Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science
Volume 7, Number 2, 2009 © Mary Ann Liebert, Inc.
DOI: 10.1089/bsp.2008.0037

Agriculture Emergencies: A Primer for First Responders

Johnnie L. Gilpen, Jr., Hélène Carabin, James L. Regens, and Ray W. Burden, Jr.

Over the past several years, the primary focus of emergency preparedness has been on terrorism, and how a CBRNE event would directly affect human health. Limited emphasis has been placed on the direct (eg, zoonotic infections) and indirect (eg, mental health, financial loss) effects that an agricultural emergency event can have on human health outcomes, and how they relate to emergency preparedness. We critically reviewed the resources and information readily accessible to our target audience, emergency responders; the resources included military and civilian books, personal communications, internet sites, GAO reports, and peer-reviewed journals. Among more than 2,000 bioterrorism-related articles, we found 51 that addressed either agroterrorism and/or veterinary public health: 2 cross-sectional studies, 28 review papers, and 21 commentary papers. In order to properly respond to future agriculture emergencies, emergency response professionals need to understand the nature and implications of the event as well as their roles and responsibilities, but the availability of educational and training opportunities is limited. The results of our review are consistent with the hypothesis that more resources, education, and training opportunities should be available to responders as well as to producers, importers and shippers, international travelers, and the general public. Increased education and training will raise awareness among these groups of the relationship between animal and human health.

Many transmissible animal diseases, such as foot-and-mouth disease (FMD), classical swine fever (CSF), and Venezuelan equine encephalitis (VEE), have been eliminated from North America because of a series of successful veterinary public health interventions during the 20th century.[1] Transmissible animal diseases, historically called "foreign animal diseases," are "diseases that are of significant economic, trade and/or food security importance for a considerable number of countries; which can easily be spread to other countries and reach epidemic proportions; and where control and management including exclusion, requires cooperation between countries."[2(p17,18)] The change in terminology reflects efforts by the United Nations' Food and Agricultural Organization (FAO) to address issues in describing "foreign" animal diseases with "domestic" origins. This applies to avian influenza, brucellosis, and exotic Newcastle disease (END) in the United States; to foot-and-mouth disease and Rift Valley fever (RVF) in Africa; and to foot-and-mouth disease and Venezuelan equine encephalitis in South America.[1-4] In this article, we will refer to them as transmissible/foreign animal diseases.

Johnnie L. Gilpen, Jr., MS, is an Adjunct Professor, Departments of Science and Criminal Justice, Redlands Community College, El Reno, Oklahoma. Hélène Carabin, DVM, PhD, is an Associate Professor, Department of Epidemiology and Biostatistics, College of Public Health, University of Oklahoma Health Sciences Center, Oklahoma City. James L. Regens, PhD, is Presidential Professor, Occupational and Environmental Health, Director of the Center for Biosecurity Research, and Associate Dean for Research, College of Public Health, University of Oklahoma Health Sciences Center, Oklahoma City. Ray W. Burden, Jr., EdD, is County Extension Director, University of Tennessee, Knoxville.

Because of the veterinary public health efforts in the last century, American livestock is now free of several transmissible animal diseases, but this also makes the animal population of the country highly susceptible to these infections. If reintroduced, these diseases could have a significant economic impact on the affected animal industry(s) (eg, cattle, equine, poultry, swine, etc.).[5] The large American livestock population, limited security measures (physical and biological) at the farm level, the susceptibility of the population to transmissible animal diseases, and the rapid transportation dynamics associated with live animals and animal-related products—all of these factors make America's agribusiness industry vulnerable to natural (eg, disease, drought), unintentional (eg, feed contamination), and intentional threats (eg, criminal and terrorist targeting). Adequate preventive and response measures can be developed to mitigate these threats only if we clearly identify, define, and understand what constitutes an agriculture emergency.

