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RESEARCH ARTICLE

Missing the outbreak for the germs: Institutionalized non-knowledge and industrial power in agrofood safety governance

Patrick F. Baur^{1,*}

Leafy greens cause a growing proportion of foodborne illness outbreaks despite heavy investment in surveillance technologies designed to control pathogenic hazards in agriculture. To understand how the governing regime maintains authority despite continual lapses in control, I examine a deadly 2018 outbreak of *Escherichia coli* O157: H7 linked to romaine lettuce. By comparing the outbreak investigation and regulatory response to the questions *not* asked and actions *not* taken, I show how the regime's methods of understanding the outbreak also organized its ignorance of dangers outside its carefully constructed field of vision. Applying agnotology theory, I argue that the industrial organization of leafy greens agriculture and the institutionalized non-knowledge of emergent social-ecological vulnerabilities coproduce one another, allowing the industrial food regime to avoid fundamental reforms that might enhance resilience. This case demonstrates that critical examination of organized non-knowledge in complex environmental governance systems can reveal limits to institutional learning and systemic reflexivity that impede sustainability transitions.

Keywords: Food safety, Agnotology, Institutionalized non-knowledge, Reflexive adaptation, Coproduction, Agriculture

Introduction

In early April of 2018, the U.S. Centers for Disease Control (CDC) and Food and Drug Administration (FDA) identified a multistate outbreak of *Escherichia coli* O157: H7, a dangerous foodborne pathogen. Agency investigators linked the outbreak to romaine lettuce grown near Yuma, along the California–Arizona–Mexico borders (CDC, 2018a), the primary growing region for winter salad greens in the United States. Over the next several weeks, 200 people fell ill, and 5 died. Consumers stopped buying romaine lettuce of any type: “romaine essentially just wasn’t being sold,” recalled a representative of the leafy greens industry (personal communication, October 1, 2018). Even more troubling, this was just the latest episode in which the lettuce industry found itself implicated in an *E. coli* outbreak (**Table 1**)—pointing to the likelihood of a systemic problem that long predates this crisis (Painter et al., 2013; Bennett et al., 2018; Marshall et al., 2020).

The 2018 Yuma outbreak closely mirrored a previous multistate outbreak of *E. coli* O157: H7 in spinach, which also sickened 200 people and killed 5 (CDC, 2006). The

leafy greens industry responded to that crisis with the most comprehensive food safety protocol ever created for fresh produce farms—the California Leafy Greens Marketing Agreement (CA LGMA, 2019). By 2007, 99% by volume of leafy greens growers in California, including spinach and romaine lettuce farmers, were following LGMA standards (Hardesty and Kusunose, 2009); Arizona soon introduced its own, near-identical program (AZ LGMA 2018).¹ Including protocols for wildlife monitoring, farmworker training, water testing, and other precautions, the LGMA sought to provide a comprehensive, science-based system to control all the possible routes through which dangerous human pathogens might contaminate crops growing in fields. Moreover, the LGMA architects promised a robust system of institutional learning and regular auditing to ensure that the standards would remain up-to-date and farmers would be held accountable for following the protocol. The linchpin of this system lay in data-intensive record-keeping practices designed to generate a chain of information that would ensure constant use of “best agricultural practices” and allow rapid traceback (and recall) of any product suspected of contamination (Baur et al., 2017).

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1. Since the Arizona LGMA standard is effectively identical to that of the California LGMA, this article references both as simply LGMA.

Table 1. Multistate *Escherichia coli* outbreaks linked to leafy green vegetables, 1999–2019. DOI: <https://doi.org/10.1525/elementa.2021.00041.t1>

Date	Implicated Vegetable	Illnesses	Hospitalizations	Deaths	Source
December 2019	Romaine lettuce, kale, cabbage	10	4	0	FDA (2020)
November 2019	Unknown leafy green type	11	3	0	FDA (2020)
November 2019	Romaine lettuce	167	85	0	FDA (2020)
October 2018	Romaine lettuce	91	35	0	Marshall et al. (2020)
October 2018	Unknown leafy green type	25	8	0	Marshall et al. (2020)
October 2018	Unknown leafy green type	19	4	0	Marshall et al. (2020)
March 2018	Romaine lettuce	248	105	5	Marshall et al. (2020)
April 2018	Romaine lettuce	10	5	0	Marshall et al. (2020)
November 2017	Unknown leafy green type	67	26	2	Marshall et al. (2020)
September 2017	Spinach	8	3	0	Marshall et al. (2020)
August 2017	Unknown leafy green type	69	18		Marshall et al. (2020)
June 2016	Iceberg lettuce	11	4	0	Marshall et al. (2020)
April 2015	Unknown leafy green type	7	5	0	Marshall et al. (2020)
March 2015	Romaine lettuce	29	12	0	Marshall et al. (2020)
April 2014	Spinach	4	1	0	Marshall et al. (2020)
June 2014	Cabbage	16	2	0	Marshall et al. (2020)
November 2014	Romaine lettuce	11	2	0	Marshall et al. (2020)
October 2013	Romaine lettuce	33	9	0	Marshall et al. (2020)
Apr 2013	Iceberg lettuce	26	5	0	Marshall et al. (2020)
April 2013	Butter lettuce, radicchio	14	9	1	Marshall et al. (2020)
November 2012	Spinach	10	0	0	Marshall et al. (2020)
October 2012	Spinach, spring mix	33	13	0	Marshall et al. (2020)
June 2012	Romaine lettuce	52	0	0	Marshall et al. (2020)
October 2011	Romaine or iceberg lettuce	26	5	0	Marshall et al. (2020)
October 2011	Romaine lettuce	61	35	0	Marshall et al. (2020)
April 2010	Romaine lettuce	31	14	0	Marshall et al. (2020)
September 2009	Romaine lettuce	22	0	0	Marshall et al. (2020)
September 2008	Iceberg lettuce	74	NA	0	NORS
July 2008	Spinach	13	0	0	NORS
August 2006	Spinach	199	102	3	CDC (2006)
September 2005	Lettuce	34	12	0	NORS
September 2002	Iceberg lettuce	16	5	0	NORS
October 1999	Romaine lettuce	45	0	0	NORS
August 1999	Romaine lettuce	14	6	0	NORS

NORS = National Outbreak Reporting System (<https://www.cdc.gov/norsdashboard/>).

Thus, by 2018, the leafy greens industry had taken extensive steps to avoid repeating the deadly spinach outbreak. Just the year before, LGMA leadership celebrated “ten years of protecting public health,” proclaiming that “the leafy greens community has gotten better at food safety” (Horsfall, 2017). Moreover, the elaboration of further public and private regulations in the

intervening years—including the U.S. Food Safety Modernization Act of 2011 (FSMA) and the Global Food Safety Initiative—seemed to offer extra layers of redundant assurance (Verbruggen and Havinga, 2016; Baur et al., 2017). Yet this massive investment in the ostensible production of knowledge around farm-level foodborne illness risks and food safety best practices failed

dramatically in a moment of crisis. As the local *Arizona Republic* reported:

None of these [food safety] procedures gets us any closer to solving the mystery of how romaine became contaminated with E. coli over the past three growing seasons. There is also no guarantee the combined efforts of the FDA, CDC, growers, scientists and food researchers will stop the next outbreak, an uneasy truth for the public to accept. (Anglen, 2018b)

This case poses twin puzzles. First, why do food scares plague leafy greens agriculture despite heavy investment in regulatory tools designed to control pathogenic contamination? Second, how do the industry and its regulators maintain authority, and avoid substantive reform, in the face of repeated lapses in control? One possible explanation, and the one favored by the food safety regime² itself, is *technoscientific deficit*: The regime's regulatory strategy is headed in the right direction, but scientific understanding, available technologies, and industry implementation have lagged behind the evolving risk posed by foodborne pathogens in the growing environment and simply need to catch up. Another plausible explanation favored by those critical of the regime is *blame avoidance*: The industry and its regulators collectively respond to outbreaks with "techniques of neutralization" in order to avert reform and preserve the existing configuration of power, as argued by Stuart and Worosz (2012). I explore the evidence for a third explanation, *institutional non-knowledge*: The food safety regime is structurally incapable of recognizing the social–ecological nature of the problem it faces. This explanation, I propose, uniquely accounts for the subtle cultural and cognitive dimensions that can lock the regime into an unsustainable pathway leading to potential breakdown of both governing authority and social–ecological function.

Focusing on institutional non-knowledge in this case provides unique insight into conditions that impede sustainability transitions. Repeated outbreaks linked to environmental contamination that occurred in farm fields suggest an acute problem in the social–ecological system of leafy greens agriculture. Yet this ongoing crisis—which causes significant health, political, and economic harms—fails to trigger meaningful learning and adaptation in the system that produced the crisis. As Lamine et al. (2019) note in their introduction to a special issue on sustainability transitions in agrifood systems, "conventional logics and power relations are constantly

contending the rise of transition processes" despite the expectation that the proliferation of profound problems stemming from the conventional agrifood sector should make such transitions "mandatory rather than optional." There seems to be an implied assumption that conventional agrifood systems, faced with their own self-defeat, will eventually have to accept fundamental changes to how and under what conditions food is produced. Yet concentrated industrial systems have continuously found ways to sidestep their own contradictions (Weis, 2010), often through "a spectacular form of temporal deferment" (Moore, 2008). Given this tendency, it is imperative to understand the causes and processes through which industrial agrifood systems refuse to adapt, even in the face of seemingly obvious systemic failure. Attending to the possibility of institutionalized non-knowledge may help illuminate a critical, though easily overlooked, facet of barriers to transition.

The paper proceeds by first laying the conceptual foundation, rooted in the field of ignorance studies (agnology), for institutionalized non-knowledge as a key factor explaining why systems fail to adapt to crisis. Next, I describe the process tracing methodology I use to analyze whether and how institutionalized non-knowledge shaped industry and regulatory responses to the outbreak. I present the results in three sections describing the outbreak investigation (highlighting questions *not* asked), the regime's response (highlighting actions *not* taken), and a hypothetical alternative way of knowing about foodborne danger (highlighting the contingency of the regime's knowledge–power configuration). In the discussion, I consider how the regime's methods of understanding the outbreak also organized its ignorance of dangers outside its carefully constructed field of vision, leading to a critical disconnect between crisis and response: The food safety problem emerges at a systemic social–ecological level, but the regime is only designed to "see" linear causal chains of contamination and the isolated accountability of individual firms. Together, I argue, these scientific and regulatory limitations blind the food safety regime both to emergent immunodeficiencies of conventional industrial agriculture and to possibilities for transitioning toward higher social–ecological resilience.

