National Security Memorandum on Strengthening the Security and Resilience of United States Food and Agriculture: 120-Day Food and Agriculture Interim Risk Review

March 2023

ABSTRACT

This 120-Day Food and Agriculture Interim Risk Review is required as part of the implementation of National Security Memorandum (NSM) 16, *Strengthening the Security and Resilience of United States Food and Agriculture*. This report leverages existing sources of information to address the primary aims of the 120-Day Food and Agriculture Risk Review, including:

1. To identify initial hazards and risks to the U.S. Food and Agriculture (FA) sector.
2. To identify initial mitigations actions to address these risks.

Because improved coordination among the Food and Agriculture (FA) stakeholders is of critical importance to risk mitigation, a section of the report addresses this topic as well.

The intended utilization of this document is to inform the risk assessment and risk mitigation analysis that will, in turn, inform the Federal Risk Mitigation Strategy, as outlined in NSM 16.

Note: The *120-Day Food and Agriculture Interim Risk Review* "shall:

(i) leverage existing information and ongoing work to identify risks to the food and agriculture sector from all hazards;
(ii) identify activities to mitigate those risks categorized as high-consequence and catastrophic;
(iii) identify and initiate steps for improved coordination and integration across the broader preparedness and response community to enhance the Nation's ability to prevent and respond to threats against the food and agriculture sector; and inform the ongoing development of the Federal Risk Mitigation Strategy, as appropriate."

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EXECUTIVE SUMMARY

U.S. agriculture and food systems (including production, processing, and distribution) are extensive, open, interconnected, diverse, and complex. These descriptors are even more apt when one considers that the Food and Agriculture (FA) sector is interconnected with not only animal and plant health but environmental and human health as well.

Food and agriculture systems are foundational to the U.S. economy and way of life. Food, agriculture and related industries contributed more than a trillion dollars to the gross domestic product in 2019 and accounted for nearly 11% of total employment, including around 2.6 million farm jobs and nearly 20 million jobs in food- and agriculture-related industries. [1] Further, every household in the United States depends on food and agricultural products.

As noted in Section 1 of National Security Memorandum-16 (NSM-16), *Strengthening the Security and Resilience of United States Food and Agriculture, "*it is the policy of the United States to ensure that the Nation's food and agriculture sector is secure and resilient in response to high-consequence and catastrophic incidents." [2] In order to ensure security and resiliency, Federal government will "identify and assess threats, vulnerabilities, and impacts from these high-consequence and catastrophic incidents, including but not limited to those presented by [chemical, biological, radiological, and nuclear] CBRN, climate change, and cybersecurity, and prioritize resources to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk." [1] To advance this policy, the following report, developed in collaboration with the Secretaries of Agriculture, Health and Human Services, and Homeland Security, and heads of other relevant agencies, provides "an interim review of critical and emergent risks to the food and agriculture sector." [1] This report is broken down into the following two sections:

1. **Identification and Mitigation of Risk:** Utilizing existing information and ongoing work, high-consequence and catastrophic risks to the FA sector are described in terms of priority hazards and threats and potential factors contributing to risk, which can increase the likelihood and/or worsen consequences of the hazards and threats.
2. **Improve Coordination and Integration:** This section presents recommendations on how to more effectively integrate and coordinate among all FA sector stakeholders and across other key stakeholder communities to allow complementary capabilities to be leveraged across multiple threat spaces, provide for more comprehensive and effective planning and execution of responses to high consequence and catastrophic incidents, and reduce overall risk to the FA sector.

ACRONYMS AND TERMS

Acronym/Term	Definition
ASF	African Swine Fever
CBRN	Chemical, Biological, Radiological, and Nuclear
CDC	Centers for Disease Control & Prevention
DHS	Department of Homeland Security
DOL	Department of Labor
FA	Food and Agriculture
FDA	Food and Drug Administration
FMD	Foot and Mouth Disease
FSLTT	Federal, State, Local, Tribal, and Territorial
FY	Fiscal Year
GCC	Government Coordination Council
GDP	Gross Domestic Product
GPS	Global Positioning Systems
HHS	Health and Human Services
HPAI	Highly Pathogenic Avian Influenza
ICLN	Integrated Consortium of Laboratory Networks
IIJA	Infrastructure Investment and Jobs Act
NASAHO	National Association of State Animal Health Officials
NAHLN	National Animal Health Laboratory Network
NASPHV	National Association of State Public Health Veterinarians
NESP	Navigation-Ecosystem Sustainability Program
NSM	National Security Memorandum
O&M	Operations and Maintenance
PHEMCE	Public Health Emergency Medical Countermeasures Enterprise
PLC	Programmable Logic Controllers
PNT	Positioning, Navigation, and Timing Systems
SARS	Severe Acute Respiratory Syndrome
SCC	Sector Coordination Council
SIB	State Infrastructure Banks
SLTT	State, Local, Tribal, and Territorial
SSP	Sector Specific Plan
TAD	Transboundary Animal Disease

Acronym/Term	Definition
U.S.	United States
USACE	US Army Corps of Engineers
USDA	United States Department of Agriculture

1. INTRODUCTION

U.S. agriculture and food systems (including production, processing, and distribution) are extensive, open, interconnected, diverse, and complex. These descriptors are even more apt when one considers that the Food and Agriculture (FA) sector is interconnected with not only animal and plant health but environmental and human health as well.

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Every household in the United States depends on food and agricultural products. National Security Memorandum-16 (NSM-16) recognizes the vulnerability of complex FA systems to terrorist attacks, major disasters, and other emergencies with the potential for catastrophic health and economic effects. [2] Vulnerabilities in food and agriculture systems create vulnerabilities for food security and public health. [3] Pathogens and bioagents deliberately introduced into animal or plant populations, or into human food or animal feed systems by malicious actors could have tremendous impacts on human health and activity given the interconnectedness and the degree of dependency on FA systems. Additionally, naturally occurring outbreaks of disease or inadvertent introductions can create catastrophic impacts on animal and plant health and subsequently on public health and on food and agriculture systems, with cascading impacts.

Consider the consequences of the COVID-19 pandemic. The rapid spread of disease caused significant human morbidity and mortality and resulted in food and agriculture worker absenteeism, along with significant secondary effects both within the sector, and among allied industries. One example of the pandemic's impact on food and agriculture was the disruption of production and processing within FA supply chains, which consequently resulted in the culling of animals that could not be readily slaughtered for consumption. [4] COVID-19 demonstrated how a pathogen with high public health consequences can significantly impact numerous other critical infrastructure sectors, including FA.

Multiple examples of intercontinental spread of livestock and animal diseases illustrate how interconnected systems and dependencies within the FA space can have compounding impacts and consequences. Transboundary diseases that directly impact livestock and crops, like African swine fever (ASF) and wheat blast, respectively, have demonstrated the potential to devastate agricultural economies in foreign countries. These experiences signal the potential threat these pests and diseases pose to both the U.S. economy and national gross domestic product (GDP) if they were to arrive on our shores. The 2018–2019 ASF outbreak in China resulted in nationwide herd losses of at least 40%, a 30% decrease in pork output, and a 97% increase in domestic pork prices. [5] Under certain conditions, wheat blast outbreaks can lead to 100% losses in affected fields, which ripple through economies. Wheat blast, first identified in Brazil in 1985, appeared in Bangladesh in 2016, thereby demonstrating its potential for wide-ranging transboundary impacts. [6]

These systems are also increasingly global in scope and interconnected, as evidenced by the value of U.S. imported and exported Food and Agriculture products. U.S. agricultural exports totaled $177 billion in 2021, with $171 billion in imports.[8] Agriculture, food, and related industries contributed roughly $1.264 trillion to U.S. GDP in 2021, a 5.4-percent share.[1]. Imports account for around 50% of fresh fruit consumption, more than 95% of fish and shellfish consumption, and more than 25% of sugar and wine consumption. [7] Livestock, plants, grains, and seeds, and their related products transit

U.S. land, sea, and air points-of-entry and exit 24 hours a day, traveling to and from U.S. trading partners on every continent except Antarctica.

As noted in the recent NSM-16, titled *Strengthening the Security and Resilience of United States Food and Agriculture, "*it is the policy of the United States to ensure that the Nation's food and agriculture sector is secure and resilient in response to high-consequence and catastrophic incidents." [2] In order to ensure this security and resiliency, it is necessary for the Federal government to "identify and assess threats, vulnerabilities, and impacts from these high-consequence and catastrophic incidents, including but not limited to those presented by [chemical, biological, radiological, and nuclear] CBRN, climate change, and cybersecurity, and prioritize resources to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk." To advance this policy, this report, developed in collaboration with the Secretaries of Agriculture, Health and Human Services, and Homeland Security, and heads of other relevant agencies, provides "an initial review of critical and emergent risks to the food and agriculture sector." This report is broken down into the following two sections:

1. **Identification and Mitigation of Risk:** Utilizing existing information and ongoing work, high-consequence and catastrophic risks to the FA sector are described in terms of priority hazards and threats and potential factors contributing to risk, which can increase the likelihood and/or worsen consequences of the hazards and threats.

2. **Improve Coordination and Integration:** This section presents recommendations on how to more effectively integrate and coordinate among all FA sector stakeholders and across other key stakeholder communities to allow complementary capabilities to be leveraged across multiple threat spaces, provide for more comprehensive and effective planning and execution of responses to high consequence and catastrophic incidents, and reduce overall risk to the FA sector.

The information contained in this report will be used in conjunction with the risk assessment and risk mitigation analysis to inform the Federal Risk Mitigation Strategy.