Homeland Security Presidential Directive 7 (HSPD-7) has identified the agricultural sector of the U.S. economy as critical infrastructure that is "vulnerable" to terrorist targeting.[6-8] In response to this designation, HSPD- 9 established a "national policy to defend the agriculture and food systems against terrorist attacks, major disasters, and other emergencies."[8] HSPD-9 specifically recognized that the preharvest livestock sector is susceptible to accidental and intentional introduction of transmissible animal diseases and other hazards (eg, natural disasters, toxic industrial chemicals).

Traditional first responders—firefighters, law enforcement officers, emergency medical service providers, urban search and rescue teams, public health workers, hospital healthcare providers—are not well trained to recognize the direct or indirect associations between animal health outcomes and human health. Thus, in recent events when animal and human health outcomes have overlapped, the appropriate response was often delayed, as, for example, in the 1999 West Nile virus outbreak in New York City.[9,10] The introduction of West Nile virus into the U.S. revealed communication and cooperation deficits among public health practitioners, traditional first responders, and nontraditional responders (eg, U.S. Department of Agriculture [USDA], U.S. Fish and Wildlife Service).[9,10] This article addresses the presidential directives and federal legislation affecting agriculture, agriculture emergencies in preharvest livestock, agroterrorism threats, agricultural hazards, transmissible animal disease outbreak response, and the nonfinancial implications of a transmissible animal disease event.

Defining Agriculture Emergencies

Because a clear definition of an agriculture emergency is not available in the literature, we suggest the following: an *agriculture emergency* is any type of event, regardless of intent, that jeopardizes the economic stability of any sector (farm level to national level) of the U.S. agricultural/agribusiness industry. Given this working definition, an agriculture emergency is the exposure of pre- and postharvest livestock, feed supply, and/or water resources to any chemical, biological, radiological, nuclear, and/or explosive (CBRNE) hazard, criminal activity (eg, arson, vandalism, "animal liberation"), or naturally occurring hazard (eg, drought, blizzard). In practice, specific agriculture emergencies should be individually defined by the industry affected (eg, cattle, equine, swine), the geographic location, and the ability of the responders to identify, respond to, recover from, and mitigate future events. It should be noted that whereas the U.S.'s agriculture industry is very encompassing and has the ability to balance itself as a whole, disasters and emergencies usually occur locally. Public health practitioners and first responders should recognize that a local or regional incident may have little or no impact on the overall national economy, but it can have a tremendous impact in their practice area.

Review of Available Information on Agriculture Emergencies

We conducted a systematic literature search of peer-reviewed journals on Medline, PubMed, and the Web of Science using the following keywords and multiple combinations of the linking terms "and/or": Agriculture Emergency(ies), Agroterrorism, Bioterrorism, Bioterrorist Agents, Foreign Animal Disease, Human and Animal Health Outcomes, Public Health Preparedness, Risk Analysis and Assessment, Veterinary Public Health, and Zoonotic Diseases. The keywords were selected based on descriptive terms found in HSPD-7 and -9.[8] A library search of secondary literature, including military and civilian books, Government Accountability Office (GAO) reports, periodicals (eg, newspapers, trade journals), and internet sites using Google, Yahoo, and Ask Jeeves was conducted using the same combinations from the primary literature search. The searches found that more than 2,000 bioterrorism-related documents had been published between 1965 and 2007.

Of the articles and texts published between January 1, 1965, and December 31, 2007, 51 addressed agroterrorism or veterinary public health or both. We found 2 cross-sectional studies, 28 review papers, and 21 commentary papers (Table 1). None of the papers focused specifically on public health, public health response, or first responders, illustrating the fact that limited peer-reviewed research has addressed agriculture emergencies, their potential impact on the American population's health, and the involvement of public health and emergency response and management professionals.

Table 1. Results of the Literature Search by Article Type and Journal Publication Type

	Journal Type			
Study Type	*Human Health*	*Veterinary Health*	*Other*	*Total*
Commentary	3	13	5	21
Review	10	14	4	28
Ecological studies	0	0	0	0
Cross-sectional studies	0	2	0	2
Case-control studies	0	0	0	0
Cohort studies	0	0	0	0
Hybrid design studies	0	0	0	0
Clinical trial studies	0	0	0	0
Total	13	29	9	51

Sources: References 1, 6, 11-60.