Trust, control, and non-knowledge

In the context of complex, ever-changing food systems, perfectly safe food cannot be guaranteed. Risk, in other words, is never zero (Wilson and Worosz, 2014). This poses a constant threat to the legitimacy and credibility of food safety regimes. To stabilize their authority, such regimes must answer a central governing problem: how to "build trust in the face of inevitable foodborne risks" (Freidberg, 2004, p. v). Food safety regimes increasingly turn to elaborate systems of standards—which promise to hold food producers and handlers to account through objective, third-party evaluation grounded in scientific evidence (Loconto and Busch, 2010; Baur et al., 2017; Verbruggen and Havinga, 2017)—as a means to produce *trust* in industry, scientists, and government regulators

2. I use the term *regime* to encompass the full network of public and private actors who govern food safety risks by setting standards, monitoring compliance, and taking enforcement actions in the case of failure (Loconto and Busch, 2010; Havinga and Verbruggen, 2017; Ansell and Baur, 2018). This network includes industry leaders, government regulators, third-party auditors, and the experts who inform their decisions.

among the consuming public.³ A primary threat to public trust in food systems are destabilizing “food scares” that garner media attention, upset normal patterns of demand and consumption, and spark political pressure for reform (Knowles et al., 2007; DeLind and Howard, 2008; Loeber et al., 2011; Lytton, 2019). Standards buffer markets from such periodic disruptions (Busch, 2007; Busch, 2011), largely through preserving an “illusion of control” (Stuart, 2008): the perception that the regime sufficiently knows the sources of foodborne danger and wields that knowledge effectively to protect the public. *Control* thus represents a particular formation of knowledge and authority upon which the regime builds its legitimacy and credibility, claims trustworthiness, and then seeks stability (Baur et al., 2017; Ansell and Baur, 2018).

Despite ostensible antipathy toward instability, however, the regime's pursuit of control exists in tension with its need to allow some foodborne pathogens to “overflow” that grid of control. As Dunn (2007) argues:

Overflow is not an occasional occurrence, or an indicator that the system has failed. It is a regular, endemic, integral part of a system that restlessly seeks dangers beyond its control, expands to encompass and regularize those dangers and begins the cycle of seeking and expansion again when it discovers dangers that have overflowed the system's parameters.

According to Dunn's “sewer state” theory, food scares are in fact a necessary product of the food safety regime. Rather than governance failures, outbreaks serve as the regime's *raison d'être*. Sewer-state theory suggests a tangible incentive for food safety regimes to preserve ignorance of the continual systemic causes of discrete foodborne outbreaks. To understand precisely *how* ignorance enables the food safety regime to simultaneously pursue control and tolerate overflow, I apply agnotology theory.

Agnotology scholars study the social production of ignorance, or non-knowledge (Proctor, 2008; Croissant, 2014; Gross and McGoey, 2015). Producing knowledge means sorting observations into those “meaningful to know” and those not. Ignorance has thus been theorized as a necessary corollary to knowledge (Harding, 2000, p. 131; Gross, 2010, p. 1), its “shadow” to extend the metaphor of knowledge as *enlightenment*. Knowing is both creative and destructive: Producing one form of knowledge entails forsaking alternate forms that could have been. Not-knowing, then, is inherently a political act, entangled with power relations (see Rubio and Baert, 2013). McGoey (2012a, 2012b), for example, shows how “strategic ignorance” can be “a productive asset, helping individuals and institutions to command resources, deny liability in the aftermath of crises, and

to assert expertise in the face of unpredictable outcomes” (McGoey, 2012b). Claiming ignorance, especially in reference to “undone science” (Hess, 2009), tacitly establishes a priority: It is imperative to know more about *X* in order to have more power, or control, over *X* (McGoey, 2012b). Likewise, strategic ignorance can facilitate blame avoidance. Stuart and Worosz (2012) argued that industrial agribusinesses embrace self-non-knowledge, or “anti-reflexivity,” toward the systemic risks they themselves produce in order to absolve themselves of responsibility and avoid regulatory reform.

Ignorance can be analyzed as a strategic resource without assuming that its production necessarily follows a “conspiratorial logic” intent on deflecting or concealing knowledge that is inconvenient or threatening to acknowledge (Frickel and Edwards, 2014). Frickel and Vincent (2007) examine how formal protocols for monitoring environmental toxins “organize ignorance” in a way that “masks ecological complexity.” Building on this argument, Frickel and Edwards (2014) demonstrate the ways in which “institutional logics of risk assessment”—in an effort to “know more about less” and “make less knowledge count for more”—tacitly make decisions as to which kinds and degrees of potential hazards matter and which do not. Other scholars have likewise examined what I refer to as *institutionalized non-knowledge*, for example, in the under-regulation of pesticides (Kleinman and Suryanarayanan, 2013), remediating contaminated soils (Gross and Bleicher, 2013), and mapping toxic water contamination (Rabinow and Poirier, 2017). Durant (2020), writing on bee-toxicity warnings for pesticide labels, and Martin (2019), writing on environmental governance of wolf-livestock conflict, both offer compelling accounts of the individually rational, yet systemically dysfunctional, production of official non-knowledge that can arise in complex governance networks. These contributions show how underlying knowledge infrastructures mask organized ignorance by black-boxing key decisions deep within technical guidance documents, data collection practices, professional norms, and social relationships within epistemic communities.

I focus on the ways in which non-knowledge is institutionalized through standards. Freidberg (2017) provides a roadmap with her insight, based on analysis of commodity grain trading, that, “by guiding the production of knowledge, standards and related tools also serve to normalize ignorance.” She argued that the non-knowledge of origin intrinsic to modern commodity grain crops (see Cronon, 1991: 97–142), which grants them a fungibility necessary for transnational corporations to reach global market dominance, is becoming a liability as sustainability demands pressure commodity traders to track grains from farm to fork. Yet, “despite these companies' size, clout, and supposedly unparalleled market intelligence, they have found it difficult to supply the needed information” (Freidberg, 2017). This observation also applies to leafy greens: Despite the food safety regime's investment in traceability and oversight, it cannot determine where contamination comes from, let alone how to stop it. That

3. On the relationship among auditing, verification, and trust, see Power (1997, 2004).

outbreaks have become “normal accidents” (Perrow, 1999) demonstrates the regimes’ ignorance of its own epistemic and political limitations, which stymies learning and adaptation.

Attending to the ways in which expert institutions, and the standards they deploy, encode non-knowledge shows how strategic *not-knowing* limits capacity to effectively, sustainably, and equitably govern complex systems (Frickel and Edwards, 2014; Rabinow and Poirier, 2017). The presence of such limits, I suggest, may help explain how dominant governance systems pose both epistemic and political obstructions to sustainability transitions. In particular, this conceptual lens articulates clearly with that of coproduction, a lens that advises scholars to observe and explain the ways in which ordering the natural world through science and ordering the social world through power relations are mutually constitutive (Jasanoff, 2004). Examining how the industrial organization of leafy greens agriculture and the institutionalized non-knowledge of systemic risks coproduce one another illuminates the peculiar knowledge–power formation that allows the food safety regime to navigate, even feed on, the tension between control and overflow, and thereby avoid fundamental reorganization of the social-ecological relationships that underpin conventional industrial agriculture.

Methods and analytical approach

Above, I posed twin puzzles: Why do outbreaks keep happening in leafy greens, and why does the food safety regime for this industry stay in power despite repeat failures? The case of the 2018 Yuma *E. coli* outbreak provides an empirical opportunity to assess whether, in what ways, and to what extent the novel hypothesis I introduced—institutionalized non-knowledge—better explains these puzzles than do either the technoscientific deficit or blame avoidance hypotheses. To do so, I employ a process tracing method of causal inference. Process tracing begins with a detailed description of the sequence of events, from which the analyst seeks to parse the most salient causal factors and compare them to the claims made by competing hypotheses that might explain the case (Bennett, 2010; Collier, 2011). For the Yuma outbreak, I organize my analysis in response to three empirical questions: How did officials investigate the outbreak, through which scientific approaches and institutional arrangements, and what did they seek to find? How did industry and its regulators respond? and What kinds of questions were not asked, and what kinds of action were not taken?

I draw on public documents that display the official knowledge institutionalized by the regime and circulated in public discourse. Through primary documents such as reports and press releases, regime members expressed their understanding of causality, uncertainty, and responsibility for the outbreak and stated their consequent plans and strategies. Secondary sources, especially newspaper articles, yield evidence on how representatives of the regime reported preliminary knowledge, interpreted findings, and expressed their

intentions for the public; these sources also provide an outlet for critiques of the outbreak investigation and response. No documents were intentionally excluded unless they provided no unique pertinent evidence.⁴ All documents analyzed are fully cited in the references.

Given these materials, I use the following criteria to assess the three competing hypotheses. The technoscientific deficit claim will explain the puzzles well if there is strong evidence that the outbreak happened because (a) the tools and best practices available to farmers were not precise or fast enough to control the microbiological threat (Marshall et al., 2020); (b) the tools and best practices were adequate, but leafy greens growers had not yet adopted them (Julien-Javaux et al., 2019); or (c) there were other controllable risk factors in the growing environment for which the risk management model had not accounted, such as seasonality (Marshall et al., 2020). Each type of evidence would plausibly establish that the outbreak was caused by a technoscientific deficit which the regime could reasonably be expected to “fix” within its existing configuration of power.

The blame avoidance claim will explain the puzzles well if there is strong evidence that groups within the regime deployed techniques of neutralization during the investigation and the interpretation of its findings that either (a) denied responsibility by shifting blame elsewhere, such as onto individual “bad actors” or agents beyond the regime’s control or (b) appealed to a “higher loyalty” such as profitability, production efficiency, or technological optimism to downplay the very idea that there is something for which to be blamed (Stuart and Worosz, 2012). Either type of evidence would plausibly establish that the regime worked to avoid inconvenient findings that might undermine its authority.

The institutionalized non-knowledge claim will explain the puzzles well if there is strong evidence that (a) the investigation failed to provide an internally consistent account of the outbreak due to omissions, discrepancies, and ambiguities in its process or findings *and* (b) the regime’s response to the outbreak failed to account for those inconsistencies in either form or content. Together, both types of evidence would plausibly establish that the regime is epistemically limited by systemic blind spots in its awareness of the risk landscape confronting leafy greens agriculture.

My approach modifies conventional process tracing in two ways. First, although counterfactuals are sometimes used in process tracing as “contrast space” in framing the analysis (Collier, 2011), agnotology requires an explicit focus on what is not there. In other words, both the explanatory factors and the outcomes to be explained include counterfactuals. Following Levy (2008), I ground

4. “Probative value” is the primary criterion by which the process tracing analyst decides whether a given piece of evidence is pertinent. As Bennett (2010) explains, “What matters is not the amount of evidence, but its contribution to adjudicating among alternative hypotheses.”