2. IDENTIFICATION & MITIGATION OF RISK

This section represents a review of the critical and emergent risks to the FA sector within the United States. Leveraging existing information and ongoing work, this section both identifies the risks to the FA sector utilizing an all-hazards approach and provides ways in which these unique hazards and threats can be mitigated in the near- and long-term. Hazards and threats are inclusive of those that may result from natural and human-made systems but that fall outside of ongoing food safety efforts.

It is worth restating that the FA sector is complex, and composed of production, processing, and delivery systems almost entirely under private ownership that operate in highly competitive global markets. There is no one-size-fits-all approach to managing risk.

2.1. Domains

This 120-Day Food and Agriculture Interim Risk Review's scope is necessarily broad, encompassing a wide range of domains, infrastructure, stakeholders, capabilities, policies, and programs. For the purposes of this report, the following four domains were selected to encompass food and agriculture:

- **Livestock and Poultry** (production, processing, and distribution)**:** Livestock and poultry include cattle, swine, poultry, and other animals (including game meat) raised or harvested for human consumption and used in other commodities (e.g., leather, wool, and fur) through pre-harvest, harvest, post-harvest, and primary processing. [8] It also includes genetic stock and dairy production.
- **Crops and Forestry** (production, processing, and distribution)**:** Crops and forestry include those seeds and plants intended for both human and animal consumption, including row and specialty crops and plants grown under controlled environment agriculture conditions through the pre-harvest and harvest phases and those crops used for fiber, industrial, or other non-food purposes. [8] Similarly, this domain is inclusive of rangelands, encompassing grasslands, shrublands, woodlands, wetlands, and deserts where livestock and wildlife graze.
- **Aquaculture and Fisheries** (production, processing, and distribution): Aquaculture and fisheries include the processes associated with the catching, breeding, raising, and harvesting of fish, shellfish, and aquatic plants in both natural and controlled environments.[1]
- **Food Manufacturing and Distribution** (manufacturing and distribution): This review adopts the definition of the U.S. Bureau of Labor Statistics, which considers food manufacturing to be any industry that transforms livestock and agricultural products into products for immediate or final consumption. [9]

2.2. Hazards & Threats

For the purposes of this review, "hazard" is defined as a "natural or [human-made] source or cause of harm or difficulty."[11] Similarly, "threat" is defined as a "natural or man-made occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, and/or property." [10]

[1] The subsequent processing and labeling of such commodities are not considered to be a function of aquaculture, rather that of food manufacturing.

The hazards and threats to be discussed in the following sections include threats posed by effects of chemical, biological, radiological, and nuclear hazards; the threats and hazards associated with cyber-attacks; and climate change.

2.2.1. *Chemical, Biological, Radiological, & Nuclear (CBRN) Threats*

As indicated in NSM-16, "Chemical, biological, radiological, and nuclear (CBRN) threats that may result in high-consequence, and catastrophic incidents to the food and agriculture sector include but are not limited to: hazardous contaminants such as poisonous agents including toxic industrial compounds and materials, toxins, and chemical agents and precursors; natural or genetically engineered pests and pathogens of livestock, poultry, fish, shellfish, wildlife, plants, and insects; and physical effects of nuclear detonations or dispersion of radioactive materials." [2] CBRN risks can be naturally occurring, intentional, or accidental in origin. The impact of a major agricultural/food-related disaster in the U.S. would be enormous and could easily extend beyond the immediate agricultural community to affect other segments of the society. [11]

In order to protect public health and food and agriculture systems against CBRN incidents, the Department of Homeland Security (DHS), Health and Human Services (HHS), and U.S. Department of Agriculture (USDA), in addition to many other Departments and Agencies, have designed and implemented programmatic activities to detect and identify CBRN consequences of potential attacks and identify and implement mitigative efforts to safeguard food and agriculture systems and public health. In addition to significant human health implications of such incidents, three major impacts are cited with respect to CBRN incidents: (1) economic destabilization from the cost of containment and decontamination in addition to direct and indirect costs to farmers and related industry, and the loss of trade due to protective embargoes implemented by major trading partners; (2) loss of confidence in the government due to loss of confidence in the food supply and effectiveness of government planning against weapons of mass destruction and the controversial nature of mass depopulation and disposal of contaminated crops and livestock, poultry and other animals; and, (3) social instability created by mass panic if the incident has a major human health impact, such as exposure to radionuclides or biological agents. [11-13] These impacts will vary with the type and magnitude of a CBRN attack and where a CBRN agent enters the supply chain.

The intentional or unintentional contamination of food with any substance, including a biological, chemical, or radiological agent, can cause wide-scale public health harm, economic and/or government destabilization, and social instability. [14] Detection capability increases the Nation's overall preparedness posture, with the nation's diagnostic laboratories playing a vital role in this area, including the Food Emergency Response Network .[15] In addition to detection capability, protective measures fortify network-based systems that support or directly contribute to the processing, manufacturing, or storing of food and other agricultural commodities. Gaps within these protective measures, or lapses in protection, increase the likelihood of realizing a food and agriculture sector hazard.

When identifying and assessing threats to food and agriculture, a critical subcategory of biological threats is pests, invasive species, pathogens, and diseases. The introduction of pests and diseases disrupt agricultural trade and have substantial economic and environmental impacts. Transboundary animal diseases (TADs) can infect livestock and poultry and quickly spread through a vulnerable population, potentially leading to heavy losses and severe trade consequences. Some TADs may be zoonotic (capable of spreading between animals and humans), which may further complicate risk. The threat to the FA sector is not limited to diseases affecting animals. Any widespread disease, including zoonotic diseases, such as COVID-19 or the 2009 H1N1 swine influenza, can cause significant human

morbidity and mortality and can impact the availability of workers for the production and inspection of crops and livestock and impact the supply chain. [11]

- **Crop and Seedborne Pests/Pathogens:** These species are often introduced through the importation of fresh fruits and vegetables, seeds, and shipping materials. This threat is increased due to fraud and misrepresentation relating to the import and export of fruits and vegetables.[16] Climate change also has an impact on the potential avenues for the entry and establishment of invasive species.
- **Transboundary Animal Diseases and Pests:** Livestock and poultry are susceptible to threats from transboundary animal diseases and pests. Animal diseases such as African swine fever (ASF), foot and mouth disease (FMD), and highly pathogenic avian influenza (HPAI) can quickly spread through vulnerable wildlife, livestock and poultry populations and cause significant economic and supply chain losses, particularly by slowing or stopping exports.
- **Human Disease/Pandemic:** A major outbreak/pandemic has the potential to cause significant human morbidity and mortality, potentially disrupting operations critical to the management of animal and plant disease due to staffing shortages, supply chain constraints, and transportation delays.

2.2.1.1. CBRN Threats Mitigation

Prevention of CBRN incidents may be achieved through expanding and enhancing existing physical security and administrative controls, including many food defense mitigation strategies, such as control of entry systems at critical points in production, processing, storage, and transportation, surveillance of critical points, pre-employment screening, and clear marking of employees who are authorized to be at critical points. [17] While there is a need to address technical capabilities as it relates to protective measures (e.g., screening tools, biodetection tools), for the purposes of this review, protective measures are only considered in two categories:

- **Physical Security:** Physical security measures generally refer to fences, access control at critical points in production, processing, storage, and transportation, and surveillance of critical points. These controls make it more difficult for an individual to access facilities and operations for food and agricultural production, processing, or storage.
- **Administrative Controls:** Administrative controls aid in monitoring and tracking both products and the staff interacting with them. These controls may include policies for pre-employment security checks, marking employees (special badges) with certain access levels, continuous personnel suitability checks during employment, and tracking and certification of products and inputs. An absence of these controls in place increases the likelihood of both intentional and unintentional adulteration and inhibits traceability following an incident. [18, 19]

While there has been significant activity to protect food and agriculture against CBRN threats, more work is needed. Given the complexity of the food and agriculture system, writ large, "no single entity possesses the authority, expertise, and resources to act unilaterally on the many complex issues that may arise in response to a food or agriculture incident, especially given the increasingly global nature of the food and agriculture system." [20] Mitigation of CBRN events in the FA sector requires an integrated approach to reducing gaps in protection and preparedness.

Currently, physical security and administrative controls support mitigation strategies that can be grouped by personnel- and operations-based mitigation and technology-assisted mitigation. As noted in FDA's draft guidance for industry regarding mitigation strategies to protect food, personnel-based mitigation strategies involve establishing who is authorized to be present at an actionable process step and prohibiting individuals from being there if not required by work function.[14] Typically, mitigation strategies that restrict access to and prohibit unauthorized individuals from, entering an area would be designed around an existing, facility-wide security measure of positively identifying people in the facility and employing some practice to easily identify workers who are authorized to work in the area. Operations-based mitigation strategies are administrative controls that define specific operational actions to significantly minimize or prevent significant vulnerabilities at actionable process steps.

Technology-assisted mitigation strategies generally rely on physical security, including the implementation of a physical access barrier or the implementation of tamper-evident seals or other detection mechanisms that would prevent access to someone intending to adulterate the food without leaving detectable evidence. [14] The most illustrative and intuitive example of a technology-assisted mitigation strategy that reduces access is that of a lock on a hatch, inspection port, lid, or other access point.

Additionally, technology-assisted mitigation strategies that reduce the ability of an inside attacker to introduce a contaminant to the product typically include measures that would detect an attacker's actions, alert management of a problem, and thereby prevent an attacker's actions from resulting in public health harm or would neutralize the threat if an act of intentional adulteration occurred. This may also include strategies that alert management when a person accesses an actionable process step, or unusual activity occurs. Alerts, notifications, alarms, and other similar measures can make a suspicious action noticeable, thereby enabling workers or supervisors in the area to investigate the action and disrupt attempted intentional contamination of the food. For example, an alarm could notify personnel in a control room that a mixing tank, which is typically not opened during operation, has been accessed. Similarly, motion detection equipment could notify supervisors or security personnel when a person enters a secure area around an actionable process step.

