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Food Security as National Security: A Survey of Natural and Intentional Biological Threats to the U.S. Food Supply

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Glossary

Amerithrax Investigation	A nine-year investigation resulting from the 2001 Anthrax attacks.
Agroterrorism	The deliberate introduction of a pathogen against crops, livestock or into the food system for the purpose of undermining socioeconomic stability, generating public fear, and creating general disorder among the American public.
Federal Select Agent Program	The joint USDA-CDC program that oversees the possession, use, and transfer of select agents and toxins which pose a threat to public, animal, or plant health.
Genetic Sequencing	A laboratory technique for determining the exact sequence of nucleotides, or bases, in a single DNA molecule.
Genomic Sequencing	A laboratory technique for determining the sequence of all or most of the genetic material (DNA or RNA) in disease-causing microbes.
Microbial Forensics	The use of sophisticated genetic, chemical, and physical techniques to characterize a pathogen or toxin agent that has been used as a weapon.
Phylogenetic Analyses	The study of the evolutionary development of a species or a group of organisms or a particular characteristic of an organism.
Synthetic Biology	The interdisciplinary science that deals with the modification of biological organisms, systems, or processes especially using genetic engineering techniques.
Zoonotic Diseases	Infectious illnesses that spread between animals and humans.

I. Introduction

Agroterrorism Defined

Agroterrorism is a subset of bioterrorism. The most prominent literature defines agroterrorism as the deliberate introduction of a pathogen into crops, livestock, or the food system to undermine socioeconomic stability, generate public fear, and create general disorder among the American public.[1] An agroterrorism attack succeeds by causing economic and psychological harm rather than inflicting human casualties. Yet even this definition, synthesized from the prevailing scholarship, is at present archaic. It frames the threat in terms of naturally occurring and naturally acquired pathogens, an assumption shared by the foundational scholarship. It does not account for what is quickly becoming the two most pressing concerns in the field: the infusion of artificial intelligence into synthetic biology and the propagation of AI-fueled misinformation surrounding food security. This review adopts the stipulated working definition above while recognizing that this definition and the present literature are insufficient to address the most pressing concerns pertaining to American agricultural security.[2]

Pathogen Selection Criteria and the Institutional Identification of Threats

Determining which biological threats pose the greatest risk to the U.S. food system may be accomplished by filtering existing animal and plant pathogens through two criteria. The first is epidemiological. Pathogens best suited to the needs of nefarious actors share a set of characteristics that maximize destructive potential. The second is economic. The U.S. agricultural sector depends disproportionately on a small set of crop and livestock commodities, and an attack directed at those commodities offers the greatest potential for destructive impact. The greatest biological risks to the United States, then, are the pathogens that both meet the optimal epidemiological conditions and target the commodities on which the U.S. economy depends most.

The literature consistently discusses specific epidemiological characteristics that define an effective agroterrorism pathogen. Many of these characteristics are basic to epidemiology and apply to any bioweapon, regardless of its target. An effective agent is highly transmissible and

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[1] Dean Olson, "Agroterrorism: Threats to America's Economy and Food Supply," *FBI Law Enforcement Bulletin*, accessed June 16, 2026, https://leb.fbi.gov/articles/featured-articles/agroterrorism-threats-to-americas-economy-and-food-supply; Tyler Hoard, Adeline E. Williams, and David Luckey, *Agricultural Security Considerations for the U.S. Corn Belt: Reviewing Key Threats and Mitigation Strategies for Bioresiliency* (Santa Monica, CA: RAND Corporation, 2026), https://www.rand.org/t/RRA4836-1; Jim Monke, *Agroterrorism: Threats and Preparedness*, CRS Report RL32521 (Washington, DC: Congressional Research Service, February 4, 2005); Peter Chalk, *Hitting America's Soft Underbelly: The Potential Threat of Deliberate Biological Attacks Against the U.S. Agricultural and Food Industry* (Santa Monica, CA: RAND Corporation, 2004).

[2] Some scholars create further delineations. Pate and Cameron and Polyak argue that agroterrorism is analytically distinct from food terrorism and biological warfare, which targets human beings directly. Pate and Cameron clarify why this delineation matters. They argue that treating mere consumer product tampering or strategic biological attack as akin to the introduction of a pathogen into livestock or crops combines incomparable threat profiles, allowing regionally confined incidents to serve as case study evidence for agroterrorism as a national, existential threat (Pate and Cameron 2001). To this end, much of the literature frames agroterrorism as an existential threat to national security, yet the case studies evidencing this framing are all better understood as regionally confined incidents than as national threats.

causes either high morbidity or high mortality. Casagrande (2012), however, identifies a further set of three characteristics distinctive to agricultural pathogens that warrant closer examination.[3] They are a non-zoonotic profile, simple natural procurement (i.e., the ability to source the pathogen from a crop field or livestock farm), and the pathogen's ability to trigger an international trade restriction upon detection.

The first of these, a non-zoonotic profile, is a convenient characteristic of many potential agroterrorism agents, including foot-and-mouth disease and African swine fever. Because the scientific community does not believe these viruses transmit to humans, nefarious actors need not worry about the rigorous safety measures required to handle and transport zoonotic bioweapons.[4] Perhaps most conveniently, a non-zoonotic virus does not pose the spillover risks that remain a concern in conventional bioweapon development: scientists culturing these non-zoonotic viruses need not worry about human spillover and thus need not develop a vaccine or other preventive measures against infection.[5] This characteristic substantially lowers the technical barrier to entry for an attack, removing conventional biosafety concerns that would otherwise complicate the sourcing, cultivation, and deployment of an agent. Chalk (2004) disputes this assessment, arguing that a zoonotic pathway is the most effective agent insofar as it creates the human harm and corresponding shock factor that terrorists thrive on.[6]

A second characteristic noted is simple, natural sourcing. Biological agents are more operationally attractive to non-state actors than their chemical or nuclear counterparts because sourcing does not require advanced laboratory infrastructure or weaponization capability. Rather, a perpetrator could simply purchase an infected animal or plant, conduct "modest processing" to obtain a sample containing the pathogen, and smuggle it into the target country for cultivation.[7] For example, environmental isolation of anti-crop fungal diseases can be accomplished using basic surface cultivation techniques (i.e., placing infected crops in an uninfected area).[8] More consequentially, only a small sample of infected organic matter is necessary to initiate an outbreak. For example, it would take only a few hundred microliters of scrapings from the blistered mucosa of an FMD-infected animal, or a small blood vial from a hemorrhaging animal with African swine fever, to start an outbreak.[9] To simplify matters further, anti-livestock pathogens are also present in countries where terrorist organizations exhibit a strong presence (e.g., African swine fever in sub-Saharan Africa), creating a baseline of environmental availability for non-state actors operating in those regions.[10]

The third characteristic is the pathogen's listing as a "notifiable" pathogen under the World Organization for Animal Health (WOAH) for livestock or as a “regulated” pathogen under the

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[3] Rocco Casagrande, “Biological Terrorism Targeted at Agriculture: The Threat to US National Security,” *The Nonproliferation Review* 7, no. 3 (Fall/Winter 2000): 93–95; Jung-Yong Yeh et al., “Livestock Agroterrorism: The Deliberate Introduction of a Highly Infectious Animal Pathogen,” *Foodborne Pathogens and Disease* 9, no. 10 (2012): 869–877; Chalk, *Hitting America's Soft Underbelly*, introduction.
[4] Casagrande, “Biological Terrorism Targeted at Agriculture,” 95.
[5] Mark G. Polyak, “The Threat of Agroterrorism: Economics of Bioterrorism,” *Georgetown Journal of International Affairs* 5, no. 2 (Summer/Fall 2004): 32.
[6] Chalk, *Hitting America's Soft Underbelly*, 15.
[7] Casagrande, “Biological Terrorism Targeted at Agriculture,” 93.
[8] Casagrande, “Biological Terrorism Targeted at Agriculture,” 94.
[9] Mark Wheelis, Rocco Casagrande, and Laurence V. Madden, “Biological Attack on Agriculture: Low-Tech, High-Impact Bioterrorism,” *BioScience* 52, no. 7 (July 2002): 572.
[10] Casagrande, “Biological Terrorism Targeted at Agriculture,” 94.

International Plant Protection Convention for crops, respectively.[11] These diseases incur harsh international sanctions upon detection and reporting to international authorities, potentiating devastating economic consequences.[12] Once an outbreak is confirmed and triggers international notification, affected nations face near-instant economic damage as trading partners impose strict trade embargoes. The literature provides both case-study evidence and empirical modeling to substantiate this. From a case study perspective, the 1997 FMD outbreak in Taiwan incurred upwards of $1 billion in damages (roughly $2 billion in 2026) from trade losses alone, and Taiwan still has not recovered its once-thriving pork export market.[13] Moreover, USDA sponsored modeling of a potential FMD outbreak in US swine estimates that a majority of economic fallout would come from trade ramifications rather than domestic damage.[14]

Livestock Pathogens

The agroterrorism literature after the September 11 attacks did not develop its own schema of threatening pathogens but rather borrowed one. Across the scholarship that emerged after 2001, the standard reference point for identifying which animal diseases were the most threatening agroterrorism pathogens was the list maintained by the World Organization for Animal Health (WOAH), specifically its "List A" classification. Early literature simply accepted the entire WOAH's List A, along with portions of List B, when identifying agents of acute concern to U.S. agriculture.[15] List A comprised transmissible animal diseases capable of "very serious and rapid spread, irrespective of national borders," carrying serious socioeconomic or public health consequences and major significance for international trade, requiring afflicted nations to report the pathogen's presence to the WOAH within twenty-four hours of detection.[16] List B captured diseases of more regional importance and endemic potential that nonetheless remained significant to trade.[17] The determinants of an agent's threat status under this framework were thus its contagiousness and potential for rapid spread, together with its status as a reportable disease subject to international quarantine under WOAH rules.[18] Reliance on this framework is consistent throughout foundational agroterrorism scholarship. Casagrande (2000), writing for *The Nonproliferation Review*, and Parker (2002), in the National Defense University's McNair Paper, both ground their identification of high-consequence agents in the WOAH's List A. Chalk (2004), in a RAND survey that remains arguably the seminal post-9/11 work on agroterrorism,