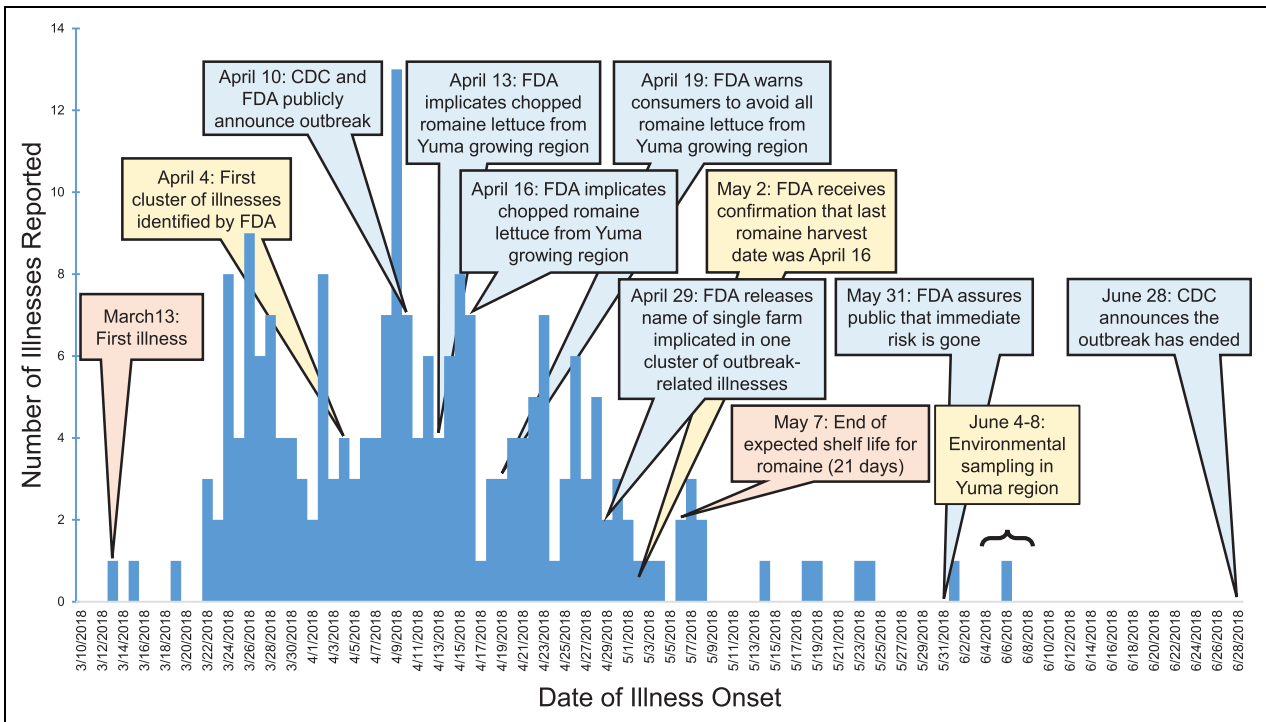


Figure 1. Timeline of *Escherichia coli* O157: H7 outbreak in romaine lettuce. Bar chart shows number of illnesses associated with the outbreak reported by day, overlaid by dates and descriptions of key epidemiologic events (red), investigation activities (yellow), and public announcements (blue). Adapted from CDC (2018a). DOI: <https://doi.org/10.1525/elementa.2021.00041.f1>

my use of counterfactuals in a strong theoretical framework (see previous section) and a careful account of how the regime could plausibly have known the nature of the risk it faces differently and how this might impact its response.

Second, although conventional process tracing concentrates on establishing causal direction between explanatory factors and outcomes (Bennett, 2010), I hew to the coproductionist framework developed in Science and Technology Studies (Jasanoff, 2004), which holds that a given settlement between scientific and social orders—such as the stable network of experts, regulators, and practitioners which I call the food safety regime—are “points of arrival rather than departure” (Cunrutt and Testa, 2012). Rather than attempting to simply disprove or weaken either the technoscientific deficit or blame avoidance claims, my analysis instead traces the networks of interdependence between the technical framework for assessing foodborne risk and the political framework for contesting its management. These underlying sociotechnical networks normally stabilize the regime’s epistemological and normative commitments in such a way that they “recede into the background” and are easily mistaken for a fixed feature rather than an active process shaping the course of events (Latour, 2005, pp. 79–82). However, moments of breakdown (e.g., an outbreak) provide a brief window into the fundamental contingency of these settlements. With its focus on what cannot and shall not be known, agnotology sharpens analysis of the destabilization and restabilization of these networks as processes that might have

unfolded via a different set of normative and epistemological commitments.

Case: multistate outbreak of *E. coli* O157: H7 linked to romaine lettuce

I turn next to my case, the outbreak of *E. coli* O157: H7 linked to romaine lettuce grown along the Arizona–California border. Trouble began in late March 2018, when the first victims began to fall ill (Figure 1). By April 10, when CDC first recognized the outbreak, the same strain of *E. coli* had sickened 17 people across seven states (CDC, 2018a). By the time CDC declared the outbreak over on June 28, the pathogen had stricken 210 people across 36 states, claiming the lives of five.

E. coli O157: H7 is the most common type of Shiga toxin-producing *E. coli* (STEC), a class of bacterial human pathogens that cause severe gastrointestinal illness, kidney damage, and even death. Over the past two decades, 31% of multistate foodborne STEC outbreaks implicated vegetable agriculture (Olimpi et al., 2019), and particularly the industrial-scale lettuce operations overseen by LGMA (Turner et al., 2019). Between 2009 and 2017 alone, leafy greens were implicated in 28 STEC outbreaks, averaging more than three per year (Ostroff and Plaisier, 2018). According to the most recent analysis, “leafy greens are the second most common source of foodborne STEC O157 outbreaks, after ground beef,” in both the United States and Canada (Marshall et al., 2020). As the list of repeated *E. coli* outbreaks in the United States presented in Table 1 suggests, food scares appear to be endemic to industrial leafy greens agriculture.

Investigation of the outbreak

The Yuma outbreak garnered significant attention from public health officials, food safety regulators, the produce industry, and the general public. Pressure was high for federal investigators to quickly identify the responsible party and halt the outbreak.

Stage 1: Traceback investigation

The outbreak investigation followed standard procedure (CDC, 2018b). Following up on a cluster of *E. coli* poisonings in New Jersey, CDC used PulseNet—a network of databases on infectious disease incidences maintained by over 80 clinical laboratories in partnership with CDC—to locate other people who had fallen ill with the same subtype of *E. coli*.⁵ Public health officials then interviewed 28 victims, 93% of whom reported eating romaine lettuce (CDC, 2018a: April 13 announcement). Based on interviewee recollections of where they purchased the romaine and the seasonal timing (Latack and Ozeran, 2020), FDA identified romaine lettuce from Yuma as the likely source of the outbreak on April 13 (FDA, 2018a). The same day, CDC warned consumers not to eat bagged, chopped romaine lettuce from the region (Chokshi, 2018), though a week later the advocacy organization Consumer Reports, citing an abundance of caution, urged consumers to avoid *all* romaine lettuce (Parker-Pope, 2018). CDC expanded its own warning the next day, April 20, based on a new report of eight inmates who had fallen ill after eating whole-head romaine at a prison in Alaska (CDC, 2018a: April 20 announcement). Although the romaine lettuce harvest in the Yuma region ended on April 16, FDA did not receive this information from the LGMA until May 2. Moreover, the 21-day shelf life of bagged romaine left officials concerned that contaminated product might still be circulating. CDC did not lift its consumer warning until May 16 (Fox, 2018).

Meanwhile, the investigation proceeded. With an initial list of 23 locations where victims had acquired the contaminated romaine, FDA initiated a traceback procedure to reverse, stepwise, the path that contaminated romaine had traveled through the supply chain (Latack and Ozeran, 2020). The outbreak investigators soon hit an unexpected roadblock, as *NPR* reported:

Many food safety experts expected [the investigation] to lead to a single farm or a factory where the contamination happened . . . But in this case, it proved impossible. The trails of contaminated

lettuce did not converge on any single point. Instead, there were lots of trails, leading to different processing plants and a bunch of different farms in Yuma, miles apart. (Charles, 2018)

The traceback paths led to 36 suspect fields from 23 farms managed by 16 different growers. The investigation stalled there: “With the exception of one instance where one of the legs of the traceback led to a single farm, it was not possible to determine which, or how many, of these farms shipped lettuce that was contaminated with the outbreak strain” (FDA, 2018b).

A transcript of a conference call between journalists and members of the investigation team on April 27 provides insight into how the investigators perceived this problem in the moment. When asked how many farms were under investigation, Dr Stic Harris, the Director of FDA’s Coordinated Outbreak Response and Evaluation Network, replied:

Over two dozen . . . One of the things about this particular outbreak is there are so many [traceback] legs to chase . . . And, you know, trying to link those altogether [sic] and, you know, there’s a lot of disparity between them. (FDA and CDC, 2018)

The journalists pressed the investigators to clarify how these “legs” represented the same outbreak and how the team planned to make sense of the “disparity between them.” The following discussion offers clues to the investigators’ expectations and awareness of their own limits. “We have many lines of evidence . . . that all of these illnesses are connected in some way through romaine grown in the Yuma growing region,” explained Dr Matthew Wise of the CDC Outbreak Response Teams, continuing, “As we get more detailed analysis done, I think, what we’ll try and see is if there’s any additional differentiation that we might be able to see in the genetic data [from WGS sequencing] that would correlate with some of these different farm sources . . . It could be two adjacent fields that share the same water source or things like that” (FDA and CDC, 2018). Crucially, Wise’s hopes rested on “more detailed analysis” that might resolve the ambiguous relationship among the traceback, epidemiological, and genetic sequencing data streams into neat causal chains.

But Harris interjected a cautionary note. “I think there’s a perception . . . when we do traceback that each leg is just a direct line down,” warned Harris, “And in this case, you’re looking more at a web . . . Ideally we’d love to get those mapped out and try and find convergence someplace to identify that specific cause. We’re just not there yet. And we—it’s entirely possible we may not get there” (FDA and CDC, 2018). When questioned further on the investigation’s limitations, the discussion turned to speed and accuracy. “Couldn’t we get some sort of labeling at harvest level and then through the supply chain that would kind of provide the traceback you guys need to do this quicker?” asked one reporter. Harris replied, “Under FSMA it’s a one step forward, one step back rule. And so, trying to find all those records whether they be

5. CDC uses the PulseNet and related FoodNet systems to detect outbreaks by linking together clusters of related illnesses (Yeni et al., 2016). The databases are populated with information from clinical samples submitted to laboratories for pathogen testing. U.S. health care providers are required to report “notifiable” pathogens like *Escherichia coli* to county or state health departments, which in turn notify CDC for entry into the databases.

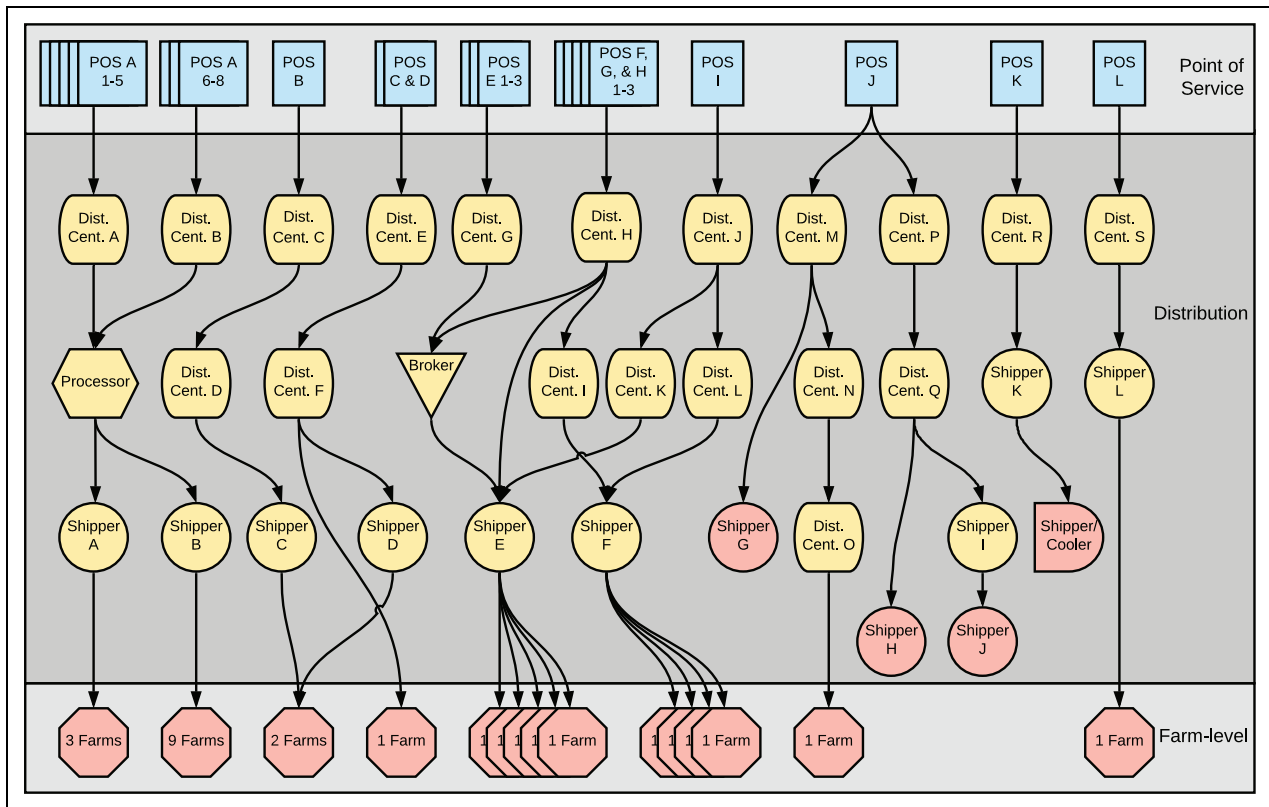


Figure 2. Final traceback diagram for Yuma outbreak, October 2018. Blue indicates the point of service from which investigators initiated traceback. Yellow indicates intermediate supply chain actors. Red indicates the last point to which investigators were able to trace suspected product. Adapted from FDA (2018c, Attachment A). DOI: <https://doi.org/10.1525/elementa.2021.00041.f2>

digital records, or written records, or handwritten records is extremely tough.”