In addition to the CBRN mitigation actions noted previously, pest and disease mitigation efforts should continue to leverage and expand existing pest and disease surveillance and rapid detection initiatives, including those that are collaborative with industry. Increasing interaction and data-sharing between public, environmental, plant, and animal health professionals can play an important role in optimizing health outcomes in all domains. Additional research and cooperation with academic partners can also aid our understanding of issues such as "species of concern, migration pathways, areas of human and/or livestock interaction, border crossings, known previous outbreaks, changes in land use creating new interactions, etc."[8] As the FA sector is not isolated to the United States, opportunities exist for the U.S. government to lead and/or participate in international dialogue. As many emerging diseases may enter the U.S. across the border, global surveillance will prepare for and prevent novel TAD introduction. [21]

Finally, DHS published a CBRN Strategic Risk Assessment Summary in 2022, providing a baseline regarding the Nation's CBRN risks. The document may be used as a resource for decision-makers mitigating the impacts of CBRN threats and incidents in the FA sector.

2.2.2. *Cyber Threats*

The food and agriculture sector involves many different industries: biotechnology, agriculture, manufacturing, transportation, logistics, restaurants, and retail. Most of these industries, if not all, rely

heavily upon digital and cyberspace technologies and communications such as Global Positioning Systems (GPS); Positioning, Navigation, and Timing Systems (PNT operational technology such as); industrial computer programmable logic controllers (PLCs); electronic databases. [22] According to the Public-Private Analytic Exchange Program's report on threats to food and agricultural resources, these risks are not specific to any specific part of the supply chain nor to any one type of criminal—the entire supply chain is at risk due to its complex and interconnected nature. These are not new risks, but as the food industry increases its dependence upon technology, the likelihood and severity of a crippling cyberattack increases. [21] FA sector entities will continually have unique sector specific risks, threat vectors, vulnerabilities, and risk tolerances; all of which can't be measured like other critical infrastructure entities.

As more production and processing move to automation, precision farming, and digital agriculture, cyber security incidents have an increasing ability to cause significant damage and disruption to the food and agricultural sector. In addition, disturbances to other critical infrastructures due to malicious cyber activities, like ransomware, could adversely affect the FA sector. For example, a disruption to transport and logistics services could result in rerouting and delivery delays for perishable items. Other possible effects of distribution disturbances include theft and/or false invoices or bills of lading. Damage and interruptions to production and processing at farms and facilities may reduce harvest yields, prevent the ability to process post-harvest materials and food products efficiently, affecting cascading delays along the entire supply chain from farm to market, and could cause economic and public health impacts as well.

Cyber security may be directly related to geopolitical disruptions, including market manipulation related to yields and control of FA sector inputs, agricultural and environmental activism (e.g., environmental impacts and carbon footprints of agricultural operations), and other geopolitical disturbances affecting crop yields or influencing agricultural activism, as well as financial motives. Cybersecurity involves people as well as processes and technology: people, the foundation of all food and agriculture critical infrastructure, are fundamental as they install, operate, and maintain systems. They have the ability to strengthen and protect systems, but also weaken or disrupt.

2.2.2.1. Cyber Threats Mitigation

Mitigation of cyber security threats relies heavily on reducing the vulnerabilities to these incidents and on improving the resilience of the FA sector private industry to reduce resulting supply chain disruptions caused by malicious cyber activities. Some FA sector entities have assessed and mitigated cybersecurity vulnerabilities through entity-specific action, using and applying the National Institute of Standards and Technology Cybersecurity Framework [23] or other actions. Future activities should include the reviewing and securing of interconnectivities between systems. To do this, all FA sector entities, both public and private, must improve their understanding of cyber threats and vulnerabilities and reduce their gaps in protection. As the full extent of these vulnerabilities is not understood, cyber security is the second focus of the first annual food and agriculture sector risk assessment.

Considering risk is vulnerability multiplied by threat multiplied by consequence, understanding, and communicating cyber threats is hugely important. Future efforts in cybersecurity in the FA sector should prioritize the sharing of information about cyberattacks, research into cybertheft of food and agriculture intellectual property, including trade secrets and data, such as genetic information, encrypted information transfer, FA sector dependency on the energy sector, and interdependencies within the FA supply chain. [21] Funding for a program to assist small and medium size facilities (that have limited financial and human resources) will increase implementation of effective cyber security mitigations (e.g., hiring third-party advisors/monitoring services, purchasing security

software/hardware, etc.). FA entities should consider investing in the approaches recommended in the Cybersecurity and Infrastructure Security Agency's Cybersecurity Performance Goals for Critical Infrastructure, as well as enrolling in the free services offered by CISA, such as Vulnerability Scanning through their Cyber Hygiene offerings.

2.2.3. *Effects of Climate Change*

The effects of climate change will be another focus of the annual FA sector risk assessment. Effects of climate change, including increased environmental hazards and degradation and increased exposure potential to pests and pathogens, encompass those unique environmental factors that directly influence the complete food and agricultural continuum – farm-to-fork, -fuel, and -fiber. Natural disasters and extreme weather events, limited water resources, loss of pollinators and pollinator services, and increased exposure potential to pests and pathogens are further discussed here and are among the threats to future agricultural productivity which may be exacerbated by climate change. Key subcategories of effects of climate change include:

- **Natural Disasters and Extreme Weather Events:** According to the Action Plan for Climate Adaptation and Resilience published by the U.S. Department of Agriculture, "climate change is causing more frequent and intense disruptive events including hurricanes, floods, and fires, which can have significant impacts on agriculture and forestry." The increased frequency and severity of extreme weather events such as these have negatively affected working lands and have increased the risk of secondary disturbances including, but not limited to, erosion, invasive species, poor water quality, and telecommunications disruptions, as well as community and animal health. [24]
- **Drought and Water Security:** According to the Action Plan for Climate Adaptation and Resilience published by USDA, crop and animal production is affected by changes to the water cycle (i.e., snowmelt, water supply, quality, drought, and flooding). Additionally, drought conditions have become more prevalent due to climate change, causing inconsistent precipitation, impacting groundwater recharge and runoff, and degrading soil quality. Due to these changes, pressure on limited water resources is increasing, and the geographic distribution of agriculture is shifting. [24]
- **Pollinator & Pollinator Service Loss:** Pollination services from honeybees and other pollinators are essential to ensuring our diets are diverse and plentiful with fruits, nuts, and vegetables. The industry is widely recognized to be facing economic decline not only due to industry stressors such as low honey prices and increasing input costs but also due to risks from a lack of habitat, forage, and nutrition; increased pests and pathogen pressures; increased environmental stressors, such as potential pesticide exposure and climatic stress; and reduced genetic diversity. [24]
- **Increased Exposure Potential:** Degradation of ecosystems and their biodiversity, increased human-wildlife-livestock interfaces, and climate change have all contributed to rising threats from diseases such as COVID-19, Ebola, severe acute respiratory syndrome, and those related to arboviruses (additional information on the threat of Pests and Diseases can be found in section 2.2.2). This can be exacerbated by FA activity. Decreased biodiversity within the FA sector also presents risks to resilient supply across all FA domains. Recently, interactions between wild birds and poultry have led to the spread of HPAI. As interactions between humans and animals, as well as the interface between agriculture and nature increase, the rate at which disease spillovers occur will continue to increase, causing disruptions to human life, the FA and other critical infrastructure sectors. These risks are also exacerbated as impacts

from climate change continue to raise the potential of emerging and/or re-emerging diseases and pests, including in new geographic regions. Regional conflicts and mass migration challenges may also contribute to the risk of disease or pest introduction to previously disease or pest-free areas. Potential risks in each of the subcategories are as follows:

- **Human-Animal Interface:** Although human-animal interface issues, including zoonotic disease, are well described in the literature, operationalizing disease response at the state and local levels can be difficult due to resources and competing priorities. [8]
- **Agriculture-Nature Interface:** In addition to economic interactions, humans and animals have significant interaction with FA systems through shared ecosystems, recreation, and companion animals. Continued disruption of healthy ecosystems, the encroachment into wildlife habitat, and subsequent interactions between livestock, companion animals, and wildlife populations have been linked to the spillover of emerging pathogens (e.g., feral swine populations and transmission of ASF and migratory bird patterns and spread of HPAI). [8]

2.2.3.1. Effects of Climate Change Mitigation

Planning and analysis are paramount to mitigate the consequences associated with the effects of climate change, including environmental hazards and degradation. Research on environmental hazards and degradation within the food and agriculture sector should include (but not be limited to): water use, irrigation system improvements, dryland management practices, and crop system utilization. Similarly, research targeting pollinator habitat, how climate change affects pollinators, pollinator forage, and pollination rates as it pertains to crop yield, and current and emerging pests and pathogens that negatively impact the optimal health outcomes of people, animals, plants, and their shared environments to include the health of pollinators is vital to long-term crop sustainability and food security. Such planning and analysis activities also may result in opportunities for greater integration across the food and agriculture sector to include Federal, State, local, tribal, territorial (FSLTT), academic, and private industry partners as key stakeholders.