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[11]World Organisation for Animal Health (WOAH), "Active Search," last modified July 31, 2023, https://www.woah.org/en/what-we-do/animal-health-and-welfare/disease-data-collection/active-search/; IPPC Secretariat, "Basic Obligations of National Plant Protection Organizations under the IPPC in Support of Trade (Import and Export)," presented at the CARE SPS Trade Knowledge Management Workshop, 2015, https://www.carecprogram.org/uploads/2015-SPS-TKM-2015-SPS-TKM-5-National-Obligations.pdf.
[12]WOAH, "Active Search," 2023; IPPC Secretariat, "Basic Obligations of National Plant Protection Organizations," 2015.
[13] Yang, P.C., R.M. Chu, W.B. Chung, and H.T. Sung. "Epidemiological Characteristics and Financial Costs of the 1997 Foot-and-Mouth Disease Epidemic in Taiwan." *Veterinary Record* 145 (1999): 731–34.
[14]Paarlberg, Philip L., Ann Hillberg Seitzinger, John G. Lee, and Kenneth H. Mathews, Jr. *Economic Impacts of Foreign Animal Disease*. Economic Research Report No. ERR-57. Washington, DC: U.S. Department of Agriculture, Economic Research Service, May 2008.
[15]Monke, *Agroterrorism: Threats and Preparedness*, 25; Henry S. Parker, *Agricultural Bioterrorism: A Federal Strategy to Meet the Threat*, McNair Paper 65 (Washington, DC: Institute for National Strategic Studies, National Defense University, 2002), 16.
[16] Monke, *Agroterrorism: Threats and Preparedness*, 25; Parker, *Agricultural Bioterrorism*, 16.
[17] Monke, *Agroterrorism: Threats and Preparedness*, 25.
[18]Monke, *Agroterrorism: Threats and Preparedness*, 24.

does the same, as do Cupp et al. (2004), Waage and Mumford (2008) in their review of agricultural biosecurity, and Yeh and colleagues (2012).[19] While the authoritative literature relies on this framework, and this was an appropriate decision at the time, the list has since become inapposite as a reference.

The explicit purpose of List A initially lent itself to agroterrorism literature. It served to isolate the transmissible animal diseases capable of the most serious and rapid spread and, in doing so, functioned as a useful proxy for which pathogens posed the gravest danger to livestock. When the scholarship of the early 2000s adopted List A as its organizing framework, it was borrowing a classification that ranked pathogens according to threat status. That is no longer what the WOAH list does. In 2004, the WOAH replaced the List A/List B tiers with a single notifiable list designed to be compatible with the World Trade Organization's Sanitary and Phytosanitary Agreement.[20] This list now classifies every included disease equally, thereby assigning each the same threat level in international trade.[21] Its inclusion criteria now focus on global trade and animal health rather than on bioweaponization potential. This loss of tiering is consequential because a framework that once distinguished the gravest threats from the merely notifiable now conflates high-consequence livestock diseases on equal footing with a glut of aquatic and non-livestock wildlife diseases that have no bearing on biosecurity concerns.

In contrast, the US recognizes that not all viruses on the WOAH notifiable list constitute equal threats to its agricultural sector. Following the passage of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (P.L. 107-188), the Agricultural Bioterrorism Protection Act created the official list of agents of greatest concern for agroterrorism, specified in the select agent rules implemented jointly by USDA-APHIS and the Centers for Disease Control and Prevention (CDC) of the Department of Health and Human Services.[22] The regulations define select agents as biological agents and toxins with the potential to pose a severe threat to public, animal, and plant health, or to animal and plant products, and whose possession, use, and transfer are federally regulated.[23] With respect to animal pathogens, two features distinguish this framework from the WOAH list. First, the act requires that the list be reviewed at least every two years to reflect an evolving threat landscape. Second, and more importantly, the select agent designation under the USDA is reserved explicitly for animal and plant pathogens that threaten national security.[24] These inclusion criteria reflect a federal

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[19] Casagrande, "Biological Terrorism Targeted at Agriculture," 92–95; Parker, *Agricultural Bioterrorism*, 16; Chalk, *Hitting America's Soft Underbelly*, introduction; Oveta S. Cupp, David A. Walker II, and Jack Hillison, "Agroterrorism in the U.S.: Key Security Challenge for the 21st Century," *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 2, no. 2 (2004): 99; J. K. Waage and J. D. Mumford, "Agricultural Biosecurity," *Philosophical Transactions of the Royal Society B: Biological Sciences* 363, no. 1492 (2008): 864, https://doi.org/10.1098/rstb.2007.2188; Yeh et al., "Livestock Agroterrorism," 871-872.
[20] Monke, *Agroterrorism: Threats and Preparedness*, 25.
[21] Monke, *Agroterrorism: Threats and Preparedness*, 25.
[22] Monke, *Agroterrorism: Threats and Preparedness*, 25.
[23] U.S. Department of Health and Human Services and U.S. Department of Agriculture, "HHS and USDA Select Agents and Toxins: 7 CFR Part 331, 9 CFR Part 121, and 42 CFR Part 73," CS357006-A, January 14, 2025, https://www.selectagents.gov/sat/list.htm.
[24] Pillai, S. P., T. West, K. Anderson, J. A. Fruetel, C. McNeil, P. Hernandez, C. Ball, N. Beck, and S. A. Morse. "Application of Multi-Criteria Decision Analysis Techniques and Decision Support Framework for Informing Select Agent Designation for Agricultural Animal Pathogens." *Frontiers in Bioengineering and Biotechnology* 11 (2023): 1185743. https://doi.org/10.3389/fbioe.2023.1185743.

determination that a pathogen is inherently dangerous enough to warrant strict oversight.[25] The list also includes a tier system similar to that forgone by the WOAH, placing pathogens into either a Tier 1 or no-tier status. As of the January 2025 biennial publication, the list designates thirteen USDA select agents, two Tier 1 and eleven no-tier agents threatening livestock.[26]

What emerges from this select agent list is that economic impact is an embedded characteristic of the list itself. Currently, only FMD and Rinderpest are listed as Tier 1 agents, signaling the importance of viable cattle, whose receipts alone accounted for 41.7 percent of all U.S. animal and animal-product cash receipts in 2024.[27] More substantially, of the thirteen listed USDA agents, nine affect primarily cattle, swine, and poultry, the three livestock groups that together accounted for roughly four-fifths of U.S. animal and animal-product receipts in 2024.[28] Moreover, all thirteen appear on the WOAH list of notifiable agents, so that their detection would spell not only severe domestic hardship but also deleterious economic effects at the global level. These viruses have seen a substantial degree of attention, especially from the scientific community. Most notably, foot-and-mouth disease commands the largest share, anchoring the economic impact and agroterrorism preparedness literature.[29] African swine fever figures prominently in the economic-consequence scholarship, and the 2014 to 2015 Avian Flu Outbreak, combined with the 2024 emergence of the novel H5N1 clade 2.3.4.4b strain in U.S. chickens and dairy cattle, has concentrated recent attention on highly pathogenic avian influenza.[30]

Crop Pathogens

The literature engages with livestock pathogens to a relatively greater degree than it does crop pathogens. This is an interesting incongruity in existing scholarship, given the United States'

[25] Monke, *Agroterrorism: Threats and Preparedness*, 25; 9 C.F.R. § 121.3 (2003).
[26] HHS and USDA, "Select Agents and Toxins," 2025. For a complete list of livestock and crop pathogens see Figure 1 in the appendix.
[27] Economic Research Service, "Cattle/Calf Receipts Comprised the Largest Portion of U.S. Animal/Animal Product Receipts in 2024," U.S. Department of Agriculture, accessed June 18, 2026, https://www.ers.usda.gov/data-products/chart-gallery/chart-detail?chartId=76949.
[28] USDA Select Agents are enumerated at 9 C.F.R. § 121.3 (2025); see also HHS and USDA, "Select Agents and Toxins," 2025. Receipts shares are calculated from Economic Research Service, USDA, "Cattle/Calf Receipts Comprised the Largest Portion," 2024.
[29] Paarlberg et al., *Economic Impacts of Foreign Animal Disease*, 2008; Vienna R. Brown, Ryan S. Miller, Sophie C. McKee, Karina H. Ernst, Nicole M. Didero, Rachel M. Maison, Meredith J. Grady, and Stephanie A. Shwiff, "Risks of Introduction and Economic Consequences Associated with African Swine Fever, Classical Swine Fever and Foot-and-Mouth Disease: A Review of the Literature," *Transboundary and Emerging Diseases* 68, no. 4 (2021): 1910–1965, https://doi.org/10.1111/tbed.13919; Pate and Cameron, "Covert Biological Weapons Attacks Against Agricultural Targets."
[30] Brown et al., "Risks of Introduction and Economic Consequences," 1910–1965; Eric R. Burrough, Drew R. Magstadt, Barbara Petersen, Simon J. Timmermans, Phillip C. Gauger, Jianqiang Zhang, Chris Siepker, Marta Mainenti, Ganwu Li, Alexis C. Thompson, Patrick J. Gorden, Paul J. Plummer, and Rodger Main, "Highly Pathogenic Avian Influenza A(H5N1) Clade 2.3.4.4b Virus Infection in Domestic Dairy Cattle and Cats, United States, 2024," *Emerging Infectious Diseases* 30, no. 7 (2024): 1335–1343, https://doi.org/10.3201/eid3007.240508.

heavy reliance on crops as an export commodity and as a source of animal feed.[31] It is especially surprising given the well-documented history of state actors such as the United States, Iraq, and the Soviet Union cultivating a comprehensive anti-crop pathogen regime.[32] There is no clear explanation in the literature for this relative lack of attention to crops. Many scholars argue that livestock attacks pose fewer operational obstacles than crop attacks, a disparity that may explain why the literature privileges livestock pathogens as primary threat agents. For example, Waage and Mumford (2008) argue that this disparity stems from historical and economic influences. First, animals have for centuries enjoyed greater protective measures than crops, and this history of disparate focus has seeped into contemporary biosecurity priorities.[33] Moreover, crop cycles are seasonal, making the abrupt elimination of a potential pathogen host a limiting factor to pathogen spread.[34] Finally, crops are typically moved as seeds, and their more stationary nature in the food system also limits the opportunity for disease spread.[35] However, a minority of the literature places greater emphasis on crop threats, and its tone is often critical of the current federal framework for identifying them.

As of 2026, the USDA-APHIS select agent list includes only six pathogens. This shortlist pales in comparison to the roughly 6,000 pathogens that the US must detect and report to the IPPC. This startling incongruity has been a subject of complaint in agroterrorism scholarship since the select agent list's inception. The list, moreover, mirrors the economic logic of the livestock pathogens, as three of the selected pathogens target the two most profitable US crops, corn and soybeans. Madden and Wheelis (2003) bemoan the lack of a globally recognized list of crop pathogens.[36] They put forward a generalizable framework for assessing a pathogen's potential severity that they argue is more comprehensive than the Federal Select Agent program's admission criteria.[37] N.W. Schaad et al. (2006), whose earlier prototype scoring system Madden and Wheelis had incorporated into their framework, formalized the model as a seventeen-point list of factors for determining a pathogen's threat potential.[38] These two efforts were, in part, responses to a perceived insufficiency of the admissions criteria for the USDA select agent list. This disagreement over how to best select the most salient potential crop pathogens presents an intriguing yet underdeveloped feature of the literature. Despite this disagreement, the USDA select agent list today remains the pivotal federal instrument for assessing crop pathogens of greatest U.S. biosecurity concern.