At the surface level, this exchange seems to reveal evidence for technoscientific deficit. The investigators are confident that the tools exist (genetic sequencing, traceback procedures) to understand the source and transmission pathway of the pathogen, but the industry has not fully adopted those tools (particularly accurate, accessible records). There may even be unaccounted risk factors such as shared irrigation water. Some evidence for blame avoidance presents itself, as well. Harris’ statement subtly shifts responsibility for the investigation’s problems by attributing technical deficit—lack of timely access to records of the lettuce’s travel through time and space—to both policymakers (an implied shortcoming in the law) and growers (whose record-keeping is implied to be disorganized).

A deeper examination of the investigation’s troubles, however, reveals the first traces of institutionalized non-knowledge. In extending their “epistemic reach” (Frickel and Edwards, 2014), the outbreak investigators also organized their ignorance of the underlying food system in a way that masked their epistemic limits. The final traceback diagram—attached to FDA’s investigation report, released in October 2018—reveals a fundamental ambiguity in the agency’s reconstruction of the contamination which led to the outbreak, one which cannot be attributed to deficit or to the actions of others. As shown in **Figure 2**, the number of farms identified in

the diagram is either 15 or 26, depending on how one interprets the final row. In either case, the numbers and labels do not match the 16 growers, 23 farms, and 36 fields cited in the text of FDA’s final investigation report, to which the diagram is attached (FDA, 2018c).

This discrepancy is compounded when comparing the October diagram to an earlier version released on May 31 (Gottlieb and Ostroff, 2018). The May diagram shows a much tidier picture (**Figure 3**), which would seem counterintuitive given that it was created before the investigation team actually visited the Yuma region to conduct an environmental assessment (discussed below).⁶ This earlier diagram eschews the “farm” label used in the final report and instead refers to “ranches”—a term for agricultural land parcels specific to California and Arizona agriculture—while also extending the traceback to individual fields (only 33), which are absent in the October diagram. Finally, the May diagram includes limited location information for shippers—who aggregate lettuce from multiple sites—that is not reported in the October diagram. Neither diagram provides farm-level locations.

These discrepancies between the diagrams suggest that FDA underwent an internal struggle to neatly categorize,

6. For ease of comparison, I have adapted each traceback diagram to a common format while preserving as closely as possible the precise labels, terminology, and linkages shown by the Food and Drug Administration (FDA) in each case.

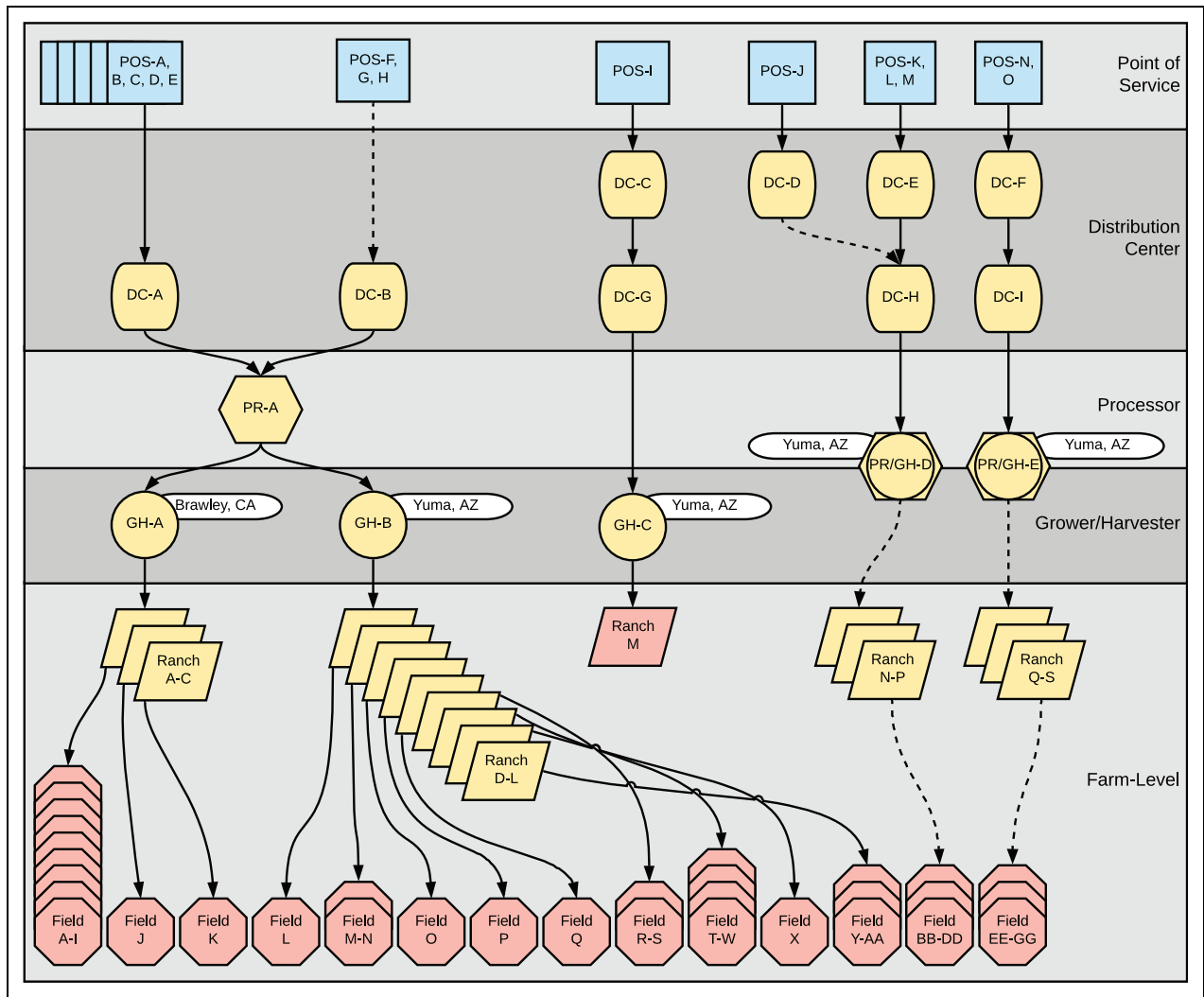


Figure 3. Early traceback diagram, May 31, 2018. POS stands for point of service, DC for distribution center, PR for processor, and GH for grower-harvester. A *ranch* refers to a contiguous area of land leased for cultivation by the grower and may contain multiple fields. Dashed lines indicate reported relationships for which no records were available. Source: Adapted from FDA (Gottlieb and Ostroff, 2018). DOI: <https://doi.org/10.1525/elementa.2021.00041.f3>

for the purposes of the standardized traceback process, a spatially and legally heterogeneous and dynamic industry.⁷ A typical row vegetable “farm” in California will grow

on multiple leased plots of land (ranches) that are physically separated and will engage in complex contracting and subcontracting arrangements that can split up cultivation, harvest, handling, and processing among legally distinct businesses. To populate categories such as “farm,” “field,” and “grower,” the investigators had to make subjective decisions about how to codify that dynamic complexity into discrete nodes and linkages that fit the simple supply chain model implicit in their standard traceback procedure. In so doing, the investigators simultaneously structured what they *would not know* about edge cases (e.g., the hybrid entities labeled processor/grower-handlers D and E in **Figure 3**), actors involved outside the immediate supply chain (e.g., the pesticide applicators discovered during the environmental assessment), and relationships other than the exchange of romaine lettuce (e.g., hydrological flows or personnel movement among fields). These forms of non-knowledge appear to be encoded within the institutions of traceback investigation, yet nowhere in the public record is any underlying inconsistency in the traceback procedure itself acknowledged,

7. Admittedly, the available evidence tells us little about the reason for the discrepancies in the traceback diagrams. There are various possible reasons why an earlier diagram might differ from a later diagram. The traceback approach might change due to an exogenous factor such as a personnel changeover within the agency or a revision to agency protocols. Conversely, differences might arise due to internal learning, for example, if investigators learned to see the nodes and linkages in a way more clearly aligned with the ways in which practitioners themselves understand the flow of leafy greens. That said, what the available evidence does demonstrate is a clear internal inconsistency within the traceback stage of the investigation. Changing the definition of the nodes used to reconstruct the path of contaminated lettuce is a significant ontological shift, especially since the later diagram seems to veer *away* from, rather than toward, terminology used by growers and shippers. That the agency did not acknowledge, let alone explain, this fundamental shift in its official narrative points to an unreflexive stance that is characteristic of institutionalized non-knowledge.