Activities and measures taken to mitigate the impacts of infectious disease-causing pest and pathogen spread, including zoonotic diseases, require coordination and cooperation at every level of government. Across the country, strong relationships exist among key organizations and agencies with a stake in zoonotic disease surveillance and response. Examples include the relationships between the National Association of State Public Health Veterinarians (NASPHV) and the National Association of State Animal Health Officials (NASAHO); between many state public health officials and state veterinarians; and between the Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), USDA agencies and others. A wealth of experience and expertise has also been gained by nationwide responses to threats from HPAI, the 2009 H1N1 flu pandemic, , to name a few.[25]

Opportunities for continued mitigation within both the human-animal and agriculture-nature interfaces span the five mission areas outlined in the National Preparedness Goal. These activities include the support of state-level planning and follow-on exercises for catastrophic events using the One Health approach, companion animal zoonotic disease surveillance to address gaps in current capabilities at the state and local level, funding to the National Animal Health Laboratories Network (NAHLN) and Veterinary Laboratory Investigation and Response Network (Vet-LIRN) veterinary diagnostic laboratories, the Integrated Consortium of Laboratory Networks (ICLN), and to enhance capabilities and capacity for zoonotic disease surveillance along with emerging threats. Similar activities also include the incorporation of human-animal health interface considerations into the

Public Health Emergency Medical Countermeasures Enterprise (PHEMCE) and advocating for training on bio-risk management best practices, consistent with the NSPHV Compendia. [8]

Similarly, the inclusion of wildlife considerations in FA sector planning is essential, given the linkages between the health of wildlife, livestock, and human populations. Proactive monitoring and surveillance of wildlife can provide early warning of emerging threats and give FA stakeholders an opportunity to intervene before human and livestock populations are impacted.

Additionally, the use of improved monitoring systems, predictive modeling to inform surveillance, early warning systems, and better control options can help reduce the risk of pest and disease agricultural damage due to climate change. Furthermore, increased international collaboration in areas like predictive modeling can help the United States prepare for agricultural pest and disease incursions that are made worse by climate change .[26]

2.3. Identification & Mitigation of Potential Factors Contributing to Risk

For the purposes of this review, a "potential factor contributing to risk" is defined as features or operational attributes that render an entity open to exploitation or susceptible to a given hazard. This includes characteristics of design, location, economic and security postures, operation, or any combination thereof that renders an asset, system, network, or entity susceptible to disruption, destruction, or exploitation. The potential factors contributing to risk to be discussed in the following sections include those associated with Food and Agriculture Industry Consolidation, Input Shortages, Aging and Insufficient Transportation, Trade Disruption, and Gaps in Preparedness. For the potential factors contributing to risk and associated mitigations identified in this section, numerous current and future actions are addressed in NSM 16 activities, as well as other areas or efforts. For example, actions associated with food and agriculture consolidation are identified in the U.S. Department of Agriculture's *Agri-Food Supply Chain Assessment*. [27] Actions mitigating input shortages and aging transportation infrastructure require critical infrastructure interdependency and cross-sector efforts and planning. There are long-established mechanisms for efforts related to food and agriculture trade and trade disruptions, and mitigative efforts will continue to be routed through those mechanisms.

2.3.1. *Food and Agriculture Industry Consolidation*

Resilience in supply chains depends on having access to reliable and diverse sources of inputs and subsequent outputs to meet both supply and demand. This is also true for the food supply chain, and according to the USDA's *Agri-Food Supply Chain Assessment*, potential risks within the agri-food supply chains can increase because of concentrated market power exercised by firms controlling large shares of production, processing (particularly when firms are producing and processing sole-source nutrition, such as some infant formula products and/or medical foods), or distribution capacity.[27] Similar significant structural changes that have occurred in other sectors have also occurred in the meat packing industry, the infant formula and medical food sectors, the crop seed sector, the food retail sectors, and the transportation sector have raised concerns about how this consolidation may factor in catastrophic supply chain disruptions. As such, the potential factors contributing to risks associated with the consolidation of producers, processors, and transporters within the food and agriculture sector are further discussed here.

- **Regional:** Livestock and poultry farms are concentrated regionally, driven by the availability of animal feed, environmental conditions, and processing capacity. Likewise, specialty crops tend to be clustered where climate and soil conditions are the most amenable. Currently, 61 percent of the U.S. beef cow herd is in the northern and southern plains states. Pork

production is concentrated in the Midwest and North Carolina. 68 percent of U.S. chicken production in 2020 occurred in seven states in the Southeast, with another 9 percent in the Delmarva peninsula, shared by Delaware, Maryland, and Virginia. This regional concentration leaves the FA sector open to environmental hazards and degradation, pests, and diseases, and CBRN incidents affecting specific regions of the country. [27]

- **Farm/Facility:** In some parts of the FA sector, such as meatpacking and infant formula production, a small number of facilities accounts for a large share of regional or national food processing capacity, and issues affecting production can cause significant impacts. For example, critical aspects of recent shortages of infant formula products—some of which are sole-source nutrition—can be attributed to issues at a facility that produces a significant amount of the infant formula for the U.S. market. [28] Similarly, animal production has moved to significantly larger, fewer, and more specialized farm operations. For example, of the 700 federally inspected beef slaughter establishments, the 10 largest facilities account for 47 percent, and the 20 largest facilities account for 72 percent of average daily beef slaughter. Figures for pork processing facilities are similar. Even temporary shutdowns of one or more of these facilities (from fire, electricity disruption, labor shortages, cyber-attacks, worker illness, severe weather, etc.) can cause ripple effects down the supply chain. [27] The impacts can be amplified by dislocations in other critical infrastructure sectors that the FA sector is interdependent with, such as transportation.

- **Ownership:** Within agri-food supply chains, firms controlling large shares of production, processing, or distribution capacity may own several processing facilities; ownership concentration, including ownership of FA-related intellectual property such as patents for genetic modifications, by the largest firms may be even higher than the concentration at the facility level. As evidenced by previous ransomware attacks, consolidation of ownership within the FA sector can result in larger and farther-reaching consequences of cyber-attacks on FA sector stakeholders. [27]

- **Transportation:** The consolidation of the transportation industry directly affects the cost and ability to ship food and agricultural inputs and products domestically and abroad. As a result, the cost of food and agricultural products is increased, and the foreign market share of exported products is reduced. [27]

    - **Railroad Consolidation:** Many agricultural inputs and products are shipped within the U.S. on railroads. As recently as 2000, the domestic railroad industry had been consolidated to 7 companies from 30, with the top two railroads accounting for 68% of the originated Class I grain carloads. With minimal competition, farmers, livestock operations, feed mills, food processors, and other agricultural operations that depend on rail transportation have experienced increased prices associated with crop inputs and feedstock. [27]

    - **Ocean Carrier Consolidation:** Most foreign trade of agricultural commodities occurs via water transport, including barges and ships on navigable U.S. waterways and oceans. Since 2016, the number of ocean carriers has been reduced from 15 to 10, which are organized into three alliances controlling 80% of the global shipping market and 95% of the critical East-West trade lanes. With U.S. exporters dependent on foreign-owned carriers, there are concerns that unequal practices will lead to permanent degradation of the U.S. reputation and market share abroad. [27]

2.3.1.1. Food and Agriculture Industry Consolidation Mitigation

To address the potential factors contributing to the risk associated with FA sector consolidation, the USDA has identified several approaches, which are summarized here. [27] These include strengthening local and regional production, distribution, and processing to contribute to a less concentrated and more diversified, and equitable agri-food system. FDA has also taken steps to increase the diversity of and support a stable supply of infant formula in the U.S. For example, FDA is providing a pathway for manufacturers of infant formula products that were imported, sold, and/or distributed under a letter of enforcement discretion received based on factors described in a guidance to industry issued on May 16, 2022, to continue marketing their products while they work toward meeting all applicable FDA requirements. [29]

Executive Order 14036: Promoting Competition in the American Economy, directed the USDA to assess competition issues in agri-food sectors. [30] USDA produced several recommendations for which the Federal government can both act independently and collaborate with SLTT partners in support of such mitigation efforts. Some of these recommendations include the execution of the January 2022 Biden-Harris Action Plan for the Meat and Poultry Supply Chain and increasing funding of public research in agricultural science and technology. USDA has worked with their stakeholders to identify and begin to address factors contributing to concentration, including the effects of climate change, active mergers and acquisitions, limited access to land and capital, inadequate education, and discrimination.

USDA has stated that congressional action is needed to sustain and consider increasing funding for programs that provide support for local and regional food systems. Mitigation of these risks is also enhanced by increased support of antitrust and unfair business practices enforcement by Federal partners from the private sector and SLTT partners. Risks of disruption related to concentration should be assessed together with other public policy goals, including the economic benefits of some efficient concentration and economic risks associated with inefficient concentration.