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[31] Economic Research Service, "Corn and Other Feed Grains—Feed Grains Sector at a Glance," U.S. Department of Agriculture, accessed June 18, 2026, https://www.ers.usda.gov/topics/crops/corn-and-other-feed-grains/feed-grains-sector-at-a-glance; Economic Research Service, "State Agricultural Trade Data—Annual State Agricultural Exports," U.S. Department of Agriculture, accessed June 18, 2026, https://www.ers.usda.gov/data-products/state-agricultural-trade-data/annual-state-agricultural-exports.
[32] Casagrande, "Biological Terrorism Targeted at Agriculture," 94.
[33] Waage and Mumford, "Agricultural Biosecurity," 865.
[34] Waage and Mumford, "Agricultural Biosecurity," 865.
[35] Waage and Mumford, "Agricultural Biosecurity," 865.
[36] L.V. Madden and M. Wheelis, "The Threat of Plant Pathogens as Weapons Against U.S. Crops," Annual Review of Phytopathology 41 (2003): 155–176, https://doi.org/10.1146/annurev.phyto.41.121902.102839.
[37] Madden and Wheelis, "The Threat of Plant Pathogens as Weapons," 155–176.
[38] N. W. Schaad, J. Abrams, L. V. Madden, R. D. Frederick, D. G. Luster, V. D. Damsteegt, and A. K. Vidaver, "An Assessment Model for Rating High-Threat Crop Pathogens," Phytopathology 96, no. 6 (2006): 616–621, https://doi.org/10.1094/PHYTO-96-0616.

II. Distinguishing Natural, Accidental, and Deliberate Outbreaks

Distinguishing Accidental from Intentional Introduction Under Uncertainty

The scholarly literature converges on a single premise, namely that the natural or intentional character of a biological threat to the food supply determines which institutions respond. However, the exact nature of the threat is often impossible to establish in real time. Dembek (2007) frames the problem as bidirectional, highlighting the complexity of threat attribution. An intentional attack can be engineered to resemble a natural outbreak, while a genuinely natural event can present features suspicious enough to invite an attribution that the evidence will ultimately not support.[39] This two-sided ambiguity recurs across the literature, motivating the recurring claim that an act's intentionality is better understood as a spectrum rather than a binary. Several factors span that spectrum, ranging from negligence to biosafety failures.

A 2026 RAND assessment of threats to the Corn Belt reaches the same conclusion, identifying a class of "crosscutting" threats that span both categories. As described, these threats are non-adversarial in origin. However, they are easily exploitable by malicious actors. Therefore, these threats resist a clean binary when assessing intentionality.[40] Writing from a security-studies perspective, Chalk (2004) situates agriculture as a distinctly exposed point on that spectrum. Chalk argues that the sector's dispersed operations, combined with its economic concentration, make it a "soft" target whose vulnerabilities are easier to exploit than those of most other critical infrastructure.[41]

However, the literature is equally clear that intent is sometimes unambiguous. Analysts found that Russia deliberately disrupted Ukrainian grain exports following the 2022 invasion, with the kinetic nature of the strikes making intent hard to miss.[42] This section addresses harder cases, in which a pathogen is introduced into a field without carrying any comparable signature. The 2025 *Fusarium graminearum* smuggling case is instructive here, precisely because it never resolved into a single category. Prosecutors characterized it as a potential agroterrorism concern, but the matter was pursued through criminal evidence that supplanted any hypothetical agricultural outbreak. Ultimately, malicious intent was never established.[43] This case demonstrates a recurring pattern that the rest of this section examines, showing that the question of intention centers on people-centered evidence far more often than analysis of an often-non-existent disease event.

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[39] Zygmunt F. Dembek, Mark G. Kortepeter, and Julie A. Pavlin, "Discernment Between Deliberate and Natural Infectious Disease Outbreaks," Epidemiology and Infection 135, no. 3 (2007): 353–371, https://doi.org/10.1017/S0950268806007011.
[40] Hoard et al., *Agricultural Security Considerations*.
[41] Chalk, *Hitting America's Soft Underbelly*.
[42] Caitlin Welsh, Joseph Glauber, and Emma Curtis, "Russia's Renewed Attacks on Ukraine's Grain Infrastructure: Why Now? What Next?" Center for Strategic and International Studies, November 25, 2024, https://www.csis.org/analysis/russias-renewed-attacks-ukraines-grain-infrastructure-why-now-what-next.
[43] U.S. Department of Justice, "Chinese Nationals Charged with Conspiracy and Smuggling a Dangerous Biological Pathogen into the U.S. for Their Work at a University of Michigan Laboratory," U.S. Attorney's Office, Eastern District of Michigan, June 3, 2025, https://www.justice.gov/usao-edmi/pr/chinese-nationals-charged-conspiracy-and-smuggling-dangerous-biological-pathogen-us; Associated Press, "Chinese Scientist Pleads Guilty in U.S. Smuggling Case Involving Fungus," November 12, 2025, https://apnews.com/article/chinese-scientist-smuggling-fungus-cee2f6fc4fa46188c7d2c7801362135c.

Criminal versus Epidemiological Investigations

Scholars describe two distinct modes of inquiry that may be applied to the same outbreak, each with its own aims. When the intentionality of an event is ambiguous, it must be established through evidence. Across the literature, authors conclude that investigation is not a neutral instrument. Much of the literature concerns the friction between the two modes of inquiry, with public health methods often coming into direct conflict with those of law enforcement.

Butler et al. (2002) characterize the two modes as historically separate paradigms that a bioterrorism event forces together.[44] Notably, this piece is the product of a joint project that brings together staff from the Centers for Disease Control and Prevention and the Federal Bureau of Investigation. This indicates institutional expertise, and their conclusions are likely the product of years spent navigating these investigatory structures. In their account, the epidemiological investigation is an inductive process. Investigators reason from effects toward causes, gathering case data with the governing aim of quickly stopping an outbreak. Criminal investigations proceed differently, seeking to attribute acts to responsible parties. Ultimately, they answer to the standard of proof that a court demands. These authors treat the resulting need for coordination largely as a problem of partnership and planning.

Richards (2002) identifies a difficulty in constitutional law, noting that evidence rapidly gathered under public health authority often lacks the procedural safeguards required in a criminal prosecution. Ultimately, this means that said evidence may later prove inadmissible in court.[45] Taken together with Butler et al., these two pieces examine a subtle distinction in the policy literature. Some experts view the tension as an organizational gap to be bridged, whereas others view it as a structural conflict between two inherently different processes.

The 2001 anthrax attacks bolster the case being advanced in the literature, with the scholarship treating it as a cautionary tale. Koblentz and Tucker (2010) trace the investigation, which shifted from a public-health emergency to the jurisdiction of the Federal Bureau of Investigation. The investigation narrowed the mailed spores to a single flask of material, but that genomic match never settled the question of attribution. More than one hundred people ultimately had access to the flask, with the principal suspect dying before any of the evidence could be tested in court.[46]

Their analysis extends to a problem the broader literature rarely addresses, namely whether novel microbial-forensic methods would satisfy the reliability standards courts impose on scientific evidence. *The National Research Council's Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters* reinforces this point, concluding that the genetic evidence linking the spores to a particular source was less definitive than the government had

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[44] Jay C. Butler et al., "Collaboration Between Public Health and Law Enforcement: New Paradigms and Partnerships for Bioterrorism Planning and Response," Emerging Infectious Diseases 8, no. 10 (2002): 1152–1156, https://doi.org/10.3201/eid0810.020400.
[45] Edward P. Richards, "Collaboration Between Public Health and Law Enforcement: The Constitutional Challenge," Emerging Infectious Diseases 8, no. 10 (2002): 1157–1159, https://doi.org/10.3201/eid0810.020465.
[46] Gregory D. Koblentz and Jonathan B. Tucker, "Tracing an Attack: The Promise and Pitfalls of Microbial Forensics," Survival 52, no. 1 (2010): 159–186, https://doi.org/10.1080/00396331003612521.

represented.[47] Ultimately, both of the aforementioned sources conclude that even exhaustive scrutiny of deliberate attacks can still fail to properly attribute certain incidents.

A notable gap emerges when the body of work is set against the agricultural context, because much of it is framed in terms of human disease. The agriculture-specific literature is generally thinner, yet it consistently points to an institutional disconnect. Several decades ago, Knowles et al. (2005) found that criminal intelligence regarding threats to the sector was essentially nonexistent.[48] Surveying the same terrain from the standpoint of defense policy, Chalk (2004) observes that directing forensic investigation to determine whether a disease outbreak was deliberately orchestrated or naturally occurring is a recommendation that is urged far more often than it is implemented. Additionally, Chalk notes that liaison between the relevant agencies remains limited.[49] Thus, the structural problem remains unresolved. The expertise to characterize agricultural outbreaks lies with animal health officials, while the authority to investigate intent rests with law enforcement. As the 2026 RAND report underscores, this disconnect persists. Hoard et al. (2026) identify agricultural attribution as an unmet capability and call for attribution methods tailored to agricultural scenarios.[50]

The *Fusarium graminearum* case illustrates how that gap is presently navigated rather than closed. Ultimately, the determination of intent never depended on an outbreak investigation. Instead, it proceeded through collection of evidence ranging from customs records to visa-fraud allegations to statements made to federal agents.[51] When examined in the context of the aforementioned literature, the fact that these cases are frequently adjudicated before a biological event occurs indicates how ill-equipped the investigative system may be in the event of an actual outbreak.

Who, Why, How Likely

To assess whether an ambiguous event is an attack, investigators must have some sense of who would attempt one. They must also understand why. The literature on this question is uneven, in a way that is ultimately revealing. Sources that address agricultural threats directly tend to be descriptive, whereas the broader analytic treatment of who commits biological attacks comes from terrorism studies framed around human targets. To address the question of actors with any rigor, these two modes must be reconciled.