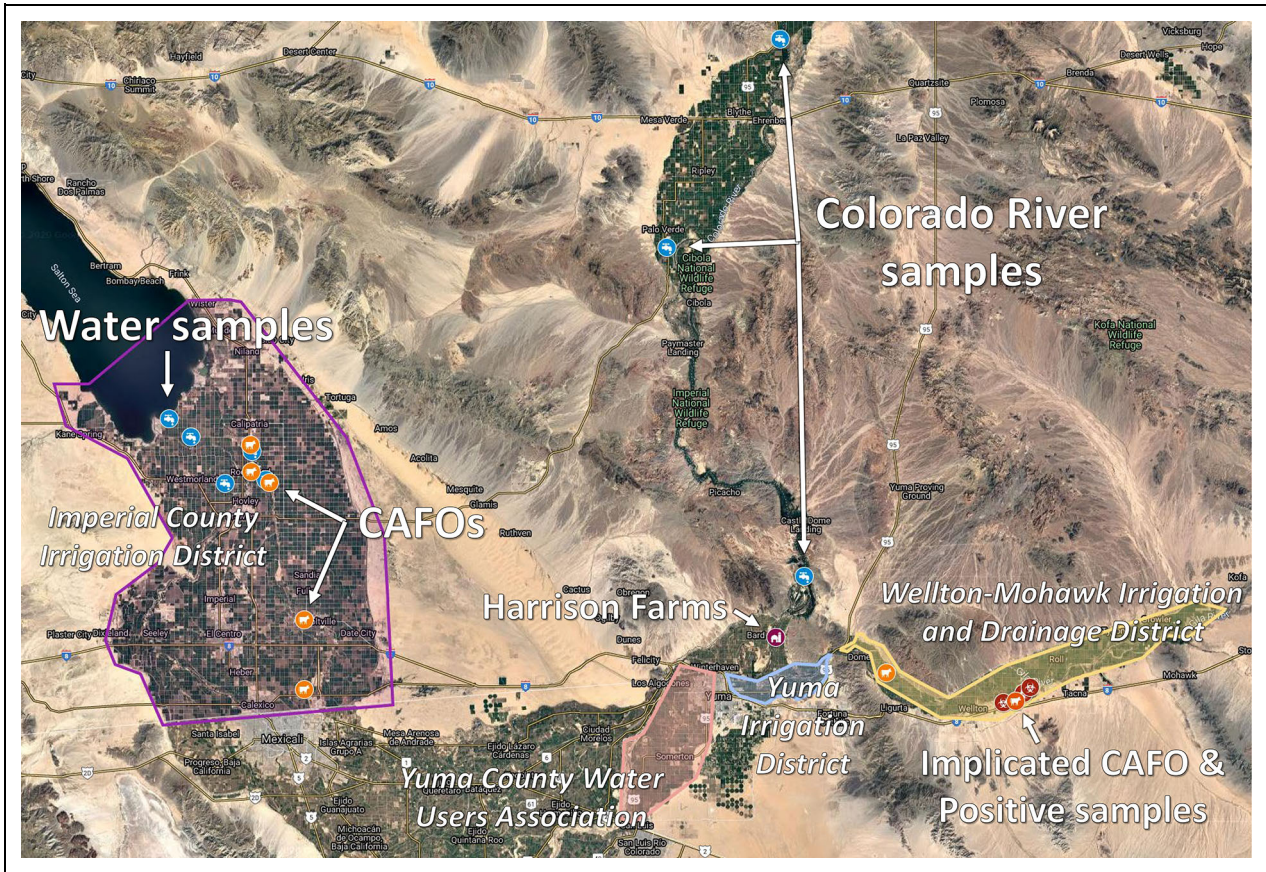


Figure 4. Environmental assessment investigation area. Affected farms drew water from all four irrigation districts, but the environmental assessment only reported samples from the Imperial County Irrigation District and the WMIDD. Harrison Farms, the only grower named in the investigation, appears to lie outside of all four irrigation districts under investigation, although it may operate fields in other locations. Investigators sampled water at numerous locations, but only three samples taken near the McElhaney Cattle Company’s concentrated animal feeding operations tested positive for the outbreak strain. Adapted from (FDA, 2018c), image created in Google Earth®. DOI: <https://doi.org/10.1525/elementa.2021.00041.f4>

let alone taken into account during the formulation of a response.

Stage 2: Environmental assessment

Given the inconclusive traceback, the FDA Commissioner conceded at the end of May, “there isn’t a simple or obvious explanation for how this outbreak occurred.” However, he reassured the public that, “We are actively evaluating a number of theories about how romaine lettuce grown on multiple farms in the same growing region could have become contaminated around the same time” (Gottlieb and Ostroff, 2018). To that end, on June 4, 6 weeks after the romaine harvest ended, FDA and CDC dispatched a team of 15 investigators to Yuma to conduct a retrospective environmental assessment. Their mission: first, to collect environmental samples from likely sources—including wild animal feces, irrigation canals, and cattle feedlots—to see whether they could detect the outbreak strain and, second, to discover the farming practices responsible for linking the pathogen source to romaine lettuce (FDA, 2018c).

The team interviewed 14 growers, who together managed 21 of the 23 farms implicated during traceback. As

shown in **Figure 4**, those farms were geographically disparate.⁸ The only plausible environmental link (assuming a one-to-one, linear contamination pathway) was the Colorado River, from which all 21 farms drew irrigation water, supplied by four independent irrigation districts. The investigators focused on these districts, where they collected environmental samples in June, July, and August. The nearest common point is the Imperial Dam, located on the California–Arizona border just north of Yuma city. However, no Colorado River samples tested positive for the outbreak strain, possibly because several months separated any hypothetical contamination event from the investigators’ samples (FDA, 2018c).

As cattle are a primary source of STEC, the investigation team paid close attention to concentrated animal feeding operations (CAFOs) in the vicinity of the suspected farms.

8. FDA generally does not publicly disclose identifying information, including addresses or coordinates, of companies involved in an investigation unless there is a pressing public health justification. Although the precise location of the implicated farms is unavailable, FDA’s public report does map general locations of concern.

Three CAFOs were found to be operating in Yuma County, AZ, though the investigation focused on one near to several affected farms, the McElhaney Cattle Company (Anglen, 2018b). Imperial County in California also has several CAFOs, and the investigators collected samples from at least two that were near other farms under investigation, as well as from nearby ponds and irrigation canals. Although they found non-O157 STEC as well as six genetically distinct strains of *E. coli* O157: H7, the team did not detect the outbreak strain. The only samples that tested positive for the outbreak strain came from a 3.5-mile stretch of the Wellton Canal running adjacent to the McElhaney Cattle Company (Anglen, 2018b; FDA, 2018c).

The investigation team struggled to make sense of these piecemeal findings, which raised new questions of “just how and why this strain of *E. coli* O157: H7 could have gotten into this body of water and how that led to contamination of romaine lettuce from multiple farms” (Gottlieb, 2018, June 28 statement). In attempting to reconstruct the contamination, the investigators hit an obstacle at each link in the causal chain. First, they could not establish firm evidence of a link between the McElhaney Cattle Company and the contaminated canal water. They collected six samples of manure and water from the CAFO site but did not detect the outbreak strain. Moreover, the investigators noted that “measures implemented to prevent contamination of the irrigation canal from the feedlot . . . suggest runoff would be prevented from entering the canal” (FDA, 2018c, p. 14). They hypothesized that the high turnover of cattle on the feedlot combined with the lag-time between any contamination and sampling might explain the lack of positive test results and that underground seepage might account for the route of transmission to the canal. Nonetheless, critical observers questioned how the pathogen traveled upstream (Anglen, 2018b) and why cattle that had been there for decades suddenly caused a problem (Charles, 2018).

Second, the investigators could not determine how water from a single canal contaminated 36 separate farm fields across multiple irrigation districts. Although irrigation water generally does not contact the edible portion of romaine lettuce, the interviewed growers indicated that canal water is often used to mix and dilute agrochemicals that are then sprayed onto the edible leaves. Most growers hire independent contractors, known as applicators, to spray agrochemicals. The investigation team interviewed two applicators contracted by 11 of the 13 farms in the irrigation district served by the Wellton Canal. One reported using canal water to mix the sprays, establishing a plausible contamination pathway for five farms. That still left the puzzle of how romaine from the other 16 farms became contaminated. The investigation concluded with these questions unresolved:

FDA has concluded that the water from the irrigation canal where the outbreak strain was found most likely led to contamination of the romaine lettuce consumed during this outbreak. FDA cannot rule out that other sources or means of

romaine lettuce contamination with the outbreak strain of E. coli O157: H7 may have occurred. There are several ways that irrigation canal water may have come in contact with the implicated romaine lettuce including direct application to the crop and/or use of irrigation canal water to dilute crop protection chemicals applied to the lettuce crop . . . How and when the irrigation canal became contaminated with the outbreak strain is unknown. A large animal feeding operation is nearby but no obvious route for contamination from this facility to the irrigation canal was identified. Other explanations are possible although the EA team found no evidence to support them. (FDA, 2018b)

This conclusion is notable more for its absences than for its positive findings. Abundantly clear, however, is the disjoint between the investigation team’s attempts to trace the causal pathway stepwise back through time and the actual conditions on the ground that produced an outbreak. Months passed between when the lettuce was contaminated (March) and the environmental assessment (June)—during this time, much evidence disappeared from the environment. Yet the environmental assessment report only references this time lag twice: first to note, “Because the Yuma region’s growing season had concluded weeks before the EA started, no leafy greens were available for sampling and testing,” and second to argue that “the outbreak strain may have been present in the irrigation canal months before the EA team collected the positive samples” (FDA, 2018b). Strikingly, FDA does not ask whether the time lag might also explain the absence of evidence on which grounds the agency effectively dismissed other possible explanatory factors—specifically leaf damage or wind-blown contamination are mentioned—in favor of its preferred culprit, contaminated canal water, which explanation itself posed unresolved mysteries.

Also unresolved is the ambiguity over precisely what counts as a contaminant. Although numerous positive samples of human pathogens were discovered throughout the environmental assessment, only those few that matched the outbreak strain mattered. Other human pathogens detected during the assessment were recorded (FDA, 2018c, Table 6), but these potentially dangerous microbes, and their sources, received no more than passing mention in the final report. Again, FDA does not ask whether the widespread presence of human pathogens beyond the outbreak strain might itself indicate a broader risk factor for the region, recommending only that government agencies and the industry continue to “explore possible source(s) and route(s) of contamination associated with the outbreak pathogen and with other food-borne pathogens of public health significance” (FDA, 2018b).

In summation, the report not only provides an internally inconsistent account of the events which led to contamination and thence to outbreak but moreover fails to acknowledge, let alone address, the potential limitations suggested by those inconsistencies. This is evidence of

institutionalized non-knowledge. The environmental assessment's failure to "solve" the outbreak does not appear to result primarily from technoscientific deficiency: although technical capacity (e.g., mobilization speed) and surprise risk factors (e.g., chemical sprays mixed with water) played a role, they cannot account for the assessment's basic incapacity to produce the kind of information about the agricultural environment that regime experts would be able to recognize as contamination. Nor does that failure seem to result directly from blame avoidance. The assessment reinforces the severity of the "largest STEC outbreak in over a decade," and its recommendations stick to FDA's long-standing strategy to exhort the leafy greens industry to more diligently follow hazard analysis and control strategies (see Baur et al., 2017), effectively arguing that all such factors *can* be managed, and are thus within the regime's orbit of control.

Considering both stages of the outbreak investigation, when confronted with a complex system, the regime fell victim to its epistemic limits, particularly an inability to recognize and address social and ecological relationships that lay outside its standard conceptual model of how pathogens contaminate food. In the traceback process, investigators lamented encountering a "web" of overlapping economic and legal dimensions in the fast-paced lettuce industry rather than the simple "line" they desired. They seemed bewildered by the possibility that contamination might flow through pathways that only imperfectly map to the physical flow of lettuce through time and space, which itself maps imperfectly to the nodes and distribution channels of the supply chain. Likewise, in the environmental assessment, investigators appeared stubbornly fixated on identifying a singular source (canal water) and a singular pathway (agrochemical sprays), downplaying or rejecting evidence which suggested a more complex web of causality encompassing layered ecological, geographic, meteorological, hydrological, and managerial relationships. The dynamic and open-ended conditions of farming in nature seem largely illegible to the environmental assessment mode of inquiry.

Due to institutionalized non-knowledge, and despite substantial motivation for all parties involved to determine the source of the outbreak, the investigation produced more unasked than answered questions. In considering these inconclusive results, FDA missed an opportunity to question whether the investigation targeted the right scale. There is another way to consider the conditions that gave rise to the outbreak: The Yuma region contains many sources of human pathogens that can flow and be dispersed through numerous environmental media (water, air, animals, equipment, people), and yet also grows vast quantities of a crop known to be susceptible to pathogenic colonization which is then centrally processed before being shipped all over the country (and abroad) as fast as possible. Is the culprit then an isolated slip in control that let STEC into the food supply, or a vulnerable production system that gave STEC an ideal platform on which to spread? Failure to grapple with the implications of the latter question left industry and government actors with treacherously unstable footing upon

which to reassert trust in the regime's control over foodborne dangers.