2.3.2. *Input Shortages*

Production and manufacturing in the FA sector, like other critical infrastructure sectors, rely on critical inputs, including labor, energy, IT/data, and consumables. Without one or more of these inputs, the production, processing, and distribution of food and agricultural products could be negatively impacted. Considerations for these critical inputs include:

- **Labor (Production, processing, distribution, and critical roles):** Labor shortages in the FA sector can put the entire FA supply chain at risk. According to the *USDA Agri-Food Supply Chain* Assessment, contributing factors include the physical difficulty of the jobs, variability of working hours, and often low salary. On average, the turnover rate for truck drivers has been 90% over the past decade, and the truck driver population is aging, with fewer entry-level drivers. Specialty crops require different planting and harvesting techniques and are often harvested by hand, requiring additional training and labor. Milk production has the highest labor cost to total expense proportion and is influenced by the population of immigrant labor. Acute labor shortages, for example, due to a disease outbreak affecting humans, may further disrupt food and agriculture production and distribution. [27]
- **Energy:** Nearly every level of the food and agricultural sector depends on the availability of energy in the form of distilled fuel (i.e., gasoline, diesel), electricity, propane, natural gas, and renewable fuels. [24] Electricity, for example, is essential to blast-freezing equipment for

meat, poultry, and seafood processing, whereas distillate fuel is the primary fuel of choice for both livestock and crop operations. [24] Failure of delivery mechanisms (e.g., pipelines and grids) would have a dramatic impact on operations across the FA sector. Loss of electricity could compromise agricultural products requiring cold chain, cause issues related to temperature/environmental control for animals and disrupt business and manufacturing operations. Therefore, business ethics, physical security, and cyber security are essential to protecting the energy grid and the FA sector. [21] Shortages of fuel can cause disruptions in production, transportation of raw materials and finished product, and emergency response. The rising cost of fuel increases transportation costs, which may be prohibitively high for some producers. Large amounts of fossil fuels are required to operate farming and production equipment and food storage. Distillate fuels, such as gasoline and diesel, are the dominant source of energy production in agricultural operations, with crop production requiring more energy than livestock production "as both a percentage of total operating expenditures and on a total energy basis." [21] Additionally, during particularly extended emergency and incident responses, fuel supplies are an important consideration. [21]

- **Other Consumables (e.g., fertilizers, feed, pesticides):** The chemical sector (and its key food and agriculture-related outputs, including fertilizers, animal feed additives, and pesticides) requires a large input of both fuel and electricity; disruptions to these sectors will also affect the chemical sector. Furthermore, the manufacturing of these goods requires the import or production of raw materials, such as nitrogen, for fertilizer production. Geopolitical disruptions, particularly regarding environmental concerns and conflict zones, have already demonstrably impacted the import and usage of fertilizers and pesticides. [31]

2.3.2.1. Input Shortages Mitigation

Factors that potentially contribute to the risk that stems from critical infrastructure interdependency, such as those due to input shortages, also require mitigation activities that stem from critical infrastructure coordination and cooperation. USDA action is needed to leverage existing research, extension, and land-grant university networks to "train individuals attending these institutions or in local communities on effective farm and land management practices, agribusiness strategies, and food safety" to improve labor inputs. [27] Similarly, action is required in the recruiting and retaining of veterinarians throughout USDA, in addition to engaging with other Federal partners (e.g., HHS and DOL) to leverage existing education and workforce development programs to address safety problems within the FA sector. Also, congressional action is needed to provide FDA with the authority to require firms to provide shortage notification for FDA-designated categories of food during a declared public health emergency. The recent COVID-19 pandemic has demonstrated the need for timely and accurate information about confirmed or likely supply chain challenges to help ensure the continuity of the food supply; so that consumers have access to a safe and adequate food supply during public health crises.

As noted in the USDA Agri-Food Supply Chain Assessment, "even temporary shutdowns of one or more [agri-food production, manufacturing, or distribution facilities] (from fire, electricity disruption, labor shortages, cyber-attacks, severe weather, etc.) can threaten significant supply chain disruption." To mitigate the consequences of such disruptions caused by electrical disruptions, USDA has highlighted several opportunities for improvement and adaptation in their 2021 Action Plan for Climate Adaptation and Resilience. Activities include the increasing of onsite renewable energy capacity and the installation of microgrids. [24]

The food and agriculture sector has successfully worked with the chemical sector for many years to ensure the continued availability of cleaning and sanitizing products used within food operations. During supply chain shortages that were exacerbated by the COVID-19 pandemic, the FA sector routinely cooperated with the chemical sector to identify key inputs necessary for food and agriculture production. Such cooperation and coordination will continue to be of utmost importance as supply chain fragility persists in some sectors.

2.3.3. *Aging and Insufficient Transportation Infrastructure*

The transportation infrastructure in the United States enables the movement from farm to table and export through inland waterways, ocean ports, containers, highways and bridges, trucking, and railroads and is of the utmost importance to a successful food and agricultural system. Agriculture is the largest user of the U.S. freight transportation system, and the need for transportation services will only continue to increase as agricultural production, exports, incomes, trade, and world population continue to grow. [27] In addition to the transportation components and factors that contribute to the risk outlined in Section 2.3.1, any disruption within this critical infrastructure will result in delays of shipment affecting the delivery of raw materials, processing, and further distribution and causing spoilage of short shelf-life products before they can get to market. Aging and insufficient transportation infrastructure subcategories include:

- **Inland Waterways:** Inland waterways are considered the lowest-cost transportation for the movement of bulk commodities. However, some sections of major waterways are obsolete and cannot handle larger barges. Unscheduled closures disrupt transport and lower capacity leading to transportation bottlenecks. These waterways are also vulnerable to climate change and severe weather impacts. [27]
- **Ocean Ports:** The U.S. economy depends on reliable and resilient freight transportation to move U.S. goods efficiently and to remain competitive globally, which are vital to the export of U.S.-made goods and products. The average size of seagoing vessels has increased substantially in recent history, however, ports, terminals, and associated inland infrastructure have not increased accordingly. Along with an inefficient shipping container market, this has slowed port operations. Port disruptions negatively impact the supply chain, stressing interconnected trucking and rail service, inland and ocean terminals, and container and truck chassis availability. Lack of storage space at ports prevents the import and processing of new goods. Besides port-side facilities, more inland facilities are needed to expedite the loading and offloading of products. In addition to infrastructure disturbances, ports are affected by climate change and severe weather, which have been increasingly disturbing the overall supply chain and freight movement. [27]
- **Highway & Bridges:** The most popular mode of transporting agricultural products is via truck. This mode of transportation is often the most expensive branch of the freight trip on a per-ton-mile basis. To support profit margins and keep costs low, the highway system must constantly be maintained. However, most highways used for agricultural transportation – urban to rural connectors and the non-interstate system – tend to be in poor condition. Interstate sections and funding are optimized within states and not for an interconnected agricultural network. Due to the annualization of traffic data, agriculturally important road sections used seasonally often miss out on maintenance funds. [27]
- **Freight Railways:** The United States hosts nearly 140,000 miles of freight rails, accounting for an $80 billion transportation industry used in many of the country's critical supply

chains.[32] Still, growth in dependent industries, aging of existing rail infrastructure, and the movement towards carbon neutrality demand investment and upgrades of domestic rail infrastructure.

2.3.3.1. Aging and Insufficient Transportation Infrastructure Mitigation

According to the USDA, mitigation measures across the subcategories include:

- **Inland Waterways:** Continued investment in improvements on the inland waterways is necessary to reduce the risk of failure and increase reliability. The Infrastructure Investment and Jobs Act (IIJA) provides the U.S. Army Corps of Engineers (USACE) with $2.5 billion for work on construction projects as well as additional funding that can be used to accelerate major maintenance of inland navigation projects. Despite rising appropriations for operations and maintenance in recent years, current funding levels are still insufficient for USACE to keep up with the growing challenges of aging and deteriorating infrastructure, climate change, and increased demand for navigation services.[27]
- **Ocean Ports:** A resilient ocean and inland transportation system are crucial to our Nation's – and our agriculture industry's – ability to recover from weather and infrastructure-related supply chain disruptions. Federal action is required to utilize funding for port infrastructure modernization from the IIJA.
- **Highway & Bridges:** The Biden-Harris Administration Trucking Plan should be implemented to maintain low transportation costs and support producers operating under already tight profit margins. Additionally, federal action should be taken to deploy relevant IIJA authorities, and financial support should be allocated to strengthen the nation's highway infrastructure, establish a commons to securely compile agricultural freight data for planning purposes, and encourage and coordinate regional infrastructure planning among States.[27]
- **Freight Railways:** The Biden Administration has made $1.4 billion available via the IIJA for Consolidated Rail Infrastructure and Safety Improvement (CRISI), which will catalyze the development of rural rail systems, and strengthen, modernize, and build resilience in existing rails.[33]

2.3.4. *Trade Disruptions*

The U.S. agricultural supply chain is reliant on the export and import of goods, with the largest export destinations being Mexico, Canada, and East Asia. Trade increases the productivity of the agricultural sector, allows for a diverse food market year-round, and provides protection against local or regional events that may disrupt production. However, many aspects of agricultural production rely on inputs from foreign import sources that could cause issues if that source is disrupted (including a CBRN event).[27] Reliance on single export markets can lead to problems for producers and the supply chain if those markets become inaccessible.

2.3.4.1. Trade Disruptions Mitigation

Innovations like electronic certifications (e-Cert) drive efficiencies in importing and exporting and facilitate animal traceability technology, thus improving the ability to find the source of a disease before it can spread.[21] Additionally, increased capacity to rapidly detect, identify, and decontaminate new pests and pathogens will reduce losses and lessen the impact of contaminated food and agricultural products that are imported.

Maintaining and diversifying trade partners creates flexibility in the supply chain. Relying on a few large foreign suppliers for goods can create challenges in the event of a supply chain disruption.

2.3.5. *Foreign Acquisition*

According to the USDA, "foreign persons held an interest in approximately 40 million acres of U.S. agricultural land as of December 31, 2021," accounting for 3.1 percent of total privately owned agricultural land. [34] Forest land accounted for 47 percent of all reported foreign-held acreage, cropland for 29 percent, pasture, and other agricultural land for 22 percent, and non-agricultural land for 2 percent. The rate of growth in foreign holdings has increased since 2015, on average.