When it comes to typologies of potential perpetrators, the literature offers two distinct subgroups that still overlap. Knowles et al. (2005) identified five specific categories, encompassing terrorists of either the home-grown or international bent. Economic opportunists are also included, as are militant animal-rights groups. Finally, the study lists disgruntled employees as potential perpetrators.[52] Keremidis et al. (2013) categorize perpetrators by belief system and potential motivation. In this framework, politically or religiously driven groups stand apart from

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[47] National Research Council, *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters* (Washington, DC: National Academies Press, 2011), https://doi.org/10.17226/13098.
[48] Terry Knowles et al., *Defining Law Enforcement's Role in Protecting American Agriculture from Agroterrorism*, NIJ Research Report, Document No. 212280 (Washington, DC: National Institute of Justice, 2005), https://www.ojp.gov/pdffiles1/nij/grants/212280.pdf.
[49] Chalk, *Hitting America's Soft Underbelly*.
[50] Hoard et al., *Agricultural Security Considerations*.
[51] U.S. Department of Justice, "Chinese Nationals Charged"; Associated Press, "Chinese Scientist Pleads Guilty."
[52] Knowles et al., *Defining Law Enforcement's Role.*

apocalyptic sects, which are often motivated by fanatical religious belief. Additionally, there are lone actors. Often, these individuals also act out of profound religious or political radicalism.[53]

While these conceptions overlap, they emphasize different points. Knowles et al. (2005) foreground the animating question of access to potential agroterrorism resources, while the latter piece primarily examines terrorist motive. Neither account would be fully constructive on its own, and the divergence serves as an important distinction within this body of literature.

Strikingly, the literature does seem united on the key point that agroterrorism is exceedingly rare. Keremidis et al. (2013) find only four documented cases over roughly sixty-five years, and even those four examples vary in reliability.[54] Chalk's (2004) assessment reaches a similar conclusion with a somewhat different count, finding roughly a dozen documented instances of substate actors using pathogens against livestock or crops in the twentieth century. Of this dozen, he concludes that only two could plausibly be labeled terrorism.[55] Ultimately, these sources lend real weight to the claim that the underlying probability of an agroterrorism event remains low and highlight the issue that differing definitions of agroterrorism in the literature create.

The rarity of agroterrorism sits somewhat awkwardly against the sector's widely acknowledged vulnerability, prompting much of the literature to explain that gap. Chalk (2004) tackles the puzzle directly, writing that agroterrorism is comparatively undemanding relative to the logistical complexity of many large-scale terrorist attacks. Chalk proceeds to explain that agroterrorism's relative rarity owes to its relative mundanity, noting that these sorts of attacks almost never produce the dramatic focal points that terrorists often seek to exploit when conducting attacks.[56] This is a plausible argument, supported by the rest of the literature, although it should be noted that Chalk's study is not peer-reviewed. While the account is well-reasoned, it may not constitute a settled finding.

The difficulty of discerning intentionality is not limited to suspected attacks, with said difficulty even shadowing ostensibly natural outbreaks. The avian influenza epidemic of 2014 to 2015 was the most destructive animal health event in national history at the time, with the scientific consensus that the virus was naturally introduced by migratory waterfowl. However, investigators were never able to establish how the virus crossed into many individual commercial operations.[57] This episode illustrates that confidence in a pathogen's general ecological origin can coexist with genuine uncertainty about its specific route of entry, and even determinations of natural origin often rest on incomplete attribution.

Taken together, the surveyed literature points to a single conclusion. If it is often impossible to achieve certainty about intent regarding an outbreak, the operative problem becomes how to act in the absence of such certainty. Treating a natural event as an attack carries real geopolitical costs, while exclusively treating a deliberate attack as a matter of public health risks forfeits the

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[53] Haralampos Keremidis et al., "Historical Perspective on Agroterrorism: Lessons Learned from 1945 to 2012," Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science 11, no. S1 (2013): S17–S24, https://doi.org/10.1089/bsp.2012.0080.
[54] Keremidis et al., "Historical Perspective on Agroterrorism."
[55] Chalk, *Hitting America's Soft Underbelly*.
[56] Chalk, *Hitting America's Soft Underbelly*.
[57] J. L. Greene, *Update on the Highly-Pathogenic Avian Influenza Outbreak of 2014–2015*, CRS Report R44114 (Washington, DC: Congressional Research Service, 2015), https://www.congress.gov/crs-product/R44114.

chance to respond to a legitimate security threat.[58] Ultimately, the policy instruments that determine the mechanisms of response are to be discussed in the following section of the paper.

Epidemiological Assessment Tools

The 2001 anthrax attacks on the United States and the resulting Amerithrax investigation revealed gaps in the epidemiological, investigative, and public health systems designed to protect the U.S. Stemming from the Amerithrax investigation, Grunow and Finke (2002), Dembek (2007), and Radosavljević (2009, 2012, 2016) integrate microbial forensics, microbiology, epidemiology, and public health to distinguish among natural, accidental, and deliberate outbreaks. Building on one another, the authors develop epidemiological assessment tools to identify an outbreak's origin. Notably, Chen (2017) reviews each, detailing their strengths, weaknesses, and developments relative to one another.[59]

Grunow and Finke (2002) established the Grunow-Finke (GFT) assessment tool, the earliest model and still the most widely used.[60] The GFT lists eleven non-conclusive criteria for distinguishing between natural and unnatural causes of a biological outbreak: bio risk, biothreat, special aspects, geographic distribution, environmental concentration, epidemic intensity, transmission mode, time, unusually rapid spread, population limitation, and clinical features. In addition, there are two conclusive criteria: identification of the agent as a biological warfare agent and proof of its release by a biological weapon. Each of the thirteen criteria is scored from zero to three points, based on data collected during the investigation and study of the outbreak, with zero indicating no data available and three indicating clear evidence of a biological attack. Each non-conclusive criterion is weighted by a multiplication factor ranging from one to three, based on its significance as an indicator of an intentional outbreak. Finally, conclusive criteria are considered conclusive proof and therefore do not require weighting. The weighted point totals are then summed and fall into four arbitrary levels of likelihood of biological warfare use, ranging from unlikely (zero to seventeen points) to highly likely (fifty-one to fifty-four points).[61]

Chen (2017) analyzed the GFT's use and compared it with other assessment tools, finding it retroactively accurate in distinguishing natural from intentional outbreaks in eight of thirteen historical cases, but correctly identifying only three of eight intentional cases. Because it is less sensitive to intentional outbreaks, it is less useful for investigators who often assume an outbreak is natural. Finally, Chen found the GFT to be the least accurate of the assessment tools reviewed, noting its subjective criteria and time-intensive procedure as key limitations, despite its strengths in quantitatively measuring those criteria.[62]

Dembek (2007) provides eleven epidemiological clues that a deliberate biological attack has occurred: a highly unusual event with large numbers of casualties, higher morbidity or mortality

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[58] Koblentz and Tucker, "Tracing an Attack."
[59] Xin Chen et al., "A Systematic Review of Risk Analysis Tools for Differentiating Unnatural From Natural Epidemics," *Military Medicine* 182, nos. 11–12 (2017): e1827–35, https://doi.org/10.7205/MILMED-D-17-00090.
[60] R. Grunow and E. J. Finke, "A Procedure for Differentiating between the Intentional Release of Biological Warfare Agents and Natural Outbreaks of Disease: Its Use in Analyzing the Tularemia Outbreak in Kosovo in 1999 and 2000," *Clinical Microbiology and Infection* 8, no. 8 (2002): 510–21, https://doi.org/10.1046/j.1469-0691.2002.00524.x; Chen et al., "A Systematic Review"
[61] Grunow and Finke, "A Procedure for Differentiating between the Intentional Release of Biological Warfare Agents and Natural Outbreaks of Disease."
[62] Chen et al., "A Systematic Review"

than is expected, uncommon disease, point-source outbreak, multiple epidemics, lower attack rates in protected individuals, dead animals, reverse spread, unusual disease manifestation, downwind plume pattern, and direct evidence. Dembek applies these epidemiological parameters to six case studies, outlining whether they appear in each natural, accidental, or deliberate outbreak. Dembek's clues and Grunow and Finke's criteria overlap significantly, and Dembek acknowledges that the GFT and his clues can jointly aid in resolving and responding to epidemics. Applying the GFT to his six case studies, Dembek found that of the four intentional outbreaks, the GFT classified only one as highly likely and one as likely to be intentional, while two were classified as doubtful.[63]

Chen (2017) notes that Dembek's clues led to the correct identification of a natural, accidental, or intentional outbreak in four of six historical case studies. Critical to the question of agroterrorism, Chen identifies Dembek as the only assessment tool that includes zoonotic diseases, which can affect animals and be transmitted to humans. Overall, the main weakness of Dembek's clues is the lack of an algorithm or model to differentiate among outbreak types, as the clues are solely red flags for investigators, not a differentiating model. However, Dembek's work is foundational to the assessment models of Radosavljević (2009, 2012, 2016).[64]

Hugh-Jones (2006) outlines characteristics of a suspicious outbreak, specifically to distinguish between natural and unnatural outbreaks of animal diseases. His paper recognizes the distinct natures of attacks targeting humans versus animals, so the focus on animal diseases, which no other author addresses, is critical to this discussion. He lays out nine characteristics indicative of unnatural outbreaks and three that would constitute conclusive proof, which are similar to Dembek's clues and the GFT. In addition, the study provides more in-depth analyses of genetic and clinical factors that signal an unusual animal epidemic.[65] Another unique yet similar vein of using epidemiological indicators to distinguish the origins of an outbreak is described by Pilch (2020) and Dhawan (2026). These studies focus on characterizing accidental outbreaks with a laboratory origin using genetics and epidemiology.[66] Like Dembek, Hugh-Jones, Pilch, and Dhawan do not provide an assessment tool or model to determine whether an outbreak is unnatural, but instead lay out indicators that should raise red flags for investigators.