Official responses to the outbreak

Despite the investigatory failure, the Yuma outbreak catalyzed significant regulatory and industry response. In a letter to the leafy greens industry released concurrently with the environmental assessment report on November 1, 2018, FDA presented a stern message: "more must be done as the status quo is unacceptable" (Ostroff and Plaisier, 2018). The letter reiterated,

It is industry's role to ensure that the foods they bring to market are safe for consumers to eat. Therefore, we urge all segments of the leafy greens industry to review their operations and make all necessary changes. FDA sets standards for the safe growing [and handling] . . . of produce and works in collaboration with our state counterparts to ensure compliance with these standards . . . We also see a need to improve our response actions during outbreaks . . .

The letter recommended that state and federal agencies:

- *Speed-up investigations*, including laboratory results, environmental assessments, and stakeholder communication.
- *Expand surveillance and testing capacity*, including routinely collecting and testing romaine lettuce samples to determine whether they are legally adulterated.⁹
- *Increase local collaboration*, stressing the importance of "local in-depth knowledge and actions" during outbreak investigation.

And recommended that industry:

- *Enhance internal policies*, including assessing and mitigating risks, verifying implementation, and conducting root cause analysis when a foodborne pathogen is detected in the "growing or processing environment."
- *Adopt state-of-the-art traceability technology*, specifically "the ability to identify specific farms or ranches" so as to expeditiously "determine which farm(s) and growing region are responsible."
- *Fund and conduct research*, specifically to identify sources of pathogens, specific contamination routes, and methods to "reduce,

9. Although pathogenic contamination is determined scientifically, adulteration is a legal determination defined by the U.S. Federal Food, Drug, and Cosmetic Act.

control or eliminate contamination of leafy greens by human pathogens.”

Next, I analyze the implications of these recommendations for key regime actors at the regulatory, supply chain, and farm levels to evaluate whether and to what extent the lessons learned represent reflexive awareness of the regime’s institutionalized non-knowledge of emergent risks in the complex social–ecological system of romaine agriculture.

Government response

In a statement on the outbreak, the FDA Commissioner extolled “the use of modern tools to advance food safety” (Gottlieb, 2018). His framing of the food safety problem, and what to do about it, concisely captures FDA’s take-away lessons:

While we know we can’t stop foodborne illness completely, these numbers underscore the need for us to do much more. We need to take additional steps, and do it faster, to improve the safety of our food supply. This is why we’ve focused on developing and using advanced technologies and science to enhance our efforts in preventing food safety problems and improve our response time when incidents occur. These are the tools that are already helping the FDA and the CDC identify more outbreaks of human illness, and trace them back to food when food is the source. We need to invest even more in these efforts, and in the tools to track and trace contaminated food in the supply chain. (emphasis added)

This statement adheres unreflexively to an assumption of technoscientific deficit, evincing technocratic reassertions to trust in the regime’s elite expertise as predicted by both Dunn (2007) and McGoey (2012b). FDA’s goal is more precise information on “contamination” gathered as close to real time as possible. The favored response is to “invest even more” in the same types of surveillance tools already in use. No mention is made of possible need for epistemic, organizational, or institutional adaptation despite the potential to do so implied by the above-referenced recommendation to increase local collaboration and value “local in-depth knowledge.” This is a missed opportunity (an action not taken). By investing in social networks, the regime could invite more diverse perspectives, which in turn might expand epistemic receptiveness to risks and vulnerabilities outside its standard grid of control—burdens that otherwise remain unrepresented and uncounted externalities. Specifically, it is plausible that incorporating the knowledge of practitioners familiar with a given region’s climate, ecosystems, modes of production, and cultural practices would help public health investigators better recognize and account for the multi-layered social and environmental relationships that confounded the Yuma investigation. In failing to center that

recommendation in its response, FDA eschewed one clear route toward reflexive institutional reform.

Instead, the agency chose to double down on surveillance technology likely to further institutionalize non-knowledge of emergent and systemic risks arising from localized agricultural conditions. Consider FDA’s investment in one technological advance predicted to play a major role “in our fight against foodborne illness” (Gottlieb, 2018): whole genome sequencing (WGS). Outbreak investigations rely on genetic subtyping to distinguish the pathogens responsible from nonrelated cases (Ronholm et al., 2016). Compared to older technologies, “WGS is fast and cheap and produces subtyping and phylogenetic resolution on a scale that was never before achievable” (Ronholm et al., 2016). CDC describes WGS as a tool to determine a “unique DNA fingerprint,” which investigators can use to piece together the events of an outbreak and thus “solve” it (CDC, 2016). CDC and FDA are collaborating to expand and standardize WGS capacity in microbiological laboratories (Allard et al., 2016; Ronholm et al., 2016).

FDA highlights two regulatory uses of WGS. First, WGS can link pathogens found in food products or facilities with pathogens isolated from victims of foodborne illness by matching the “DNA fingerprints.” Second, the “most promising and far reaching” application of WGS is to trace the history of pathogenic contamination by “pairing a foodborne pathogen’s genomic information with its geographic location and applying the principles of evolutionary biology to determine the relatedness of the pathogens” (FDA, 2018d). Because microbes steadily accumulate mutations over time, the degree of DNA difference between two isolates can tell investigators how recently they shared a common ancestor (Ronholm et al., 2016). When paired with the FDA’s pathogen database, Genome-Trak—which includes genetic information along with the date and source of the isolate—WGS “enables effective monitoring of foodborne pathogens across the United States and potentially across the globe” (Allard et al., 2016). WGS thus represents, for FDA, a potent *centralized* tool for surveillance, regulation, and, ultimately, control.

However, it is difficult to see how the extra genetic information WGS offers would have changed the outcome of the Yuma investigation or how future expansion of WGS will address ignorance of the underlying social–ecological conditions that make food unsafe in specific places. No matter how advanced the test, the result is only as useful as the samples obtained to test. It is unclear how better testing would resolve one of the primary hurdles for the environmental assessment: The Yuma agricultural environment, and traces of the outbreak strain it may have harbored, had already moved on from the conditions that gave rise to the outbreak. The failure to produce a satisfactory culprit for the outbreak did not stem from laboratories but rather from the investigation team’s inability to make sense of a complex, heterogeneous, and rapidly changing production environment. The agency seems to have formulated the problem to fit the solution rather than the other way around. FDA’s fixation with centralized surveillance technologies such as WGS not only distracts

from efforts to cultivate “local in-depth knowledge” of the production environments it is charged to oversee but forces the regime to ask about the pathogen itself rather than about the social–ecological conditions that allow it to be dangerous.

Retail industry response

The retail industry, meanwhile, leveraged FDA’s technocratic endorsement of surveillance tools to justify shifting responsibility (and thus blame) toward growers and shippers. On September 24, 2018—a week before FDA released its final environmental assessment report—Walmart announced that all of its leafy greens suppliers would henceforth adhere to a new food traceability initiative (Redfield et al., 2018). Based on blockchain technology, the initiative “will increase transparency in the food system,” the letter stated, further specifying that, “All fresh leafy greens suppliers are expected to be able to trace their products back to farm(s) (by production lot) in seconds – not days” (Redfield et al., 2018). In this letter, Walmart revealed the powerful role the retail sector plays in the food safety regime. Through the pseudo-vertically integrated system of supply chain management (Busch, 2007), retailers wield tremendous control over their suppliers and intermediary handlers. In a move that parallels FDA’s insistence on advanced surveillance technologies, Walmart insisted that requiring advanced traceability technologies would resolve foodborne danger:

This change means that the information gathered by these suppliers will be open and accessible through technology that offers real-time, end-to-end traceability from farm to table. (Smith, 2018)

The letter and accompanying promotional materials prominently cited a partnership with IBM crypto-experts and the soon-to-be-realized digitization of agriculture, framing the problem as an outdated system in need of high-tech modernization. Notably, Walmart also claimed that blockchain empowers the individual consumer: “In the future,” said Frank Yiannas, then VP of food safety at Walmart, “using the technology we’re requiring, a customer could potentially scan a bag of salad and know with certainty where it came from” (Smith, 2018). The rhetoric explicitly tied traceability to transparency and then to trust. Blockchain technology keeps records “open to users” and also “makes falsifying information very difficult”: “The information is out in the open creating greater transparency . . . With increased accessibility comes more accuracy and trust” (Smith, 2018). Although FDA promoted WGS technology to render pathogens legible to the state, the retail sector promoted blockchain technology to render suppliers legible to buyers.

The interrelationship between these two surveillance initiatives was further institutionalized through the December 2018 appointment of Yiannas to the FDA as Deputy Commissioner for Food Policy and Response. In early 2019, Yiannas and the FDA Commissioner’s office announced “a new era of smarter food safety” in which “all those involved in making food products available to

consumers must walk in lockstep on this path” to create “a more digital, traceable, and safer system” (Sharpless and Yiannas, 2019). In remarks before the International Association for Food Protection several months later, Yiannas promoted blockchain technology and predictive analytics, stating, “We want consumers to have the confidence in the safety of new and existing products that a transparent, data-driven food safety system can provide” (Yiannas, 2019).

Despite these glossy promises, and for all the talk of speed, new surveillance tools cannot unilaterally transmute a fundamentally reactive method into a preventive strategy. CDC and FDA identified the outbreak just 6 days before the Yuma harvest ended; due to inherent lag time from harvest to table to symptoms, nearly all the contaminated romaine had already reached consumers. Brightly illuminating the supply chain could have yielded limited improvements in warning the public and recalling product, but it could not have addressed the multilayered factors that led to the outbreak and confounded the investigation. Blockchain-enabled traceability once again focuses on “lines,” even though a “web” more closely resembles the Yuma scenario: Romaine lettuce from multiple farms selling through separate supply chains was all contaminated simultaneously. Rendering each link in the chain of transactions “transparent” also narrowly isolates the responsibility of individual growers and shippers. This forces the regime to ask, “What did individual firms fail to do?” precluding the question of whether their level of operational agency is commensurate with their level of operational risk. Hence, the retail industry seems to have formulated the problem to fit their expectations about who should be responsible for fixing it, even though landscape-level risks extend beyond the bounds of farm-level authority. In this way, the regime’s institutionalized non-knowledge preserves an epistemic “safe” space within which technocratic assertions and blame avoidance strategies coproduce one another, together reinforcing the retail sector’s power.

Leafy greens industry response

In late May 2018, the leafy greens industry organized the Leafy Greens Food Safety Task Force (2018) to respond to the vulnerabilities exposed by the outbreak. Representing those directly responsible for growing and handling romaine lettuce, the task force diverged from the regulatory emphasis on surveillance and traceability. “[W]e’re going to focus heavily on practices that are going to prevent illnesses in the future,” said Scott Horsfall, CEO of LGMA and a steering committee member for the task force, “because traceback and the investigation often just takes a long time, so far better if we prevent the pathogens from ever getting in the marketplace” (Nickle, 2018a). The final recommendations issued by the task force reflect that intention. Of the 26 recommendations, only 4 involved traceability and 2 surveillance, while 5 aimed to enhance communications and 15 to improve best practices to prevent contamination (Leafy Greens Food Safety Task Force, 2018).

