goods and services it produces, the gross domestic product (GDP). But the lack of novelty in this maneuver should not distract from the material implications of it. Framing eradication projects as good for everyone precludes opportunities to assess if the systems they protect are in fact good for everyone. Indeed, as shown in Chapter 3, they clearly are not. Suffering in and around industrial agricultural production areas is part of how industrial agricultural systems maintain their profitability. And communities that do not see or feel the “slow violence” (Nixon 2011) of California’s agricultural regions are not immune either. The conflation of economic health and public well-being works instead to pivot attention away from the violence and vulnerabilities of industrial, export-oriented agriculture. It casts other villains—introduced pests and NIMBYs—as the real threats while racing to hold California’s industrial agriculture together by picking off one insect at a time.

Third, the accounts of encounters with eradication projects—exposures to pest control methods as well as field experiments with the insects themselves—ground us in the impacts of how regulatory agencies know and govern. To whom governments feel accountable and how they demonstrate that accountability changes the composition of our air, soil, water, and bodies.

The research presented here tells a handful of stories, but there are more to tell. Below I outline three possible future directions that would build on the research to date.

The first line of inquiry would assess the frequency and impact of emergency declarations, quarantines, and other exceptions to protect plant health. How much of California's food system is governed through exceptions to the regulatory processes designed to protect environmental and public health at any given time? How do these exceptions, whether standalone or in tandem with each other, impact California's communities, agrarian and otherwise? Such a project would look at a range of intersecting exceptions, including CDFA-authorized emergency responses, which are exempt from California's Environmental Quality Act (CEQA), plant health quarantines, pesticide emergency exemptions (Section 18 of the Federal Insecticide, Fungicide, and Rodenticide Act, which authorizes EPA to allow unregistered uses of pesticides), and critical use exemptions, which are also granted through the EPA and allow ozone-depleting substances phased out under the Montreal Protocol, such as methyl bromide, to be used in certain situations (EPA 2021). Exceptions to risk assessment and harm prevention in agri-environmental governance tend to pool and layer on top of one another, often compounded by exceptions enacted at multiple scales of government. For example, a federal critical use exemption may be authorized when preparing an international shipment out of an area under a state plant health quarantine, or a federal pesticide emergency exemption may be granted specifically because a state has declared a plant health emergency. Impacts may be toxicological. The project could investigate if and how vulnerabilities are exacerbated in production areas at the same time that they are introduced to urban and suburban areas. What substances are used, in what concentrations and formulations, over what kinds of spaces and timescales? How do the regulatory exceptions change occupational and environmental exposures in different communities and how frequently does that occur? Impacts may also include decreased civic participation in environmental governance. Michelle Anderson (2010) and Camille Pannu (2012) have described how communities across California's Central Valley have been excluded from democratic processes; exemptions likely compound this exclusion. Specifically, how do the declarations of plant health emergencies and quarantines temporally and spatially impact the rights to environmental and health protections that do exist?

Lastly, the project could investigate whether regulatory efforts to curb emergencies have succeeded in their aims or, instead, serve themselves as exceptions to public and environmental health oversight. This would look specifically at the Statewide Plant Pest Prevention and Management Program (Horizon 2011, 2014), which does not address emergency projects but is supposed to reduce how many emergencies are enacted (Horizon 2014, 1-6). As a tiered programmatic environmental impact report, the Statewide Plant Pest Prevention and Management Program provides umbrella CEQA compliance for a range of plant pest activities. The tiering allows CDFA to fast track projects to manage specific pests in specific locations, because they have already conducted a broad assessment and, importantly, the public interfacing required by CEQA. How does community engagement regarding specific interventions change under the Statewide Plant Pest Prevention and Management Program? Does the Program simply exchange one form of exception—emergencies—for another—the use of prior blanket approval to forego place, time, and target specific assessments?

The second line of inquiry would extend the analysis of emergency declarations and how to eradicate economic pests into the future. How might regulatory exceptions set the groundwork for the use of emerging technologies, such as gene drives, in plant health emergencies? And how would their use under emergency conditions impact public controversies over gene edited organisms and the merits—ethical, ecological, political, economic—of eradication as policy? Gene drives allow scientists to push a hereditary trait through a population into future generations. As a genetic pest control strategy, gene drives promise to target pest populations with precision and are "likely to have relatively low levels of non-target toxicity (toxic impacts on non-target organisms) compared to chemical approaches" (Legros et al. 2021, 9; see also Gould et al. 2018).