Radosavljević (2009, 2012, 2016) developed three assessment tools that build on one another. Radosavljević (2009) created a risk assessment tool for biological attacks. Across the four components of a biological attack (perpetrator, agent, media of delivery, and target), there are twenty-three qualitative and quantitative parameters. Each parameter is scored zero for low probability and one for high probability. Higher scores help narrow the likely perpetrator, agent, media of delivery, and target. This method can be tested on historical cases, as Radosavljević did

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[63] Z. F. Dembek et al., "Discernment between Deliberate and Natural Infectious Disease Outbreaks," *Epidemiology and Infection* 135, no. 3 (2007): 353–71, https://doi.org/10.1017/S0950268806007011.
[64] Chen et al., "A Systematic Review"
[65] M. Hugh-Jones, "Distinguishing between Natural and Unnatural Outbreaks of Animal Diseases," *Revue Scientifique et Technique de l'WOAH* 25, no. 1 (2006): 173–86, https://doi.org/10.20506/rst.25.1.1660.
[66] Richard Pilch et al., *Front Matter*, A Guide to Investigating Outbreak Origins: (James Martin Center for Nonproliferation Studies (CNS), 2020), [i]-[ii], https://www.jstor.org/stable/resrep28859.1; Sandhya Dhawan et al., "Epidemiological Indicators of Accidental Laboratory-Origin Outbreaks," *Epidemiology and Infection* 154 (2026): e16, https://doi.org/10.1017/S0950268825100915.

for the Amerithrax case, or used to support future threat assessments.[67] While applicable to other biological threats, this model was only tested and worked for the 2001 Anthrax attacks. Chen highlights its more detailed parameters compared to the GFT, but acknowledges that it has low validity, has been applied to only one case, and lacks a model that differentiates natural from unnatural outbreaks.[68]

Radosavljević (2012) builds directly on the 2009 bioterrorism risk assessment, creating a scoring system to differentiate among outbreaks of a new or re-emerging disease, those following an accidental release, and natural outbreaks. The tool includes eight qualitative and six quantitative indicators grouped under three variables (person, time, and place). The fourteen indicators largely stem from Dembek's epidemiological clues.[69] Each indicator is once again scored 0 or 1. The points are summed, with a range from a natural outbreak (one to four points) to a highly probable deliberate or accidental outbreak (ten to fourteen points).[70] Chen notes its refined criteria, as it correctly identified two out of three cases; however, it lacks quantitative measures for those criteria.[71]

Interestingly, Chen's review does not include a different Radosavljević (2012) model. This model has twenty-three qualitative indicators and ten quantitative ones that fall into the categories of perpetrator/source of infection/reservoir of pathogen; biological agent/pathogen; means/media of delivery/factors of transmission; and target/susceptible population at risk. Each criterion is scored N/A, zero, or one for each of the four possible scenarios. Summing the scores yields four levels of probability for that outbreak type, ranging from a lowly probable type of outbreak (zero to eight points) to a certain type of outbreak (twenty-five to thirty-three points). The model provides probabilities for four types of outbreaks: natural outbreaks of endemic diseases, natural outbreaks of new or re-emerging diseases, outbreaks caused by accidental release of a pathogen, and deliberate outbreaks.[72] Chen describes this model and attributes it to Radosavljević (2016), in which the second Radosavljević (2012) model is applied to a new case involving the 2011 Escherichia coli O104:H4 outbreak in Germany; thus, it is not a novel model.[73] Nevertheless, Chen correctly identifies that this third model builds on the previous two. As with the first Radosavljević (2012) model, Chen considers the criteria refined but recognizes the lack of quantitative measures for them as a key limitation. Additionally, Chen cites a lack of applicability to other outbreak scenarios as a limitation, based on Radosavljević (2016), which

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[67] Vladan Radosavljević and Goran Belojevic, "A New Model of Bioterrorism Risk Assessment," *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 7, no. 4 (2009): 443–51, https://doi.org/10.1089/bsp.2009.0016.

[68] Chen et al., "A Systematic Review"

[69] Dembek et al., "Discernment between Deliberate and Natural Infectious Disease Outbreaks"; Chen et al., "A Systematic Review"

[70] V. Radosavljević and G. Belojevic, "Unusual Epidemic Events: A New Method of Early Orientation and Differentiation between Natural and Deliberate Epidemics," *Public Health* 126, no. 1 (2012): 77–81, https://doi.org/10.1016/j.puhe.2011.11.006.

[71] Chen et al., "A Systematic Review"

[72] Vladan Radosavljević, "A New Method of Differentiation Between a Biological Attack and Other Epidemics," in *Biopreparedness and Public Health*, ed. Iris Hunger et al., NATO Science for Peace and Security Series A: Chemistry and Biology (Springer Netherlands, 2013), https://doi.org/10.1007/978-94-007-5273-3_3.

[73] Vladan Radosavljević et al., "Analysis of Escherichia Coli O104:H4 Outbreak in Germany in 2011 Using Differentiation Method for Unusual Epidemiological Events," *Central European Journal of Public Health* 24, no. 1 (2016): 9–15, https://doi.org/10.21101/cejph.a4255.

correctly examines a single case. However, the second model by Radosavljević (2012) correctly differentiated four additional cases, partially alleviating this concern.

Overall, Chen (2017) emphasizes the need to improve the models' sensitivity to unnatural outbreaks, specificity, and timeliness. Additionally, the models have yet to be tested proactively during an epidemic, as each study examines historical cases and tests the models retroactively.[74] Since 2002, the GFT has been adapted in many ways to improve its accuracy and reduce subjectivity in its criteria (Chen 2019 & Lin 2023). Chen (2019) improves the GFT's accuracy in identifying unnatural outbreaks by removing criteria, adjusting weighting factors, and adding refinement criteria. Through model iterations, Chen recalibrated the GFT to retain its 100% specificity while increasing sensitivity for unnatural outbreaks from 38% to 100% when tested against both the original and new case studies.[75]

Lin (2023) similarly adds five criteria and, to reduce human error, incorporates Grey Relational Analysis (GRA). This statistical analysis compares each outbreak to an "ideal" unnatural outbreak, defined as one that is undeniably unnatural and is scored as such for each criterion of the GFT by the researchers. The difference between the ideal and the tested outbreaks indicates how likely the tested outbreak is to be unnatural. GRA is well-suited to the small sample size in this field and provides a more objective measure in the assessment category, while still relying on human input for evidence collection and scoring. This method was validated retrospectively using the original and new case studies, yielding 100% accuracy.[76] Given the recent modifications to the GFT, both Chen (2017) and Lin (2023) cite advances in synthetic biology and genetic engineering, making it more challenging and more important to differentiate among natural, accidental, and intentional outbreaks.[77] Contrary to their discussion and the arguments of Grunow and Finke (2002), Dembek (2007), and Radosavljević (2009, 2012, 2016), Koch (2020) argues that natural and unnatural epidemics are too difficult to distinguish epidemiologically; therefore, valuable time and effort should be prioritized for preparedness, early detection, and crisis management.[78]

Importantly, these studies primarily focus on distinguishing biological threats to human populations, with only a few tools designed for or applicable to agricultural contexts (Dembek 2007 & Hugh-Jones 2006). Hence, a critical gap in the literature remains, with limited discussion of assessment tools and characteristics for crop and livestock diseases and outbreaks. One such resource that may serve as a model for filling this gap is Nichols (2015), an EPA report outlining a disease-specific roadmap for identifying Bacillus anthracis and distinguishing between unnatural and natural outbreaks in both humans and animals.[79] Her measure sets out an easy-to-

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[74] Chen et al., "A Systematic Review"

[75] Xin Chen et al., "Recalibration of the Grunow–Finke Assessment Tool to Improve Performance in Detecting Unnatural Epidemics," *Risk Analysis* 39, no. 7 (2019): 1465–75, https://doi.org/10.1111/risa.13255.

[76] Mengxuan Lin et al., "Using a Grey Relational Analysis in an Improved Grunow–Finke Assessment Tool to Detect Unnatural Epidemics," *Risk Analysis* 43, no. 7 (2023): 1508–17, https://doi.org/10.1111/risa.14016.

[77] Chen et al., "Recalibration of the Grunow–Finke Assessment Tool to Improve Performance in Detecting Unnatural Epidemics"; Lin et al., "Using a Grey Relational Analysis in an Improved Grunow–Finke Assessment Tool to Detect Unnatural Epidemics."

[78] Lionel Koch et al., "Natural Outbreaks and Bioterrorism: How to Deal with the Two Sides of the Same Coin?," *Journal of Global Health* 10, no. 2 (2020): 1–13, https://doi.org/10.7189/jogh.10.020317.

[79] Tonya Nichols and Erin Silvestri, *Distinguishing Intentional Releases from Natural Occurrences and Unintentional Releases of Bacillus Anthracis: Literature Search and Analysis*, EPA 600/R-15/O66 (EPA, DHS, 2015), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100QYCY.PDF?Dockey=P100QYCY.PDF.

follow key revolving around four categories of unexpected genetic strains, anomaly in vaccine efficacy, site anomalies, and epidemiological anomalies, which provides an easy-to-use, rapid approach to conclude if an epizootic outbreak was natural or intentional.[80]

Microbial Forensics

Also stemming from the Amerithrax investigation, and adjacent to the literature on epidemiological assessment tools and characteristics, is microbial forensics, a more technical approach to distinguishing between natural, accidental, and intentional outbreaks. As Koblentz (2010) analyzes Amerithrax, he describes how it became the impetus for the new field of microbial forensics, which he defines as the "use of sophisticated genetic, chemical, and physical techniques to characterize a pathogen or toxin agent that has been used as a weapon."[81] In an overview of the field, McEwen (2006) emphasizes the importance of microbial forensics, specifically for infectious diseases among animal populations. Shifting the discussion toward animals provides useful information on the laboratory techniques and stakeholder partnerships required in an agricultural setting to successfully differentiate between natural and intentional outbreaks.[82] Similarly, Fletcher (2008) combines microbial forensics with forensic plant pathology to discuss their applications to crop security and outbreak differentiation, recognizing the difficulty of the process and recommending increased education and collaboration within the two fields.[83] Drawing lessons from the Amerithrax investigation, Koblentz, McEwen, and Fletcher discuss the importance of microbial forensics in responding to an outbreak, identifying those responsible, and deterring future attacks.

DNA sequencing and molecular biology are central to microbial forensics and integral to some of the epidemiological approaches described above. The literature in this area is broad, so a discussion of sequencing technologies, genetic signatures, phylogenetic analysis, and classical microbiology techniques provides a good overview of the key methods. Gilchrist (2015) and a team from the University of Virginia present the most comprehensive application of genomic sequencing in outbreak analysis. Recognizing the challenges of information availability and accuracy during real-time outbreaks, they criticize the assessment tools put forth by Grunow and Finke (2002), Dembek (2007), and Radosavljević (2009, 2012, 2016), arguing that Whole Genome Sequencing (WGS) and other microbial forensic methods provide more rapid and accurate results. Simply put, WGS first involves sequencing samples to obtain a complete genome assembly from DNA. Second, using metagenomic analysis software, you can compare the sample to a reference database. Finally, Gilchrist also describes other approaches, including culturing, protein-based methods, and spectrometry, and how they can contribute alongside WGS.[84] A more recent publication by Oliveira (2024) describes Next Generation Sequencing

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[80] See Figure 2 in the appendix for a flowchart of the natural/accidental/deliberate classification process

[81] Gregory D. Koblentz and Jonathan B. Tucker, "Tracing an Attack: The Promise and Pitfalls of Microbial Forensics," *Survival* 52, no. 1 (2010): 159–86, https://doi.org/10.1080/00396331003612521.