Foreign acquisition of U.S. agricultural assets may pose risks to the U.S. food and agriculture sector in some cases. For example, a recent research report prepared to support the deliberations of the U.S.-China Economic and Security Review Commission describes several potential risks to U.S. agriculture associated with recent acquisitions and attempted acquisitions of U.S.-based agricultural assets (including agricultural land, intellectual property [such as IP related to genetically modified seeds], and U.S.-based food producers and logistics companies), which may include loss of economic competitiveness, reduced exports, negative environmental impacts, and associated public health risks. [35]

2.3.5.1. Foreign Acquisition Mitigation

Current Federal law imposes no restrictions on the amount of private U.S. agricultural land that can be foreign owned and does not grant the USDA the ability to regulate these purchases. All foreign persons holding agricultural land are required to file a report of such holdings with the Secretary of Agriculture per the Agricultural Foreign Investment Disclosure Act. All foreign persons who acquire or transfer an interest in agricultural land are required to report such transactions within 90 days of the date of acquisition or transfer. Currently, 13 states either limit or outright forbid foreign entities from purchasing or owning agricultural lands within their borders. However, state laws vary widely, and some states restrict only certain purchases while allowing for at least some level of foreign ownership of agricultural land. Additional states have recently begun to consider new legislation restricting ownership and investment in agricultural land by foreign owners and companies.

In addition, the Committee on Foreign Investment in the United States (CFIUS) is an interagency committee authorized to review certain transactions involving foreign investment in the United States and certain real estate transactions by foreign persons in order to determine the effect of such transactions on the national security of the United States.[36] CFIUS is an interagency body comprised of nine Cabinet members, two ex officio members, and other members as appointed by the President.

2.3.6. *Gaps in Preparedness*

Preparedness includes those activities associated with the identification and prioritization of risks to the food and agriculture sector, strategy development and operational planning, stakeholder awareness outreach, training, and exercises, among other supporting functions further detailed in the National Response Framework. [37]

Some current FA sector planning, preparedness, and response activities lack integration with other critical infrastructure sector stakeholders and partners, while other planning, preparedness, and response activities are robust. Coordination of these activities, as well as preparedness exercises and training, are often underfunded and inconsistent across the broader FA sector. Combined with a lack of cross-sector integration, frequent personnel turnover, and gaps in communication between

industry, government, and academia, there are many gaps to fill in FA sector preparedness. Filling these gaps in preparedness will enable the ability to better anticipate and mitigate catastrophic and high-consequence events. The gaps in preparedness across the subcategories include:

- **Planning, Exercising, and Training:** While some areas of strong coordination exist, coordination in planning and exercising across the FA sector is recognized as a critical area for improvement. Planning at the state and local levels is inconsistent due to a shortage of funding, personnel turnover in key positions, and lack of cross-sector integration. Exercises and training are needed to build relationships, test the implementation of existing plans as well as identify training needs, resources, and plan improvements. [8]
- **Sustained and Flexible Funding:** Currently, significant funding is deployed at all levels of the FA sector in support of responses to singular or recurring events, which may result in fluctuation in funding to support food and agriculture sector preparedness over time.
- **Cross-Sector Integration:** Cross-sector integration tends to occur when an issue affecting multiple sectors has been realized. Both intra- and inter-sector planning and response need to occur prior to a catastrophic or high-consequence event. A lack of increased integration inhibits complementary capabilities from being leveraged across threat spaces, which, in the event of an incident, could enable more comprehensive and effective planning and execution. Cross- sector integration here is inclusive of all members within the FA defense community, including the wildlife sector, which is often left out of the broader planning and response community. [8]
- **Personnel Turnover:** Staff turnover and consolidation among industries have contributed to losses in institutional knowledge supporting FA defense, which is a challenge for maintaining both core competencies and working relationships. [8]

2.3.6.1. Gaps in Preparedness Mitigation

Preparedness ensures that the FA sector possesses the capabilities and capacity needed to prevent, detect, mitigate, respond to, and recover from a catastrophic or high-consequence event. Mitigation measures across the subcategories include:

- **Planning, Exercising, Training:** Recommendations to improve planning, exercising, and training include but are not limited to the following list [8, 21, 38]:
  - Risk assessments across the FA sector would inform stakeholders of possible threats and vulnerabilities and identify mitigations that may be needed. The risk assessment process should include stakeholders from across the sector (government, industry, academia, international partners, etc.). Upon completion, risk assessments can be used to inform tabletop exercises, scenarios, and recommended training.
  - Current training can be built upon to further develop capabilities and plans and identify areas that improve the optimal health outcomes of people, animals, plants, and their shared environments.
  - Improve communication technology and protocols to ensure all levels of responses are receiving the same information during catastrophic and high-consequence events. Information processing and analytics will help to "detect, identify, model, and predict spread and consequences of transboundary, emerging, and novel pests and infectious diseases of plants and animals."[38] This will include tools for planning and decision-

making, improved intelligence gathering and analysis, and tools to detect and intercept CBRN, cyber, and health threats.

- In some cases, response and recovery may extend for months to years – exercises should consider longer-term response and recovery issues and activities.
- It is vital that there is continuity of business both domestically and internationally following an incident. If a raw material becomes unavailable to a sector, there must be plans in place to assist that sector.

- **Sustained and Flexible Funding:** Informed by risk assessments discussed above, funding at all levels of the FA sector, including sustained funding to state, local, tribal, and territorial partners, is needed to support all phases of preparedness and to ensure resilient food and agriculture systems.
- **Cross-Sector Integration:** Resources and capabilities, including cooperative extension and laboratory resources, volunteer registries, and assessments of expertise at the state and local level, should be mapped so they can be properly allocated in an emergency. Incident Command System cross-training will allow those with training to respond in other sectors while information sharing, and risk mitigation can be improved through public-private partnerships. Wildlife stakeholders can be better integrated through the formalization of the Federal Animal Emergency Working Group and the inclusion of natural resource and environmental agencies, tribal authorities, and rehabilitation facilities. Existing wildlife organizations can also be used in an all-hazard response.[8, 21]

  A prioritization matrix may provide an adaptable method for prioritizing engagements and assessing supply chain risks and stakeholder relationships. Similarly, decision matrices with associated geospatial data visualization can highlight data relationships. Tabletop exercises based on modeled disturbances in the supply chain and reference downstream effects could test the Model Workflow for defending against threats.
  This topic is also discussed in Section 3: Recommendations.
- **Personnel Turnover:** Sustainable funding and advanced planning for training will maintain and update capabilities even through personnel turnover.[8, 27]

3. IMPROVED COORDINATION & INTEGRATION

Preparedness and response practices are diverse and varied among responsible federal, state, local, tribal, and territorial authorities, as well as industry partners and other pertinent stakeholders within the FA sector. Better integration amongst FA sector stakeholders will allow complementary capabilities to be leveraged across threat spaces, provide for more comprehensive and effective planning and execution of responses to high consequence and catastrophic incidents, and further reduce overall risk to the FA sector. The following sub-sections are broken down into actions to be taken in the short, medium, and long term, respectively, and to describe some efforts that are already being taken.

3.1. Proposed Actions

3.1.1. *Short-Term (6-12 months)*

1. Strategic Planning
    - Develop a preliminary work plan for updating the Sector Specific Plan (SSP), acknowledging both the critical importance of updating the SSP and the need for guiding documents to be completed, including updated policy and the National Infrastructure Protection Plan.
2. Information Sharing and Engagement
    - Continue participating and providing feedback on policy documents that are being updated that address critical infrastructure and resilience.
    - In consultation with Sector Coordinating Council (SCC) and Government Coordinating Council (GCC), define at least one concrete and ongoing engagement strategy for GCC and SCC members, including those in academia and SLTT, to support fluid information sharing and problem-solving. These may leverage existing mechanisms to discuss NSM-16 implementation.
    - Address SCC/GCC involvement in NSM-16 in a Food and Agriculture Sector Joint Membership Meeting or other engagement.
    - Continue engagement in the National Biodefense Strategy and in NSM-15, Countering Biological Threats, Enhancing Pandemic Preparedness, and Achieving Global Health Security, processes that will help protect U.S. plants and animals from biological incidents.
3. Understanding of Sector Risks
    - Define scope and requirements of the NSM-16 Threat Assessment, in collaboration with agencies responsible for NSM-16 Threat Assessments and Risk Assessments, then identify and assign responsibilities for effectively addressing scope and requirements in future iterations.
    - Identify gaps between Title 50 and Non-Title 50 agencies and improve communication on the threat assessment component.
    - Begin the development of a common nomenclature for events in the food and agricultural sector, so all stakeholders – public, private, SLTT, academic – can speak

about events – including those that cause indirect impacts with a collective understanding of potential consequences and actions that can be taken.

3.1.2. *Mid-Term (12-18 months)*

1. Strategic Planning
    - Update the work plan (to develop the Sector Specific Plan) with new policy documents, as appropriate.
    - Work with the SCC and GCC leadership to identify how and where SLTT and Sector partners should continue to engage on NSM-16 for FY24 and FY25.
2. Information Sharing and Engagement
    - If funding is available, convene a Food and Agriculture Defense Summit to guide one or more Food and Agriculture Defense Research Workshop topics and agendas.
    - Establish an interagency working group for food and agricultural threat discussions that bridges the Title (T) 50 and Non-Title (NT) 50 communities.
    - Continue engagement in the National Biodefense Strategy and in NSM-15 processes that will help protect U.S. plants and animals from biological incidents.
    - Review the Federal Interagency Operations Plans within the National Planning Frameworks to align the federal government's actions with the Sector Specific Plan.
3. Understanding of Risks
    - Finalize a draft of a common nomenclature for incidents in the food and agricultural sector.
    - Continue to evolve approaches to the requirements in NSM-16 as indicated by identified gap.