Specifically, the task force aimed to toughen LGMA production standards to protect against the hazards posed by CAFOs, extreme weather events, and waterborne contamination. Here, the growers missed an opportunity to challenge the distribution of responsibility (and costs) within the regime. They positioned the problem at the farm level, implicitly accepting the regulatory presumption that the burden of responsibility lies with individual growers. Another task force leader, quoted in the industry periodical *The Packer*, said, “We need to do some really robust hazard assessments at every individual site because every individual site is different and every individual site is going to require different levels of control and different mitigations” (Nickle, 2018b). The article further reported that the task force “is now developing tools to help growers conduct those assessments—which consider topography, weather, management practices of nearby operations and other relevant factors.” Although the task force framed this effort as empowering growers to prevent pathogenic contamination, the recommendations also imply that growers needed to do more because farm-level efforts to date had been inadequate.

This stance dovetails with a common consumer advocacy narrative that frames food safety as a function of grower diligence and outbreaks as the result of industry negligence. For example, in late 2018, *Consumer Reports* published an article titled, “Grower Steps to Keep Romaine Safe May Not Be Enough.” Although food scares catalyze growers to take more precaution, the article concluded, “how long that will last... is anyone’s guess” because “after things get quiet for a while, everything gets lax again” (Hirsch, 2019). The industry itself also questioned growers’ commitment to food safety. The article quotes the chief science and technology officer for the powerful Produce Marketing Association: “It shouldn’t take outbreaks like these to make produce companies be more diligent... there needs to be a corporate culture that takes them seriously.” The same argument for a “food safety culture” to instill diligence and commitment has circulated among industry elites for over a decade (Baur et al., 2017). However, growers are already under significant pressure to prioritize food safety; if an outbreak occurs, they face steep financial and reputational losses, lawsuits from victims, and even criminal charges (Baur et al., 2017). Given these existential threats to livelihood, it is unclear how much additional diligence and commitment can be instilled in growers.

The task force’s interest in understanding the interdependency of environmental conditions represents a recognition of systemic biophysical vulnerabilities that is not evident in regulatory or retail responses. Yet growers’ capacity to act on that expanded awareness is limited to the boundaries of their farms—it does not extend to off-farm sources of hazards or to risk multipliers after they ship the lettuce. Moreover, growers must still conform to an economic “higher loyalty” and maintain high productivity. Ratcheting up preventive practices at the farm level thus articulates tightly with surveillance and traceability. Each response turns a blind eye to disparities between sources of foodborne risk and assignment of

responsibility. Together they divert the regime from recognizing and adapting to structural vulnerabilities at the food system level. Non-knowledge institutionalized within the food safety regime thus precludes coordinated actions that might, for example, seek to curb the pathogenicity of CAFOs or cap the potential for contamination to spread by restricting romaine harvests to small batches strictly sequestered from one another. In both the epistemic and strategic sense, the food safety regime *cannot know* that overflow might be endemic to its control-oriented design.

Paths not taken

Recounting the outbreak investigation and response through an agnotology lens revealed internal inconsistencies and missed opportunities that together suggest that institutionalized non-knowledge plays a critical role in both the continued occurrence of outbreaks and the regime’s incapacity to adapt to the crisis. What remains to be seen, however, is whether alternative normative and epistemological commitments might plausibly trigger reflexive reform in the food safety regime. The methodological obstacles to this section are substantial. As Gross and McGoey (2015, p. 7) asked, “How can a researcher know what an individual or an observed group of actors do not know?” To tether my analysis to empirical roots, I took a course that hews to published critiques of the outbreak investigation, response, and the food safety regime’s general control strategy. Although the results are no less speculative—an inevitability when dealing with the hypothetical—they do represent alternative courses of inquiry and action that external observers believed would be worthwhile. This is neither an exhaustive nor a prescriptive analysis. Instead, these hypothetical examples of what and how to “know differently” demonstrate the contingency of institutionalized non-knowledge exposed by the Yuma outbreak.

Critiques of the outbreak investigation and response

As the investigation haltingly proceeded, many romaine lettuce producers—especially growers from other regions whose romaine products were also circulating in the marketplace as the outbreak unfolded—expressed frustration with what they saw as FDA’s unjust commodity-wide moratorium. CAFF and The Farmers Guild (2018), an organization representing family farms, blogged, “While romaine grown by small California farms selling directly to consumers (at venues such as farmers markets) could in no way be implicated, they nonetheless take the hit.” Growers in this position felt the warnings against romaine punished *all* growers, irrespective of their location or “their autonomy from the vast supply chain currently under investigation.” This sense of unfair assignment of blame extended even to those growers whose products *were* implicated. Consider the single farm that was publicly named in the investigation. As the *Arizona Republic* reported,

Health officials were able to link Harrison [Farms] to the eight cases [of E. coli poisoning among Alaska

inmates] because the farm used an intermediate shipper to send whole heads of lettuce to the prison. Lettuce from other farms was mixed together by shippers, making it impossible for investigators to determine where it came from. (Anglen, 2018b)

Only the lone farm unlucky enough to supply a shipper that did not mix romaine from different farms was singled out, a result that some commentators attributed to political expedience rather than due process, saying, “FDA was under pressure to name someone” (Anglen, 2018a). Underlying the sense of unfairness expressed in these examples is an implicit belief that the investigators failed to adequately identify who actually bore responsibility for the outbreak. In both cases, the commentators suggest that the corporate industrial lettuce *system* deserved scrutiny.

The environmental assessment’s fixation with contaminated canal water as the singular causal suspect also met with criticism. The Leafy Greens Task Force (2018) advanced a theory proposing that “unusual weather” may have created what one participant called a “perfect storm of conditions” (personal communication, October 1, 2018). First, a hard freeze hit, which may have caused “epidermal peel” in the delicate romaine and “allowed the pathogen to enter the leaves.” Shortly afterward, strong winds blew across the region, potentially carrying *E. coli* from feedlots to the fields on dust particles. A subsequent heavy rain could have spread the contamination even further. “So that’s the other idea,” this task force participant noted, “that there was just a combination of anomalous problems” (personal communication, October 1, 2018). This is the closest that any member of the food safety regime came to acknowledging the possibility of an emergent risk produced not from an isolated causal agent but rather from the chaotic, emergent, and interacting effects of a dangerously vulnerable farm environment. Attorney Bill Marler, a prominent litigator for victims of foodborne illness, made the case more bluntly:

[T]he undeterred insistence of growing, processing, sourcing, and selling romaine lettuce from a region repeatedly plagued by STEC contamination and subsequent outbreaks is a considerably reckless activity. (Marler, 2019, emphasis added)

Taking the point to its extreme, Marler argues that it should be considered “reckless misconduct” to grow, process and sell romaine lettuce” because “the risk of environmental contamination was in fact a well-known and long-standing risk” at a *regional* level (Marler, 2019). In other words, the risk is of a type that is beyond the control of any individual grower, and therefore, trust is no longer merited.

Agroecological alternatives to control

Both critiques of the investigation hint at an underlying frustration with the basic framework used to produce knowledge about both who and what caused the

outbreak. The food safety regime presumes that control is the only strategy. All frameworks have limitations, but those limitations rise to the level of institutionalized non-knowledge in cases where experts do not acknowledge the possibility of normative and epistemic alternatives. To illustrate the contingency of the control strategy, I briefly outline several alternative ways in which a perspective grounded in agroecology—a participatory science that seeks to enhance sustainable agriculture through deep ecological knowledge of the interrelationships between a farm and its environment (Rosset and Altieri, 2017; Vandermeer and Perfecto, 2017)—might seek to understand and manage the dangers posed by foodborne pathogens. Specifically, the regime’s seek-and-destroy approach to achieving control contrasts sharply against the resilient adaptation approach advanced by agroecology, which seeks to bolster the “immune system” of agriculture by enhancing biodiversity (Rosset and Altieri, 2017, p. 20).

This perspective appeared early in the course of food safety reform for U.S. vegetable agriculture, when the National Sustainable Agriculture Coalition advanced the following argument in counterpoint to a perceived “war on nature” (Stuart, 2008) embedded in the LGMA and nascent FSMA:

Agriculture is a human endeavor based on biological processes, and nature cannot be eliminated from the equation. Food safety will not be achieved simply by monitoring and killing bacteria—it must come from a food system that values human relationships and environmental stewardship. (NSAC, 2009)

Farmers walk an ever-shifting line between *adaptation* to the environment as given and *intervention* to make that environment more congenial to their vision of farming (Henke, 2008, p. 114). Ironically, although industrial agriculture is premised on remaking hydrological regimes, soils, and ecosystems to resemble a factory, the food safety regime appears to accept as given the dangerous pathogenicity and immunodeficiency of the industrial farm landscape. An agroecological perspective, in contrast, acknowledges anthropogenic effects on the evolution of the very pathogens that the food safety regime battles against. Wallace (2016), for example, documents the coevolution between corporate-industrial chicken farms and deadly viruses. Yet, rather than recognize coevolution, Russell observes (2003, pp. 85–102):

We have largely ignored . . . the impact of ecological changes and public health measures on the constitutions of other species. By changing the environments in which organisms live, we have changed the selective regimes in which they evolve. In some cases, the resulting evolution has forced humans to interact with versions of those species in very different ways.

What the food safety regime fails to imagine, and thus fails to know and act upon, are the consequences that

result from the perpetually unresolved “tension inherent in applying food-safety principles developed for the controlled industrial context of factories to the dynamic ecological matrix of farm fields” (Karp et al., 2015a). Stuart (2008) argues that control-based food safety might “actually serve to increase risks to human health” by producing sterile environments that are *more* favorable to pathogenic bacteria.

From this perspective, treating fields as factories also obscures social–ecological feedback dynamics and forecloses possibilities to cultivate resilience. Recent research indicates that ecologically based farm management can encourage ecosystem services that mitigate risks from human pathogens in farm soil (Jones et al., 2019) and wildlife (Karp et al., 2015b), examples of emerging knowledge on how to enhance agroecological resilience to pathogenic dangers (Stuart and Worosz, 2011; Olimpi et al., 2019). More radically, a framework aimed at resilient adaptation might mean the regime should loosen its grip on control. Some argue that tolerating periodic, low-grade illness is necessary in order to mitigate the severity and scale of more extreme outbreaks:

One could make a case that, just as we want some level of exposure to infectious agents—or simulated exposures such as vaccination—to maintain the resilience of our immune system, so we may want to tolerate the smaller disease outbreaks that come with a more decentralized agrifood system. . . . In this sense at least, a little bit of food poisoning is probably a good thing. It helps us to keep up our personal immunity as well as our capacity to respond to outbreaks, and serves the crucial role of reminding all participants in this shortened, more visible, food chain about the inherent risks of eating our environments. (Waltner-Toews, 1996)

Notably, this statement consciously takes both an epistemic and normative stance, embracing a framework that reimagines safety as a function of resilience and adaptability, with the goal “not to eliminate the danger, but to manage it” (Delind and Howard, 2008). The food safety governance regime’s core epistemological assumption is that science and technology can defend society against whatever dangers nature throws at it, a stance that also obviates deliberation about the distribution of burdens and benefits. In contrast, an agroecological perspective assumes that adaptive management with nature can diffuse danger into “tolerable” background perturbations. Moreover, the question of what foodborne risks are tolerable, and who has to do the tolerating when and where on behalf of whom, is foregrounded for consideration.