[82] S. A. Mcewen et al., "Microbial Forensics for Natural and Intentional Incidents of Infectious Disease Involving Animals," *Revue Scientifique et Technique de l'WOAH* 25, no. 1 (2006): 329–39, https://doi.org/10.20506/rst.25.1.1662.

[83] Jacqueline Fletcher, "The Need for Forensic Tools in a Balanced National Agricultural Security Program," in *Crop Biosecurity*, ed. Maria Lodovica Gullino et al., NATO Science for Peace and Security Series C: Environmental Security (Springer Netherlands, 2008), https://doi.org/10.1007/978-1-4020-8476-8_8.

[84] Carol A. Gilchrist et al., "Whole-Genome Sequencing in Outbreak Analysis," *Clinical Microbiology Reviews* 28, no. 3 (2015): 541–63, https://doi.org/10.1128/CMR.00075-13.

(NGS), a faster WGS technology, which can extract longer genetic sequences and provide more data.[85] Together, Gilchrist (2015) and Oliveira (2024) describe the strengths and weaknesses of WGS and NGS and how they can help identify the route of disease transmission and obtain useful information about the probable source of the outbreak.

Genomic and genetic sequencing can provide a whole genetic fingerprint indicating whether a pathogen has been genetically modified, weaponized, or is novel. Gilchrist (2015), Oliveira (2024), Nichols (2015), Pilch (2020), and Hugh-Jones (2006) describe what to look for in genetic signatures after laboratory work is complete, and the drawbacks of such methodology. Commonly, the most significant marker of a deliberate introduction of a pathogen is evidence of genetic engineering. Hugh-Jones identifies a few genetic markers of weaponization, including engineered virulence, a pathogen capable of evading diagnostic DNA tests, and genome discontinuities suggestive of human engineering.[86] Pilch also highlights how genetic mutations can serve as markers of a deliberate introduction of a pathogen. Using sequencing methods, you can compare the sample's genome with well-known genomes of the same strain to determine whether the sample genome has mutated in ways consistent with the natural strain. Inconsistent genetic mutations may indicate an alternative origin for that pathogen.[87] Lastly, as Gilchrist mentions, tracking mutations is part of phylogenetic analyses, which help reconstruct the evolutionary tree of the sample strain by comparing it with natural strains to detect unnatural mutations or genetically modified portions.[88]

Overall, microbial forensic methodology is best used in tandem with epidemiological assessment tools. In the current models, microbial forensic evidence serves a supporting role in epidemiological assessment tools rather than driving their core criteria. However, given the rise of synthetic biology, future models should further incorporate evidence from microbial forensics and DNA sequencing.

Technology and the Future

Within the field of agricultural epidemiology and plant pathogen forensics, alternative mathematical, algorithmic, and geospatial methods that differ significantly from those discussed are being introduced and developed. Primarily, these methods are used to track and predict the outbreak and spread of an epidemic; however, there is some discussion about the possibility of using such technologies to distinguish between natural and intentional outbreaks. Fletcher (2006) highlights the Australian DYMEX model, a generic weather-based model that assesses whether weather conditions at a suspected release site would prompt disease development, thereby helping determine whether an outbreak was intentionally induced. Fletcher also recognizes the potential for algorithm development based on disease spatial patterns to distinguish between natural and unnatural outbreaks.[89] MacIntyre (2018) describes how mathematical modeling can be used to track transmission dynamics and the impact of outbreaks and notes the potential for open-source intelligence to support early detection. Importantly, she also highlights the

[85] Manuela Oliveira et al., "Sequencing Technologies in Forensic Microbiology: Current Trends and Advancements," *Forensic Sciences* 4, no. 4 (2024): 523–45, https://doi.org/10.3390/forensicsci4040035.
[86] Hugh-Jones, "Distinguishing between Natural and Unnatural Outbreaks of Animal Diseases."
[87] Pilch et al., *Front Matter*.
[88] Gilchrist et al., "Whole-Genome Sequencing in Outbreak Analysis."
[89] J. Fletcher et al., "Plant Pathogen Forensics: Capabilities, Needs, and Recommendations," *Microbiology and Molecular Biology Reviews* 70, no. 2 (2006): 450–71, https://doi.org/10.1128/mmbr.00022-05.

popularity of mathematical modeling in academic communities and its relatively limited adoption in practice.[90] Overall, further research is needed to assess the viability of such models in agricultural settings for distinguishing among natural, accidental, and deliberate outbreaks.

[90] C. Raina MacIntyre et al., "Converging and Emerging Threats to Health Security," *Environment Systems and Decisions* 38, no. 2 (2018): 198–207, https://doi.org/10.1007/s10669-017-9667-0.

III. Policy Landscape

Overview

Although agroterrorism appeared infrequently in government reports and policy before the September 11 attacks, it was after that event that agroterrorism began to be more fully incorporated into the U.S. national security framework. Since then, policy on agroterrorism has followed a relatively linear trajectory, with responses, improvements, and recommendations remaining largely similar over time. Major themes in both government documents and independent policy recommendations include greater investment in research (particularly into new and emerging diseases); increased surveillance and monitoring capabilities for rapid detection; creating emergency response frameworks to effectively respond to potential attacks; hiring more knowledgeable personnel and modifying the veterinary science curriculum to include areas useful for assessing threats to livestock; stronger coordination and cooperation among federal agencies, local governments, farmers/agricultural producers, and the private food and agricultural sector.[91]

Legislative Action

After the September 11 attacks, congressional legislation focused primarily on structural changes within and between federal agencies to improve monitoring, prevention, and response to a bioterrorist attack, whether agroterrorism or otherwise.

The *Bioterrorism Preparedness Act of 2002* was the first major piece of legislation related to bioterrorism passed after the September 11 attacks. The Act was designed to fill perceived gaps in bioterrorism prevention and response. While the Act addressed bioterrorism more generally, it also included important measures to protect agriculture and food. For example, the Act increased the Food and Drug Administration's (FDA) control "over food manufacturing and imports." It also imposed stricter restrictions on the movement and exchange of certain biological agents and expanded security measures at USDA sites.[92]

The *Homeland Security Act of 2002*, a landmark piece of legislation passed in the wake of the September 11 attacks, created the Department of Homeland Security (DHS). With respect to biological threats to agriculture, the Act transferred two functions formerly under the USDA's jurisdiction to DHS. Agricultural border inspections would now be the responsibility of Customs and Border Protection under DHS, but USDA would still maintain a "significant presence" in border inspection. Furthermore, the DHS would now have jurisdiction over the Plum Island Animal Disease Center, located in New York.[93] The Act seemed to set a precedent for the coming years, establishing a pattern of cooperation and coordination between USDA and DHS.

A detailed emergency response system for rapid response to an agroterrorism attack did not begin to take shape until after Hurricane Katrina. Although it did not address agroterrorism specifically, the *Post-Katrina Emergency Management Reform Act of 2006* redefined how the

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[91] For a full list of government policies relating to bioterrorism and agroterrorism, see Figure 3 in Appendix.
[92] Monke, *Agroterrorism: Threats and Preparedness*.
[93] Monke, *Agroterrorism: Threats and Preparedness*, 15–16.

federal government responded to emergencies, including both “natural disasters” and “acts of terrorism” within its response framework.[94]

The *Food Safety Modernization Act* (FSMA) (2011) redefined the FDA’s approach to food safety and security. Rather than responding retroactively to food safety incidents, FSMA enabled the FDA to be more proactive and preventive.[95] The implementation of the Act required the FDA to issue several rules regulating specific parts of the food supply chain, including animal and human food facilities. These rules ordered food production facilities to assess vulnerabilities and enforce preventive measures. One rule explicitly required food facilities to provide and implement strategies to prevent intentional adulteration, or sabotage, of food at these facilities.

Executive Action

The executive branch was given broad mandates after the September 11 attacks to implement any policies necessary to protect national security. As such, much of the implementation has fallen within the jurisdiction of federal agencies, including the Department of Agriculture (USDA), the Department of Homeland Security (DHS), the Department of Justice (DOJ), and the Department of Health and Human Services (HHS).

Homeland Security Presidential Directive 7 (HSPD-7), published in 2003, required federal agencies to develop plans, guidelines, and risk-mitigation initiatives to protect “critical infrastructure” from terrorist threats. Notably, HSPD-7 included “agriculture and food” industries as part of “critical infrastructure.” [96] Following HSPD-7, *Homeland Security Presidential Directive 9* (HSPD-9) focused specifically on the food and agriculture sector. This directive ordered federal agencies to increase coordination and intelligence sharing among the Director of Central Intelligence, the Secretary of Homeland Security, the Attorney General, the Secretary of Agriculture, the Secretary of Health and Human Services, and the Administrator of the Environmental Protection Agency regarding “the agriculture, food, and water sectors”; strengthen surveillance and monitoring programs to identify, detect, and track biological agents that pose a threat to food and agriculture; and promote higher education initiatives, in coordination with the Secretary of Education, for programs in veterinary medicine, animal disease, plant pathogens, and related fields.

The *Strategic Partnership Program Agroterrorism (SPPA) Initiative* was an interagency partnership began operations in 2005 and involved coordination among DHS, USDA, FBI, and FDA, as well as private-sector partners. The initiative's role was to assess vulnerabilities within the food and agriculture sector and identify areas for further research.[97] Between 2005 and 2007, the initiative produced two annual status reports that described the group’s efforts and analyses from the previous year and recommended remedies for vulnerabilities. Some vulnerabilities identified in the first report included risks during food processing, where “direct human contact” with “the largest amount of product” was required, and during agricultural production, when

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[94] Post-Katrina Emergency Management Reform Act, S. 3721, 109th Cong. (2006) (enacted).

[95] Dileep Thatte, *The Food Safety Modernization Act in a Nutshell*, October 17, 2019, https://www.nist.gov/blogs/manufacturing-innovation-blog/food-safety-modernization-act-nutshell.

[96] George W. Bush, “Homeland Security Presidential Directive 7,” CISA, December 17, 2003, https://www.cisa.gov/news-events/directives/homeland-security-presidential-directive-7.

[97] US Government, *First Year Status Report (September 2005 - June 2006)* (Strategic Partnership Program Agroterrorism (SPPA) Initiative, n.d.), accessed June 11, 2026, https://www.usda.gov/sites/default/files/documents/8-10-06%201%20yr%20report%20SPPA%20agroter5.pdf.

plants and animals were at risk of disease exposure.[98] The report provided mitigation strategies to address these vulnerabilities. These strategies included physically securing high-risk sites at food processing facilities (through surveillance, restricted movement, etc.); conducting “site-specific vulnerability assessments” to develop strategies tailored to specific food processing facilities; adopting biosecurity practices at agricultural sites (decontaminating clothing, “isolating new livestock acquisitions,” etc.); and increasing awareness and cooperation among employees and industry members.[99] After 2007, it is unclear whether the group continued to publish reports, as none were found online.