3.1.3. *Long-Term (18-24 months)*

1. Strategic Planning
    - Initiate a roadshow of the new Sector Specific Plan that includes education and outreach with non-traditional stakeholders, other Sectors, other Departments and Agencies, etc.
2. Information Sharing and Engagement
    - Convene a Food and Agriculture Defense Research Workshop based on topics and areas identified in the Food and Agriculture Defense Summit.
    - Hold a formal session with SCC and GCC to obtain feedback on existing mechanisms for information sharing and engagement and gauge their effectiveness.
    - Continue engagement in the National Biodefense Strategy and in NSM-15 processes that will help protect U.S. plants and animals from biological incidents.
3. Understanding of Risks
    - Participate in a Food and Agriculture Sector Exercise – this could be a separate event or leverage the Senior Official Exercise Plan and enable SLTT/Academic/Sector participation in a broader exercise. The purpose is to bring Food and Agriculture Sector

stakeholders together to address an incident, but not to duplicate existing exercise planning.

- Use existing working groups to identify if there are new threats that need to be addressed in future iterations of the threat assessment.

3.2. A Unifying Food and Agriculture Community Architecture

To a great degree, the ability to improve coordination within the U.S. FA sector relies on clarification of roles and responsibilities along with mapping capabilities and capacities from the Federal through SLTT levels. Furthermore, an over-arching framework is needed to direct and maintain a consistent approach to preparedness and response to high-consequence and catastrophic incidents within the FA sector. Recognizing the importance of universal adoption and strategic implementation of such a model, in **Error! Reference source not found.** we introduce a Food and Agriculture Resilience Architecture to unify the greater FA sector community and highlight the potential advantages of its implementation within the larger system.[2]

The objective of this architecture is to serve the following purposes:

1. Facilitate communication of systems-level concepts with stakeholders;
2. Structure capability evaluation; and
3. Inform strategy development.

3.2.1. *Definition*

The following is a definition of the proposed FA Resilience Architecture:

> The integrated, whole-of-community and whole-of-government system of stakeholders and capabilities ensure human, animal, plant, and environmental health security by strengthening the readiness and resilience of critical food and agriculture infrastructure against high-consequence and/or catastrophic intentional, accidental, and/or natural disruptions.[3]

The FA Resilience Architecture requires participation and engagement across a broad community of stakeholders, given the ubiquity of food and agriculture infrastructure across society and the economy and the pervasiveness of potential natural and man-made threats to that infrastructure. The U.S. food

[2] Architectures have utility in applications that involve one or more systems characterized by the complexity and interdependence of numerous diverse elements. In the national security space, an architecture serves as a framework or model for conceptualizing and describing the system of organizations, personnel, technology systems, and other assets and capabilities employed in service of defined national security objectives. Examples of architectures applied to U.S. national security challenges include the Department of Defense (DoD) Architecture Framework (DoDAF) and the Department of Homeland Security (DHS) Global Nuclear Detection Architecture (GNDA). See:
https://dodcio.defense.gov/Library/DoD-Architecture-Framework/dodaf20_background/
https://www.nationalacademies.org/our-work/evaluating-the-performance-measures-and-metrics-development-for-the-global-nuclear-detection-architecture

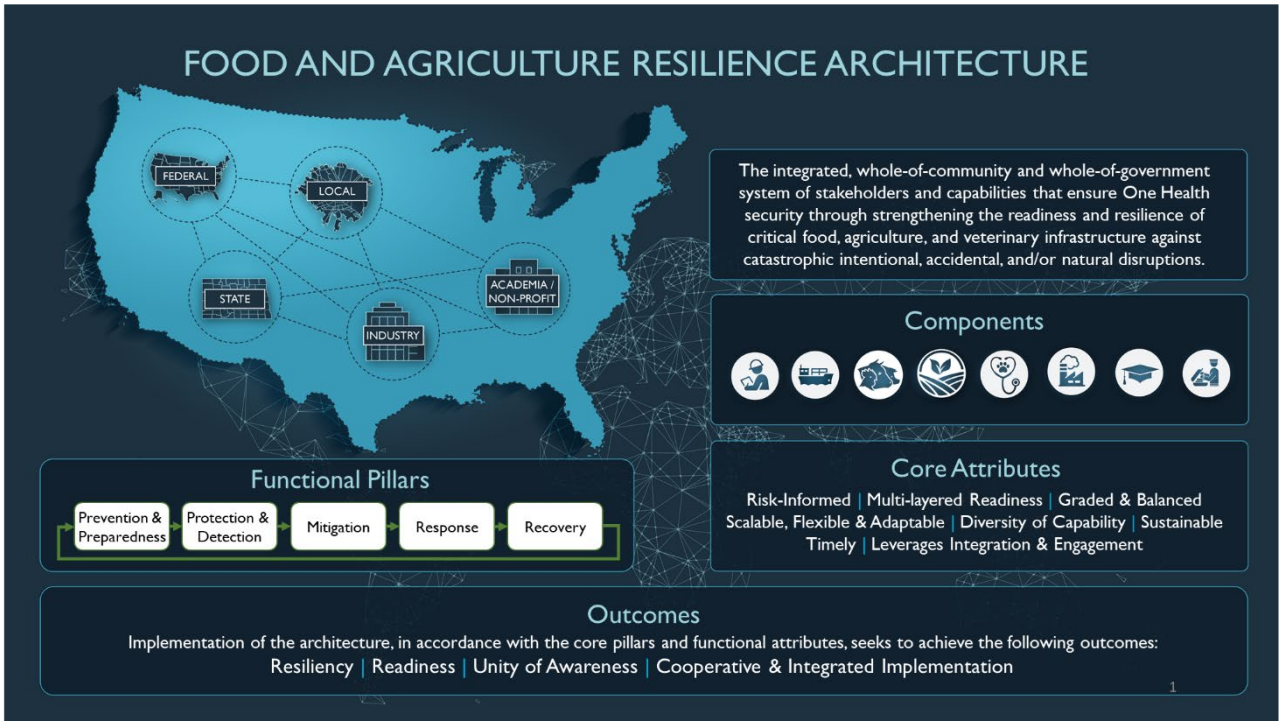
[3] For the purposes of this architecture, the term "catastrophic" incorporates the concepts of a "consequence event" as defined by the National Institutes of Health (NIH) as "disruptive events that would significantly inhibit a lead federal agency's ability to provide the critical services and functions deemed fundamental." The National Response Framework published by the Federal Emergency Management Agency (FEMA) defines a catastrophic incident as "an incident that is of such extreme and remarkable severity or magnitude that the Nation's collective capability to manage all response requirements would be overwhelmed, thereby posing potential threats to national security, national economic security, and/or the public health and safety of the Nation."

and agriculture sector is primarily owned and operated by private sector and non-Federal entities. In addition, most Federal authorities are related to food safety issues, with few, if any, existing authorities related to the security of the sector. The three categories of stakeholders mentioned below are important partners, but their authority and ability to put solutions into action are not equal amongst each other. Key stakeholders include (but are not limited to):

- **Government**: This includes leaders and organizations at the federal, state, local, territorial, and tribal levels. Relevant stakeholders include not just those responsible for oversight and regulation of the food and agriculture sectors but also public health authorities, law enforcement, and first responders who play crucial roles in the event of a high-consequence incident.
- **Industry:** This includes the full spectrum of private sector players, from individual farmers to local small businesses to major corporations involved in the production, processing, import/export, and distribution of food and agriculture commodities. Industry also includes the trade associations and operators that represent and advocate on behalf of these industries. Industry not only has direct material and financial interests in the outcomes of the FA Resilience Architecture but is likely to be at the forefront of detecting, mitigating, and responding to high-consequence events.
- **Academia and nonprofit organizations**: Academic institutions play a critical role by educating FA specialists; carrying out research on emerging threats and hazards and potential mitigation measures; providing laboratory support for diagnostic activities; contributing expertise in support of both the government and private sectors; and engaging with industry representatives and the community through cooperative extension programs. Other nonprofit institutions also contribute to the FA Resilience Architecture through advocacy, outreach, and independent research.

The architecture definition and key concepts are represented in Figure 1 below. The geographic representation in this high-level, operational view is intended to emphasize the concept of integration within the architecture definition. The success of the FA Resilience Architecture depends on integrated communication, coordination, planning, and operations across government, industry, and academic/nonprofit stakeholders. Given the globally interconnected nature of supply chains, this integrated approach should also extend to international cooperation with stakeholder counterparts in other countries and international organizations.

Figure 1: Food and Agriculture Resilience Architecture, High-Level Operational View



3.2.2. *Outcomes*

This preliminary architecture provides a starting framework upon which to begin conducting further integration and coordination activities, in addition to helping inform what is needed to build an optimized and resilient system that is prepared for upstream and downstream impacts from catastrophic and high-consequence events. The FA Resilience Architecture could be used by policymakers and programs across local, state, territorial, federal, and global levels to assess how best to strengthen their ability to respond to such overwhelming and devastating incidents.

Next Steps

To mitigate the myriad risks, the FA sector needs to take a whole-of-community and whole-of-government approach to integrating preparedness and operational response planning across stakeholders within and outside of the FA sector. The information provided in this report will be used, in conjunction with the subsequent risk assessment and mitigation analysis, to inform the ongoing development of the Federal Risk Mitigation Strategy as outlined in NSM-16 across the activities presented in Table 1.