I present these agroecologically inspired perspectives not as prescriptions but as plausible examples of an alternative strategy for knowing and acting upon foodborne dangers that is reflexively adaptive at the social–ecological system level. My point is that the regime has a *choice* in which values and epistemologies to embrace, and that

choice has real consequences for the nature, magnitude, and distribution of benefits and burdens in food systems—including whether and to what extent the regime can accept change now in order to transition toward a more sustainable future. Ultimately, this is a societal choice of “how to live democratically and at peace with the knowledge that our societies are inevitably ‘at risk’” (Jasanoff, 2003), but the regime has organized its ignorance so as to bury presumed answers to this question deep within its technical institutions.

Discussion

My analysis of the Yuma outbreak investigation, official response, and comparison to plausible paths not taken demonstrates the ways in which the food safety regime produces positive knowledge of some kinds of danger (proximate and amenable to technical “fixes”) while institutionalizing non-knowledge of other kinds (systemic and requiring structural change). Critically, this knowledge–ignorance duality is coproduced with a strategy of reform that reinforces the regime’s authority and power across scientific, policy, and management domains, albeit at the cost of precluding possibilities for reflexive adaptation.

Institutionalized non-knowledge

At the scientific level, the regime reductively equates danger with the presence of discrete hazards. Investigation, surveillance, and traceback protocols are designed to pinpoint isolated causes—such as canal water, animal feces, or human hands—that might endanger leafy greens. They further presume that isolated hazards cause discrete contamination events, which in turn propagate stepwise along a linear chain of causality following the supply chain. The regime hinges its claim to control on its capacity to identify and sever the chain of contamination as close to the first link as possible. In so doing, the regime embraces a reactive, after-the-fact form of action that seeks to patch individual leaks rather than a preventive, systemic approach to remedy vulnerabilities across the agricultural landscape.

At the policy level, the regime pursues centralized, top-down control over leafy greens agriculture, evidenced by the emphasis on surveillance and traceability technologies among both public and private regulators. The locus of power in the regime is maintained by enforcing a “regulatory chain” that parallels the supply chain, and in principle, the chain of contamination (Abbott et al., 2017; Havinga and Verbruggen, 2017). Regimes based on regulatory chains entangle numerous intermediaries, such as auditors and technical consultants, who also have a vested interest in preserving the status quo (Lytton and McAllister, 2014; Lytton, 2017). In this hierarchical system, trust is presumed to derive from the capacity for “higher” levels within the regime to see precisely what actors at “lower” levels (i.e., on the farm) are doing. Overlooked by this presumption is the need for the most abstracted levels of governance regimes to learn from the most grounded, a prerequisite process for adaptively cultivating

social–ecological resilience to crisis-level outbreaks from the ground up.¹⁰

Finally, at the management level, the regime assumes a neoliberal model of human agency that individualizes responsibility and accountability, evidenced by the regime's fixation with refining farm-level best practices and asserting food safety culture irrespective of the scale of risk. The “individualization of responsibility” for food safety at the company level parallels that which sociologists have long critiqued among individual consumers, who are encouraged to accept responsibility for structural failings in the modern industrial economy—such as environmental degradation or exploitation of workers—over which they have little direct power (Maniates, 2001; Szasz, 2007). The current food safety governance regime likewise places responsibility for structural failings of the entire agrifood system onto individual leafy greens growers, obscuring the role that political economic forces play in shaping and distributing systemic risks.

The strategic value of non-knowledge

The U.S. food safety regime is hypervigilant in identifying outbreaks and increasingly effective at linking them to their proximate cause, for example, romaine lettuce. But the regime's dominant epistemology obscures the political economic connection between knowing *what* causes illness and *who* causes illness. The sophisticated institutional arrangements to coordinate technical analysis of aggregated, standardized, and decontextualized data en masse distance the technical work from the exercise of power. Yet tracing and predicting contamination also implicates real people and real production environments. At stake, in other words, is not just the epistemological status of foodborne disease outbreaks—the ways in which knowledge (and non-knowledge) about outbreaks and their causes is produced—but also the locus of power in terms of who can “reveal,” that is, represent or speak for, public danger.

I have argued that the locus of power maintained through epistemic and regulatory standards intended to control human pathogenic risks is continually reproduced not only through positive identification of discrete hazards but also through strategic omission of emergent hazards and the ways in which the industrial agrifood environment may itself be dangerous and risky. The food safety regime's agnosticism toward systemic risks—which expose large-scale industrial leafy greens agriculture to periodic invasion by deadly pathogens—is strikingly convenient for the expert elites who control the produce safety regime. The situation is reminiscent of what McGoey (2007) termed the “will to ignorance” evident in the circular faith that audit-based bureaucracy places in its own authority:

[A]udits are remarkably invulnerable to their own failure, and that, in the rare instance when attention does occasionally turn to the question of process, either individuals, or the specifics of individual audits, are blamed instead of the system of auditing itself.

Discrete contamination hazards can be “controlled”—and public trust in the food supply upheld—without fundamentally restructuring the centralized, simplified, and corporate-owned agrifood system.

Institutionalized non-knowledge impedes reflexive adaptation

That “sewer-state” mentality (Dunn, 2007), however, comes at a cost: “By dictating, if not manufacturing, the dangers to be controlled, the state obscures the fact that danger and diversity are essential elements of life . . . Far from eliminating all risk, it keeps us desperate and in perpetual need of protection” (DeLind and Howard, 2008). DuPuis (2015, pp. 112–123) contends that, to escape this “sanitary treadmill,” it would be healthier, more equitable, and more sustainable to openly accept that the safety–danger boundary is “constructed through a discursive political process.” Acknowledging the futility of chasing perfect control over an agricultural environment that is clearly capable of surprising us would mean adopting a reflexive stance toward systemic risk (Beck et al., 2003). Reflexivity entails restructuring and reprioritizing the food safety regime to internalize and more justly distribute negative consequences of its self-perpetuating vulnerability to outbreaks of foodborne infectious disease (Stuart and Worosz, 2011). Reflexive adaptation would need to squarely address the intersecting political economic and biophysical conditions that generate systemic immunodeficiency. A food safety governance regime adaptively responsive to systemic risks would acknowledge the divergence between capital accumulation and public health, as well as the deeply problematic linkages among farmland consolidation, agroecosystem homogenization, coevolving pathogens, and the risk-magnifying effects of a centralized industrial food system. Yet this complexity is precisely what the modern food safety governance regime fails to know.

Limitations and next steps

In focusing on authoritative claims made by the food safety regime and its constituent groups, the scope of my analysis is limited to formal public documents. I intentionally restricted my data set to those public documents that the regime chose to make freely accessible in order to examine the regime's preferred narrative. Future research using these methods might consider utilizing the U.S. Freedom of Information Act—or comparable transparency laws in other jurisdictions—to access “backstage” documents that are legally public but not necessarily made publicly accessible. Other sources of evidence, such as social media posts or interviews, could provide further insight into the informal or nonpublic aspects of

10. There is a vast literature on institutional learning, but see especially Ansell (2011: 104–125) on recursive learning. On the importance of learning for sustainable agricultural adaptation, see Darnhofer et al. (2010) and Duru et al. (2015).

epistemic culture—the internal norms governing what questions shall be asked, how they shall be answered, and what shall be done about it—within different facets of the regime.

I concluded that the regime remains formally unaware of certain limitations to its knowledge, particularly emergent vulnerabilities of social–ecological systems, at the *organizational* level. An important future research question is whether and in what ways experts and decision makers acting within the regime (as growers, buyers, or regulators) conform to the same contours of ignorance at the *individual* level. Studying the interplay between organization and individual and between external (public, formal) and internal (private, informal) non-knowledge could elucidate the ways in which non-knowledge becomes institutionalized in the first place, as well as suggesting mechanisms through which such organized ignorance might be consciously reflected upon and even deconstructed. In terms of practical intervention, however, organizational culture, professional norms, or standards of evidence-based analysis do not emerge nor are they maintained in isolation; rather, they interact with structural constraints shaped by factors including rules, markets, and liability. Future research might therefore also address the degrees of freedom to reflect on and adapt to organized non-knowledge afforded to regime members within these intersecting structural constraints.

Conclusion

In *Risk Society*, Ulrich Beck (1992) famously argued that modern society is organized around one central problem: how to deal with the systemic risks unleashed by industrial capitalism's global manipulation of social–ecological systems. Perhaps nowhere else are these projected risks more unavoidably manifest than in agrifood systems, where harmful “boomerang effects” of industrial agriculture are readily observable across health, economic, ecological, climatic, geopolitical, and cultural dimensions. Yet, like the outbreak investigation process in my case, the governing regimes responsible for understanding and responding to this complex risk landscape in agrifood systems may be woefully ill-equipped with the epistemic and normative tools to meaningfully grapple with the intersectional problems before them. Ansell and Baur (2018) suggest that regimes caught in this situation tend toward instability, leading either to breakdown and dissolution or to a degree of “mission drift” so severe that they lose their purpose.

This article is motivated by a desire to understand and thereby better stabilize the regimes that govern the health and sustainability of our agrifood systems. To make governing regimes more stable, I suggest, takes not just increased technical capacity (to overcome deficit) or stronger mechanisms of accountability (to deter blame avoidance) but heightened cultural and cognitive adaptability to navigate the limits of their own structured ignorance. I am not arguing that ignorance merely constitutes “undone” science that should be completed. To do so would risk falling into the technocratic hubris against which Stuart and Worosz (2011) warn. Instead, I cleave

to the theory that the boundaries between the normative categories of safe and unsafe are inextricably entwined with those between the epistemological categories of the known and the not-known. This insight suggests that in place of control, it might be healthier, in all senses of the word, to collectively accept “positive non-knowledge,” “where the limits and the borders of knowing are intentionally taken into account for acting or planning” (Gross and Bleicher, 2013). Accessibly accounting for non-knowledge may facilitate public deliberation, as Jasanoff (2003) argues in her advocacy for “technologies of humility,” and can reduce paralysis to the extent that society is willing to accept action even in the absence of calculable, and thus controllable, futures (Gross, 2016).

Another way of framing the point is to draw on adaptive capacity theory, within which strict control and certainty are eschewed in favor of flexibility, learning, and resilience (Darnhofer et al., 2010; Duru et al., 2015). In this context, systemic reflexivity is a necessary condition for initiating sustainability transitions; applying agnotology to complex environmental governance systems reveals the barriers to reflexivity encoded in organized non-knowledge. Specifically, the inertia of long-standing cultural and cognitive structures for understanding and responding to problems may prevent even acute social–ecological crises from catalyzing adaptation and transition, especially in cases where those structures are largely taken for granted. Significant theoretical development and empirical analysis are needed to thoroughly conceptualize and examine the role that positive non-knowledge might play in critically evaluating those limitations and opening up food systems to the degree of sustainable and just transformation increasingly recommended (Hinrichs, 2014; Bui et al., 2016; Maye and Duncan, 2017; Lamine et al., 2019). At the very least, positive non-knowledge requires the imaginative capacity to envision a broader range of what might be possible, including challenging dominant political economic formations such as the highly centralized supply chain that funnels nearly all salad greens through a handful of corporate suppliers. This case reinforces the urgency of such work, and more broadly the value of incorporating perspectives from the field of ignorance studies (Gross and McGoey, 2015) into interdisciplinary efforts to shift society–environment interactions toward sustainability.

Data accessibility statement

All data sources used in this study are freely accessible in the public domain and fully cited in the text and references.

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Author contributions

PB is the sole author of this article.

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