Much of the literature, including HSPD-9 and some scholarly papers, has emphasized the need for surveillance and monitoring of potential agroterrorism attacks. The *National Biosurveillance Science and Technology Roadmap*, published by the National Science and Technology Council in 2013, follows the *National Strategy for Biosurveillance*, a prior document on biosurveillance.[100] The *National Strategy* laid out general objectives and guidelines for developing biosurveillance initiatives. The *Roadmap* was intended to build on this by identifying critical areas for further research and development to improve biosurveillance capabilities. General themes across these areas include developing advanced models to detect anomalies in communities and ecosystems; creating data technologies to better synthesize and integrate a wide range of biosurveillance information; and improving diagnostic technologies to enable earlier, faster detection of threats.

In 2017, an audit by the USDA Office of Inspector General assessed whether USDA had sufficiently developed plans and guidelines to combat agroterrorism threats.[101] The audit concluded that USDA had not done so. Furthermore, the Office of Homeland Security and Emergency Coordination (OHSEC) within USDA lacked a “detailed process to oversee USDA’s agroterrorism response,” relying instead on “broad and high-level” directives. The report noted that OHSEC was responsible for coordinating interagency programs and planning within USDA, but chose to rely on individual agency officials to “manage their own response plans” without coordination or synthesis across USDA.[102]

National Security Memorandum 16 (NSM-16) (2022), officially titled “Strengthening the Security and Resilience of United States Food and Agriculture,” directly addressed the potential threat that agroterrorism poses to the food and agriculture industry.[103] The memorandum directed various federal agencies to conduct risk analyses, vulnerability assessments, and policy reviews of the security of the food and agriculture industry. A prominent theme in this memorandum was interagency coordination. Many of these assessments were to be conducted through a combined effort by multiple agencies and officials. For example, NSM-16 ordered the Secretary of Agriculture, the Secretary of Health and Human Services, and the Secretary of Homeland Security to conduct an “Interim Risk Review” of “critical and emergent” threats to food and

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[98] US Government, *First Year Status Report (September 2005 - June 2006)*, 6.
[99] US Government, *First Year Status Report (September 2005 - June 2006)*, 7–9.
[100] *National Biosurveillance Science and Technology Roadmap* (National Science and Technology Council, 2013), 1, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/biosurveillance_roadmap_2013.pdf.
[101] *Agroterrorism Prevention, Detection, and Response*, Audit Report 61701-0001-21 (USDA Office of Inspector General, 2017), https://www.oversight.gov/sites/default/files/documents/reports/2020-07/61701-0001-21.pdf.
[102] *Agroterrorism Prevention, Detection, and Response*, 4–7.
[103] Joseph R. Biden, *National Security Memorandum on Strengthening the Security and Resilience of United States Food and Agriculture* (Office of the Federal Register, National Archives and Records Administration, 2022), https://www.govinfo.gov/content/pkg/DCPD-202201030/pdf/DCPD-202201030.pdf.

agriculture.[104] This was later published in March 2023. The review concluded that a variety of factors created security risks in the food and agriculture sector, including the concentration of "market power" in the industry held by a few firms; foreign acquisition of farmland; and a "gap in preparedness" between the federal government and the private sector.[105] The report also provided risk mitigation strategies for each security risk and short-, mid-, and long-term frameworks to improve coordination among federal, state, and local authorities.[106]

The *National Farm Security Action Plan*, published in 2025 during the second Trump administration, further integrated agricultural security into a national security framework.[107] The plan expressed concern about the acquisition of U.S. farmland by foreign nationals, particularly those from adversarial nations. The plan also called for the USDA to ensure that all research and programs within the Department support the American food and agriculture sector and did not benefit "adversarial interests."[108] The plan also directed USDA to investigate ways to minimize reliance on international agricultural supply chains (particularly dependence on "critical agricultural inputs and materials"), and instead invest in domestic manufacturing and production infrastructure, thereby making the U.S. agricultural industry more self-reliant.[109]

Non-Government Scholarly Reports

Parallel to policy developments in Congress and the executive branch, an emerging scholarly literature on agroterrorism was developing. Much of this literature has been discussed in previous sections of this paper, but it still merits further analysis, particularly regarding the policy recommendations and implications the authors address.

Parker's (2002) paper was an in-depth analysis of potential agroterrorism threats after the September 11 attacks and gaps in prevention and response infrastructure.[110] In Parker's view, efforts to counter agroterrorism threats should be intertwined with other parts of the national security apparatus. However, USDA should still maintain significant control over such operations, Parker argued, as they are better able to utilize existing initiatives and capabilities to "deter and respond to threats against food and agriculture."[111] Beyond this, Parker gave a list of objectives and recommendations for establishing a national security approach to agroterrorism. Among these were creating interagency initiatives to improve intelligence sharing and coordination; conducting more research into agricultural issues and bioterrorism potential; increasing knowledgeable personnel on relevant subject matter; increasing vaccine stockpiles of

[104] Biden, *National Security Memorandum on Strengthening the Security and Resilience of United States Food and Agriculture*, 3.
[105] *National Security Memorandum on Strengthening the Security and Resilience of United States Food and Agriculture: 120-Day Food and Agriculture Interim Risk Review* (Department of Health and Human Services and Department of Agriculture and Department of Homeland Security, 2023), 16, https://www.fda.gov/media/170114/download.
[106] *National Security Memorandum on Strengthening the Security and Resilience of United States Food and Agriculture: 120-Day Food and Agriculture Interim Risk Review*, 25.
[107] *National Farm Security Action Plan* (USDA, 2025), https://www.usda.gov/sites/default/files/documents/farm-security-nat-sec.pdf.
[108] *National Farm Security Action Plan*, 5–10.
[109] *National Farm Security Action Plan*, 7.
[110] Parker, *Agricultural Bioterrorism*.
[111] Parker, *Agricultural Bioterrorism,* xi.

known agricultural diseases; improving communication between the agriculture industry, the private sector, local government officials, and the federal government.[112]

Chalk (2004) assessed vulnerabilities in the agricultural and food industries, and how nefarious actors could potentially exploit them.[113] Chalk argued that such vulnerabilities arise primarily from the “concentrated and intensive” nature of U.S. farming, particularly regarding the high density of animals that live in enclosed quarters in livestock facilities, thereby rendering them more susceptible to disease; insufficient surveillance and monitoring networks at farms and food processing facilities; “inefficient” systems of communication between farmers and regulators, compounded by reluctancy among farmers to report emerging outbreaks; declining numbers of qualified veterinarians who have the expertise to identify and treat foreign animal diseases (FADs) and work with large-scale husbandry programs.[114] This last point was also raised in HSPD-9, as mentioned above. Chalk’s policy recommendations primarily involved remedying these vulnerabilities by hiring more qualified personnel, practicing greater interagency coordination amongst federal agricultural and intelligence agencies, and implementing stronger surveillance and monitoring systems.[115] Chalk also emphasized the importance of greater research into foreign animal diseases and the infrastructure needed to prevent their spread into the United States. Chalk specifically recommended “the upgrading of existing diagnostic laboratories to biosafety level 4 (BSL4)” which would allow scientists to use more dangerous and contagious animal pathogens in their research on prevention.[116] When Chalk published his paper in 2004, no such facility existed specifically for animal diseases. However, as of 2023, the National Bio and Agro-Defense Facility (NBAF) has finished construction in Manhattan, Kansas. This new facility is equipped with BSL4 capabilities.

Charlet’s (2018) article, published in Foreign Affairs, discussed the implications of gene-editing technology for biological weapons.[117] Although Charlet didn’t address agroterrorism directly, her conclusions apply equally to agroterrorism and to bioterrorism in general. Policymakers, Charlet argued, must balance awareness of the dangers of gene-editing, particularly with respect to manufacturing biological weapons, with the need to allow the public to reap the benefits of this technology.[118] One of Charlet’s principal recommendations was to develop an “international biological security strategy” that leveraged international health infrastructure and partnerships to quickly detect biological threats and to use gene editing as a harm-reduction technology.[119] Such a strategy could also involve the existing Biological Weapons Convention, an international agreement between nations to stop the development and use of biological weapons, which could be strengthened to deter bad actors from using gene-editing technology to make such weapons.[120]

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[112] Parker, *Agricultural Bioterrorism,* xii.
[113] Chalk, *Hitting America’s Soft Underbelly*.
[114] Chalk, *Hitting America’s Soft Underbelly*, 7–13.
[115] Chalk, *Hitting America’s Soft Underbelly*, 37–39.
[116] Chalk, *Hitting America’s Soft Underbelly*, 37.
[117] Kate Charlet, “The New Killer Pathogens,” *Foreign Affairs* 97, no. 3 (2018): 178–84, 128950345, pp. 178–84, Political Science Complete.
[118] Charlet, “The New Killer Pathogens.”
[119] Charlet, “The New Killer Pathogens.”
[120] Charlet, “The New Killer Pathogens.”

Devitt (2019), although focused specifically on Australia rather than the U.S., discussed the advantages and challenges of implementing biosurveillance technologies on farms.[121] It is important to note that biosurveillance involves many types of data collection, including sample collection, digital/remote monitoring, and hospital data.[122] This paper addressed biosurveillance on farms. Biosurveillance technologies that can be used on farms, the authors explained, include "smart traps" that can quickly supply data such as "insect capture" through GPS, "telemetry data transmission," and more; automated physical sampling, perhaps using robots or other autonomous technology; "satellite imagery and RPAs (Remote Piloted Air Systems)" which enable the detection of pests or animals remotely. Such technologies allow for quick identification of "pest and disease incursions" and for more efficient farming practices, thus increasing farm productivity and sustainability.[123] However, the authors recognized that such technologies could pose privacy risks to farmers and others involved in the agricultural industry, thereby making farmers hesitant to cooperate with surveillance efforts. The authors' solution was to develop a "biosurveillance social contract" that respects the boundaries of farmers, communicates with them on appropriate practices, and gives them control over their own "personal and agricultural data."[124]

Policy Implications

In the age of rapidly advancing artificial intelligence, the literature on agroterrorism quickly becomes somewhat outdated. However, a few key policy implications remain. The need for public health infrastructure to better coordinate with law enforcement endures, given the unique investigative challenges posed by agroterrorism. Additionally, epidemiological tools need to be updated to reflect the new technology landscape the sector now occupies. Finally, federal officials need to work with international partners to build stronger global networks to deter or prevent the spread of agroterrorism across borders.