Much gene drive research focuses on how to spatially and temporally limit the spread of gene drive organisms once released (cf. Noble et al. 2019), yet funders of this research are often explicit in their aim to use technology in the complete, global elimination of, most notably, disease vectors. Under the slogan, “A world free of malaria,” the Gates Foundation proudly declares, “Eradication is the only sustainable approach to addressing malaria” (Gates Foundation 2021). Most of the candidates on that list are public health pests, such as disease-transmitting mosquitoes or rodents. However, considerable research is also going into eliminating agricultural and economic pests. As of August 2021, only a small number of species have been subjected to gene drives (*Anopholese* sp. and *Aedes* sp. mosquitoes, *Drosophila suzukii*, and *Drosophila melanogaster*) (Legros et al. 2021) and none have been released into the wild, although there is growing consensus on how such releases should occur (Long et al. 2020). There are projects underway to understand how the public responds to gene drive technology broadly, such a major National Institute of Health funded project at UC San Diego “Public Engagement for Gene Drive Technology” (NIH R01TR003514) led by Cinnamon Bloss, as well as projects on public perceptions of gene drives in responses to malaria (Teem et al. 2019) and agriculture writ large (Jones et al. 2019). However, they do not account for how the release of a gene drive could occur under exceptional or emergency conditions.

Looking backwards at the history of both eradication generally and eradication via emergency responses specifically, it is within the realm of possibility that gene drive organisms could be released as part of an emergency response. This would likely happen in response to a major new or on-going economic threat presented by invasive species where conventional treatments have failed, are predicted to fail, and/or would be politically impossible or unattractive because too many people would be directly impacted. Under such circumstances, opportunities for public participation—something stressed by virtually everyone researching gene drives—could be seriously curtailed by the very regulatory structures designed to protect environmental and public health, thereby intensifying another round of conflict.[1]

[1] The bar would like have to be very high given the sensitivity of the U.S. Department of Agriculture- Animal and Plant Inspection Services (USDA-APHIS) to public perceptions of GM organisms. During the webinar, Sterile Insect Technique Forum – Advancing SIT Science and

Lastly, future work could take moments of crisis to re-envision how the state regulates and protects agriculture to support more ecologically sound and socially just practices. The collective crises of the past few years-the COVID-19 pandemic, extreme climate change-related events, and police violence against Black Americans have spurred scholars and activists to not only detail how systemic failures (and sometimes systemic intentions) have caused widespread ecological and social harm, but also to envision ways forward. In the edited collection, "This is how we come back stronger" (Feminist Book Society 2021), feminist writers living the United States and United Kingdom speak from the middle of the pandemic and offer wide-ranging takes on how to, as the book's subtitle says, "turn crisis into change." The stories are personal, charged. The reader sees the violence of entire systems through the fragments the authors offer. The essays show how intersecting crises also are openings for imagining and enacting different futures. In this same vein, Maywa Montenegro de Wit (2021) asks "What grows from a pandemic?" Her answer is to transform our foodways through an agroecology informed by "the politics and practices of abolition in the Black Radical Tradition" (100). The resilience of biodiverse farming systems combined with the restructuring of social systems *away* from punishment and enforced scarcity and *toward* structures that support flourishing would not only mitigate the risks of another pandemic (from developing ecologically and then spreading so rampantly) but also improve our collective chance for survival on this planet more generally. I do not feign to have such sweeping answers to how to save our future, but I do know that when the violence of the everyday systems of which we are a part is exposed, then we have a duty to change it. To wonder how else all this might be. And, in the case of securing agricultural commodities for export, we might ask: what if agricultural health was not defined by its absences? What if the production systems themselves did not so actively encourage the proliferation of pests, which "benefit from many conditions associated with modern agriculture, particularly the use of extensive monocultures and the intensive use of fertilizers" (Legros et al. 2021, 8)? If we shifted the funding, oversight, and networks away from identifying and rooting out one pest at a time, what new

Applications, 2/4/2021, Eoin Davis, with USDA-APHIS-Plant Protection and Quarantine, offered the following written response to a question about GM insect technologies during an online symposium on advances in sterile insect technique: "The negative perception of GM organisms was the primary (only?) reason they were not deployed in the PBW [pink bollworm] eradication program" systems could we build? And would it better allow our regulatory agencies to demonstrate their accountability to the people of California's foodways?

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