Presidential Directives and Federal Legislation

Presidential Decision Directive 63

The 1998 Presidential Decision Directive 63 (PDD-63) was the first federal legislation to address critical infrastructure. However, PDD-63 did not specifically discuss or outline any stage of the agricultural "farm to fork" industry(s).[61] Executive Order 13228 (2001), which established the Office of Homeland Security, was the first federal guidance to identify American agriculture and the food supply as part of the critical infrastructure vulnerable to a terrorist threat.[62]

Bioterrorism Act of 2002

The 2002 Public Health Security and Bioterrorism and Response Act (Pub L No. 107-188), referred to as the Bioterrorism Act of 2002, amended the Federal Food, Drug, and Cosmetic Act (21 USC 381) to require the FDA to issue new regulations in the following areas: (a) food adulteration (§302); (b) administration detention and expedited procedures for perishable foods (§303); (c) registration of domestic or foreign food processing facilities supplying the U.S. (§305); (d) establishment and maintenance of industry records (§306); and (e) prior notice of imported food shipments (§307).[63]

Subtitle C provided the USDA with the legislation and direction for: (a) expansion of the Animal and Plant Health Inspection Service (APHIS)(§331); (b) expansion of the Food Safety Inspection Service (FSIS); (c) biosecurity upgrades at the USDA facilities (§333); and (c) increasing agricultural biosecurity standards and procedures (§335).[63] Section 333 laid the groundwork for the new $450 million National Bio and Agro-Defense Facility to be built at Kansas State University, replacing the research facility at Plum Island, NY.[64]

2002 Farm Bill

Title VII, Section 7221, of the Farm Security and Rural Investment Act of 2002 (The Farm Bill) (Pub L No. 107-17) established programs for agricultural biosecurity planning and response. It provided funding to focus on research, education, and extension activities that are geared to reducing the U.S. "farm-to-fork" system's CBRNE vulnerability, increasing USDA partnerships with higher education, and increasing funding for improving research and analysis of agroterrorism-related issues.[65]

Homeland Security Presidential Directive 7

HSPD-7 (2003) identified agriculture and its associated food supply system as one of the critical areas for additional critical infrastructure protective measures. HSPD-7 guidelines state that a critical infrastructure is

> any system that, if intentionally or unintentionally were to suffer a catastrophic failure, would: (a) cause catastrophic health effects or mass casualties comparable to those from the use of a weapon of mass destruction; (b) impair Federal departments and agencies' abilities to perform essential missions, or to ensure the public's health and safety; (c) undermine State and local government capacities to maintain order and to deliver minimum essential public services; (d) damage the private sector's capability to ensure the orderly functioning of the economy and delivery of essential services; (e) have a negative effect on the economy through the cascading disruption of other critical infrastructure and key resources; or (f) undermine the public's morale and confidence in our national economic and political institution.[8]

Critical infrastructure designation places the nation's food production system under additional protective measures that are outlined in HSPD-9.

Homeland Security Presidential Directive 9

HSPD-9 (2004) specifically states that the U.S. agriculture and food systems are "vulnerable to disease, pest, or poisonous agents that occur naturally, are unintentionally introduced, or are intentionally delivered by acts of terrorism."[8] The key assumption is that because the food and agriculture system is an "extensive, open, interconnected, diverse, and complex structure providing potential targets for terrorist attacks," adequate protective measures for the prevention and/or deterrence of "catastrophic health and economic effects" must be provided.[8]

HSPD-9 provides the structure for interagency coordination. It states that the duty to provide for the safety of these animal and human health outcomes is shared by the

Secretaries of Agriculture, Health and Human Services (HHS), Interior, and Environmental Protection.[8] The directive provides stipulations for additional cooperation focusing on intelligence gathering and analysis by sharing topics relating to agriculture and food safety among agriculture, health, and national intelligence agencies.