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[121] S. K. Devitt et al., "The Ethics of Biosurveillance," *Journal of Agricultural and Environmental Ethics* 32, nos. 5–6 (2019): 709–40, https://doi.org/10.1007/s10806-019-09775-2.
[122] Michael M. Wagner et al., eds., *Handbook of Biosurveillance* (Academic Press, 2006), 3–6.
[123] Devitt et al., "The Ethics of Biosurveillance," 3–4.
[124] Devitt et al., "The Ethics of Biosurveillance."

IV. Directions for Future Research

Synthetic Biology and Information Security as Emerging Concerns

Present agroterrorism literature pays little attention to the most pressing biosecurity issues. This issue, however, speaks more to the pace of technological advancement over the past quarter-century than to the veracity of early twenty-first-century scholarship. Early scholarship acknowledged the potential for synthetic biology–a field of science that involves redesigning organisms through protein engineering—to spill into the agroterrorism domain.[125] Decades later, however, advancements in synthetic biology—especially the 2012 demonstration that clustered regularly interspaced short palindromic repeats (CRISPR) could aid in gene editing—have outpaced the current literature.[126] To further exacerbate the divide between literature and reality, the emergence of AI assisted bioengineering poses a new front in this question, and the literature in this regard often exhibits woeful underdevelopment or fatalistic alarmism.[127] One of the more measured and salient descriptions of future risks is a recent open letter signed by experts in artificial intelligence, biotech, and government.[128]

A 2026 RAND report on agricultural terrorism illustrates the pressing concern that AI-fueled misinformation presents to US agricultural security. It is already a truism in the agroterrorism literature that even the mere fear of a pathogen outbreak, prior to the actual confirmation of infected crops and livestock, is sufficient to cause economic harm.[129] The incorporation of artificial intelligence in spreading this fear may force policymakers to reimagine available threat profiles for agroterrorism. In this respect, the RAND 2026 report notes that AI deepfake imagery could convince the American public that agriculture has been tampered with in some way, injecting fear that could feasibly trigger a negative demand shock and sow distrust in the US government.[130] Most importantly, this method requires that no pathogen be handled or introduced; the operative pathogen in this instance is simply fear itself, and its potential spread is fueled by AI-enhanced or AI-generated video and imagery.

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[125] Parker, *Agricultural Bioterrorism,* 3.

[126] Jinek, Martin, Krzysztof Chylinski, Ines Fonfara, Michael Hauer, Jennifer A. Doudna, and Emmanuelle Charpentier. "A Programmable Dual-RNA–Guided DNA Endonuclease in Adaptive Bacterial Immunity." *Science* 337, no. 6096 (2012): 816–821.

[127] For an example of such alarmism, see Hynek, Nik. "Synthetic Biology/AI Convergence (SynBioAI): Security Threats in Frontier Science and Regulatory Challenges." *AI & Society* 41, no. 2 (2026): 951–968. https://doi.org/10.1007/s00146-025-02576-4.

[128] "In Support of Mandatory Nucleic Acid Synthesis Screening and Recordkeeping." Open letter. ScreenDNA. June 2026. https://screendna.org/.; Grant, Ashley. Testimony before the House Committee on Homeland Security, Subcommittee on Emergency Management and Technology, on "Surveying the Threat of Agroterrorism, Part II: Assessing Federal Government Efforts." February 11, 2026. https://homeland.house.gov/wp-content/uploads/2026/02/2026-02-11-EMT-HRG-Testimony.pdf.

[129] Cupp, Walker, and Hillison, "Agroterrorism in the U.S.," 100. See discussion on FMD scare in Kansas.

[130] Hoard, Williams, and Luckey, *Agricultural Security Considerations*.

Appendix

Figure 1: The USDA select agent list for crop and livestock pathogens alongside the agricultural commodities they target.[131]

USDA Select Agents: Pathogen → Host Targets

9 CFR Part 121 (livestock) & USDA-PPQ (plant) · HHS-USDA Select Agents and Toxins List, 2025

LIVESTOCK PATHOGENS (13)

PATHOGEN	TARGETS / INFECTS
African swine fever virus	Swine
Avian influenza virus	Poultry & wild birds (zoonotic potential)
Classical swine fever virus	Swine
Foot-and-mouth disease virus **TIER 1**	Cattle, swine, sheep, goats (cloven-hoofed)
Goat pox virus	Goats, sheep
Lumpy skin disease virus	Cattle
Mycoplasma capricolum	Goats (contagious caprine pleuropneumonia)
Mycoplasma mycoides	Cattle (contagious bovine pleuropneumonia)
Newcastle disease virus	Poultry
Peste des petits ruminants virus	Sheep, goats
Rinderpest virus **TIER 1**	Cattle & other ruminants
Sheep pox virus	Sheep
Swine vesicular disease virus	Swine

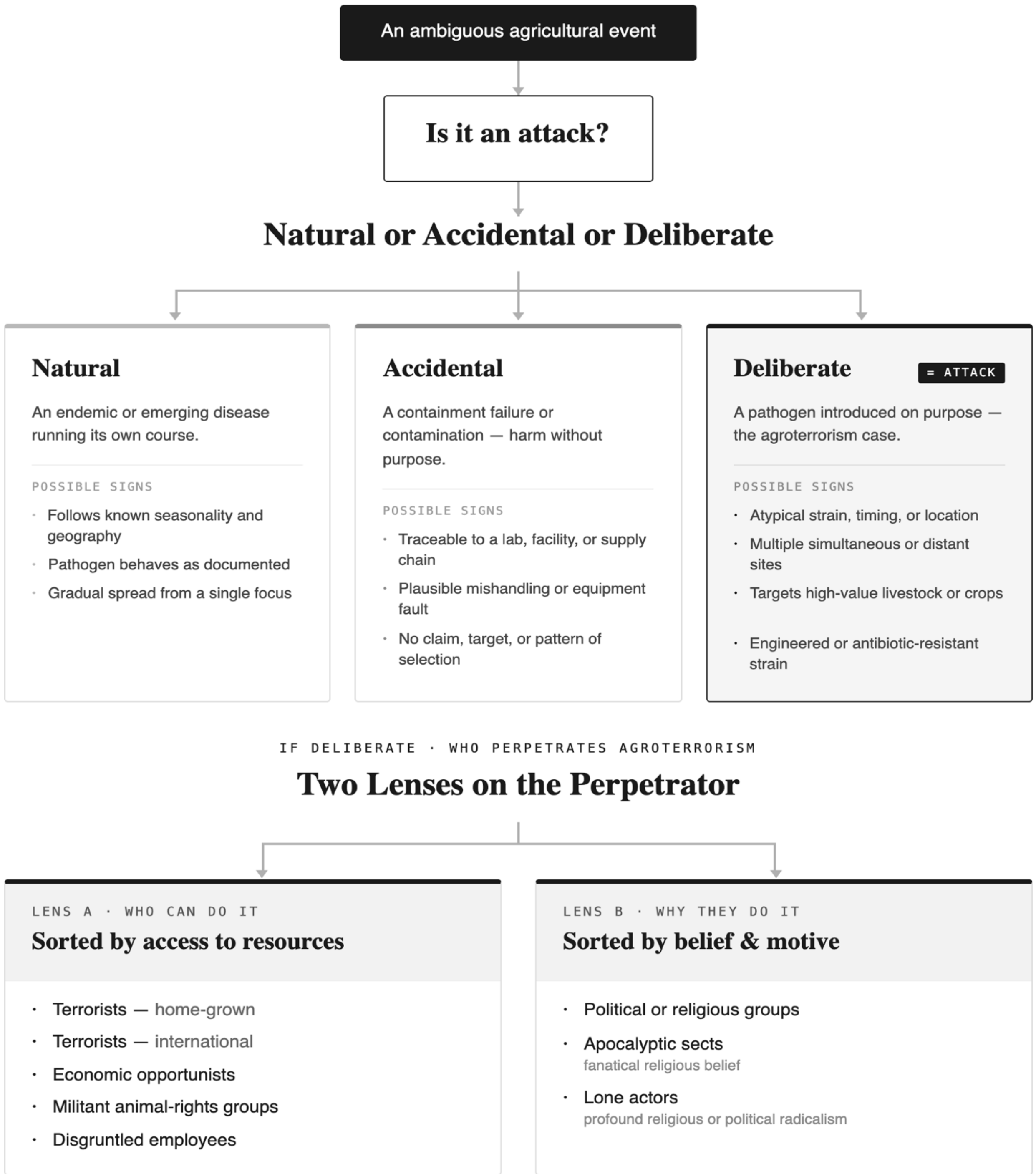
PLANT PATHOGENS (6)

PATHOGEN	TARGETS / INFECTS
Coniothyrium glycines	Soybean (red leaf blotch)
Ralstonia solanacearum	Potato, tomato (bacterial wilt / brown rot)
Rathayibacter toxicus	Forage grasses (annual ryegrass toxicity)
Sclerophthora rayssiae	Corn / maize (brown stripe downy mildew)
Synchytrium endobioticum	Potato (potato wart)
Xanthomonas oryzae	Rice (bacterial blight)

TIER 1 = highest-consequence agents (FMD, rinderpest). Corn, soybean & potato hosts reflect the list's economic-impact logic.
Source: HHS & USDA, "Select Agents and Toxins," 7 CFR 331 / 9 CFR 121 / 42 CFR 73 (Jan. 2025).

[131] Graphic generated using Claude AI.

Figure 2: Agroterrorism threat-classification flowchart: distinguishing origin and, if deliberate, the actor's means and motive.[132]



[132] Graphic generated using Claude AI.

Figure 3: List of government policies related to bioterrorism and agroterrorism.[133]

U.S. Food & Agriculture Security: Key Legislative and Executive Actions

Post-9/11 policy responses to biological threats to the food supply · 2002–2025

YEAR	LEGISLATIVE ACTION
2002	Bioterrorism Preparedness Act of 2002
2002	Homeland Security Act of 2002
2006	Post-Katrina Emergency Management Reform Act
2011	Food Safety Modernization Act (FSMA)

YEAR	EXECUTIVE ACTION
2003	Homeland Security Presidential Directive 7 (HSPD-7)
2004	Homeland Security Presidential Directive 9 (HSPD-9)
2005	Strategic Partnership Program Agroterrorism (SPPA) Initiative
2012	National Strategy for Biosurveillance
2013	National Biosurveillance Science and Technology Roadmap
2017	Agroterrorism Prevention, Detection, and Response — USDA OIG Audit Report
2022	National Security Memorandum 16 (NSM-16)
2025	National Farm Security Action Plan

[133] Graphic generated using Claude AI.