Table 1: Activities contributing to the Food and Agriculture Sector Federal Risk Mitigation Strategy, as described in NSM-16

Task	Details included	Timeline (days from signing NSM-16)
Threat Assessment	• Identify potential actors and threats, delivery systems, and methods that could be directed against or affect the U.S. food and agriculture sector.	60 (& annually thereafter)
120-Day FA Risk Review	• Identify risks to the FA sector from all hazards. • Identify activities to mitigate risks categorized as high-consequence and catastrophic. • Identify steps to improve coordination and integration across the FA sector. • Inform ongoing development of the Federal Risk Mitigation Strategy.	120
Vulnerability Assessments	• Identify vulnerabilities within the FA sector in consultation with FSLTT and private sector partners, as appropriate.	180
Risk Assessment	• Informed by threat and vulnerability assessments. Prioritized by the highest risks for the food and agriculture sector. • Benchmarking off of results generated from the CBRN Strategic Risk Assessment Summary • Data-driven, sector specific, and founded on interagency coordination. • 1st draft to focus on CBRN and cyber threats. • Later iterations to include other threats (e.g., energy disruption, pandemics, catastrophic weather events, consequences of climate change)	365
Risk Mitigation Analysis	• Informed by risk assessment. • Include high-level actions for mitigating threats and a proposed timeline for their completion. • Identify strategies, capabilities, and areas of research and development that prioritize mitigation of the greatest risks as described in the risk assessment. • Identify approaches to determine the effectiveness of national risk reduction measures. • Include a communication plan for sharing information.	545

APPENDIX A. FA ARCHITECTURE DETAILED DESCRIPTION [8]

A.1. Stakeholders

The FA Resilience Architecture requires participation and engagement across a broad community of stakeholders. Given the ubiquity of food and agriculture infrastructure across society and the economy, and the pervasiveness of potential natural and man-made threats to that infrastructure, the FA Resilience Architecture necessarily requires participation and coordination across government and communities at the federal, state, local, territorial, and tribal levels. Key stakeholders include (but are not limited to):

- **Government**: This includes leaders and organizations at the federal, state, local, territorial, and tribal levels. Relevant stakeholders include not just those responsible for oversight and regulation of the food and agriculture sectors but also public health authorities, law enforcement, and first responders who play crucial roles in the event of a high-consequence incident.
- **Industry:** This includes the full spectrum of private sector players, from individual farmers to local small businesses to major corporations involved in the production, processing, and distribution of food and agriculture commodities. Industry also includes the trade associations that represent and advocate on behalf of these industries. Industry not only has direct material and financial interests in the outcomes of the FA Resilience Architecture but is likely to be at the forefront of detecting, mitigating, and responding to high-consequence events.
- **Academia and nonprofit organizations**: Academic institutions play a critical role by educating FA specialists; carrying out research on emerging threats and hazards and potential mitigation measures; providing laboratory support for diagnostic activities; contributing expertise in support of both the government and private sectors; and engaging with industry representatives and the community through cooperative extension programs. Other nonprofit institutions also contribute to the FA Resilience Architecture through advocacy, outreach, and independent research.

A.2. Functional Pillars and Capabilities

The FA Resilience Architecture is organized around five functional pillars adapted for the food, agriculture, and veterinary context from NSM-16 and the NRF. These pillars encapsulate the highest-level functions to be accomplished by the architecture. They also provide organizing concepts for key capabilities in the architecture (as illustrated in

Table below). The pillars include the following:

- **Prevention and Preparedness:** The Prevention and Preparedness pillar is comprised of activities that inform and guide implementation across the remaining pillars, including identification, characterization of threats, and prioritization of risks to the food, agriculture, and veterinary sectors; strategy development and operational planning; and stakeholder awareness outreach, training, and exercises in support of the remaining pillars.
- **Protection and Detection:** Activities in the Protection and Detection pillar are intended to identify and interdict threats and hazards, ideally before significant disruption or damage occurs. These include surveillance, inspection, diagnostics, attribution, and reporting on emerging pests and pathogenic threats; efforts to intervene/interdict emergent threats (intervening to prevent further spread of pathogens and interdiction of criminal/terrorist activity); as well as securing critical facilities, processes, and supply chains against natural and man-made threats.
- **Mitigation**: Mitigation activities aim to address critical vulnerabilities that may exist in FA infrastructure and minimize the effects of disruptive events. Importantly, mitigation measures are implemented before any disruptive event takes place (separating mitigation from response activities that take place post-event). Mitigation activities include identifying and rectifying vulnerabilities in critical infrastructure; developing, distributing, and administering prophylaxis; pre-staging response resources and countermeasures; and ensuring planning for continuity of operations and business should an event take place.

- **Response**: In the event of an emergency, response measures aim to deploy resources and countermeasures to effectively contain impacts to minimize effects on health and operations. Response activities may be wide-ranging, depending on the magnitude of a disruptive event. Activities can include managing impacted human, animal, and plant cases; implementing measures to quarantine impacted populations, contain the spread of pathogens, delimit relevant geographic and procedural boundaries, and define the permitted movement of people, animals, and commodities; decontamination of impacted areas; the depopulation of impacted animal inhabitants; and burn/till impacted plants, if necessary. Just-in-time training may need to be administered to first responders, while appropriate public messaging is critical to keep the public accurately informed. Testing and diagnostic activities inform the development and distribution of appropriate human, animal, and agricultural countermeasures. Response also includes law enforcement activities and incident investigation to ensure accountability, attribution, and eventual criminal investigation.
- **Recovery:** Recovery pillar activities aim to restore impacted critical infrastructure and populations to a resolved state and to document lessons learned for future reference. This may include the provision of financial assistance to affected individuals and businesses; repair of physical infrastructure; restoration of economic and trade activities; replenishment of depleted resources, including countermeasures and prophylaxis; and after-action reviews informing potential revision of strategy and plans.

A.2.1. Performance Attributes

In the performance of the core functions, the architecture should aspire to key performance attributes. These include:

- **Risk-Informed**: Deployment of capabilities and resources should be informed by careful consideration of the risks presented by intentional, accidental, and/or naturally occurring scenarios as a function of the probability of those scenarios occurring and their prospective consequences. A risk-informed architecture maximizes efficiency and effectiveness.
- **Graded and Balanced**: In a graded architecture, capabilities, and resources are distributed in a deliberate, risk-informed manner commensurate with the likelihood and potential impact of threats and hazards—rather than in an arbitrary or uniform manner. In a balanced architecture, the distribution of capabilities and resources should not over-emphasize the mitigation of certain risks at the expense of others.
- **Multilayered Readiness**: Any single readiness measure or line of defense can be overcome by an intelligent adversary, an evolving pest or pathogen, or an unexpected accident or natural disaster. A multi-layered architecture protects against single-point failures and promotes resiliency.
- **Scalable, Flexible, and Adaptable**: In a scalable architecture, the scope and complexity of capabilities, systems, and measures can be tailored to specific conditions and circumstances. A flexible architecture employs capabilities and assets that can be repurposed, redistributed, and/or reconfigured to address a range of potential scenarios and uncertainties. Finally, an adaptable architecture is one in which capabilities evolve to reflect changing and uncertain/unpredictable risks, operating environments, technology, and policy.
- **Diversity of Capability**: The architecture should not be overly reliant on any singular capability (particularly those based on technology) by employing a range of diverse but complementary human, informational, scientific, and technical approaches.
- **Sustainable**: A sustainable architecture is one in which resources are employed in an efficient manner that allows the architecture to persist and grow over time. Moreover, the architecture does not place an undue burden on the ability of stakeholders to conduct and benefit from regular business operations.
- **Timely**: Many of the threats and hazards facing FA infrastructure are extremely time sensitive. If detection, mitigation, and response activities do not take place quickly at the first sign of a problem, impacts may grow at exponential rates and exceed the resources of stakeholders at all levels. The architecture needs to emphasize timeliness across activities in all five functional pillars, thus minimizing logistical, procedural, and political barriers to implementation.

- **Leverages Integration and Engagement**: Finally, the architecture should be characterized by an active and engaged partnership among relevant public, private, academic, and individual citizen stakeholders with equities in the architecture. These partnerships and engagements should begin at the local level and extend to the highest levels of the federal government. Stakeholders should be active in sharing best practices; building relevant capabilities through awareness, education, and exercises; and sharing information on threats and risks as appropriate.

A.2.2. Outcomes

This preliminary architecture provides a starting framework upon which to begin conducting further integration and coordination activities, in addition to helping inform what is needed to build an optimized and resilient system that is prepared for upstream and downstream impacts from catastrophic and high-consequence events, a system that could leverage capabilities across the vast FA sector space. The FA Resilience Architecture could be used by policymakers and programs across local, state, territorial, federal, and global levels to assess how best to strengthen their ability to respond to such overwhelming and devastating incidents.

Table 4: FA Architecture Pillars and Capabilities

Prevention and Preparedness	Protection and Detection	Mitigation	Response	Recover
Coordination & Communication	Coordination & Communication	Coordination & Communication	Coordination & Communication	Coordination & Communication
Policy/Strategy Development	Surveillance	Infrastructure Vulnerability Mitigation	Med/Vet/Wildlife/Plant Case Management	Financial Assistance
Operational Planning	Inspection	Prophylaxis Development, Distribution & Administration	Quarantine, Containment, Delimitation & Permitted Movement	Infrastructure Repair/ Restoration
Risk Assessment & Forecasting	Diagnostics	Countermeasures/ Resource Staging	Decontamination	Economy & Trade Restoration
Intelligence & Information Sharing	Reporting	Continuity of Operations Planning	Depopulation & Burn/ Till	After Action Review & Plan Updates
Regulation & Compliance	Intervention/ Interdiction		Law Enforcement	Stockpile Replenishment
Awareness & Outreach	Biosecurity & Physical Security		Incident Investigation	
Training & Exercises	Cyber Security		Testing & Diagnostics	
	Commodity Movement & Trade Control		Counter Measures Development & Distribution	
			Public Messaging	
			Just-in-Time Training & Exercises	

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