In March 2003, APHIS was tasked with 2 primary objectives to strengthen its strategic plans: (a) provide a national system for coordinating pest and disease surveillance and detection, and (b) strengthen USDA's emergency response capabilities and incorporate completely the National Incident Management System (NIMS) and the Incident Command System (ICS). The outcome of the first objective was the establishment of the national network of animal and plant disease diagnostic laboratories known as the National Animal Health Laboratory Network (NAHLN) and the National Plant Diagnostic Network (NPDN).[8] The outcome of the second is discussed below.

Homeland Security Presidential Directive 5

HSPD-5 (2003) calls for the implementation of a national system to address domestic incidents regardless of size or scope. NIMS is designed to address and implement a coordinated plan that includes prevention, preparedness, response, and recovery. HSPD-5 further directed the development of the National Response Plan (NRP) (now the National Response Framework [NFR]).[8]

NIMS provides agencies with the flexibility to expand and contract response actions according to the emergency. The development of the USDA-APHIS National Response Management Team (NRMT) is the result of integrating NIMS and ICS into the USDA's Emergency Management and Homeland Security operations. The NRMT Roles and Responsibilities document provides the framework for establishing a group of individuals who are regarded as specialists in incident management to provide leadership in the event of a national agricultural emergency.[66] The NRMT guidelines delineate 5 key roles for team members: (a) leadership and safety; (b) guidance for disease surveillance and eradication; (c) resource identification and acquisition; (d) resolution of administrative and policy issues associated with emergency response; and (e) coordination and dissemination of information (see Figure 1).[66]

The National Response Management Team defines the roles and responsibilities of individuals involved at all stages of response, including the National Incident Coordinator, the Multi-Agency Coordination (MAC), the economic impacts, and the epidemiologic response.[66,67] Coordination of efforts between federal officials (eg, USDA) and state, local, tribal, and territorial agencies has been carefully considered. Emphasis has been placed on the use of multiagency and unified incident response actions, including the coordination of human and material resources.

In order to implement the Homeland Security Directives, the USDA's Office of Emergency Management and Homeland Security (OEMHS) has been established within APHIS. It has been tasked with 5 primary functions: (a) implement ICS training throughout APHIS; (b) strengthen administrative support for emergency response; (c) strengthen agency leadership of emergency management; (d) build an emergency response network; and (e) identify the emergency response roles and responsibilities of agency employees.[68-70]

Threats Facing Agriculture

Traditional and nontraditional first responders must clearly understand the different types of agriculture emergency threats and hazards to adequately plan and prepare for such an event. There are 2 basic categories of agriculture emergency threats: *unintentional* and *intentional* (Figure 2).

Unintentional Threats

Unintentional threats are classified as *natural* or *accidental* according to the knowledge of their origin and the presence of human intervention. Natural threats are hazards introduced into a susceptible population, where the point of origination is *unknown* and there is *no evidence* of human intervention. Often they are the result of a biological invasion: for example, avian influenza (Virginia 2001),[11,23,71,72] West Nile virus (U.S. 1999).[73-78] Or they may be the repercussions of natural disasters (eg, Hurricane Katrina 2005), drought and extreme heat (U.S. Atlantic states 2001),[72] or freezing temperatures (North Central U.S. 1997).[72]

Accidental threats are unintentional introductions of a hazard(s) into a susceptible population with a *known* point of origination and *evidence* of unintentional human intervention. Often they are the result of individuals trying to circumvent existing laws and regulations (eg, monkey pox, U.S. 2003),[79] improper processing techniques/methods (eg, foot-and-mouth disease, UK 2001),[80] or changes in production policies, such as the change in rendering processes of bovine feed products (eg, bovine spongiform encephalitis [BSE], UK 1987).[35]

Little, if anything, can be done to prevent naturally occurring events such as the West Nile virus epizootic or avian influenza infections in waterfowl. However, physical and biological preventive practices can greatly minimize the need for mitigation efforts associated with such events. Accidental threats pose a significant risk that could exceed the risks posed by criminal and terrorist events. For example, the 2001 UK foot-and-mouth disease outbreak is believed to have resulted from the legal practice of feeding processed waste to pigs. In that particular case, the waste had not been sufficiently processed, and this incident

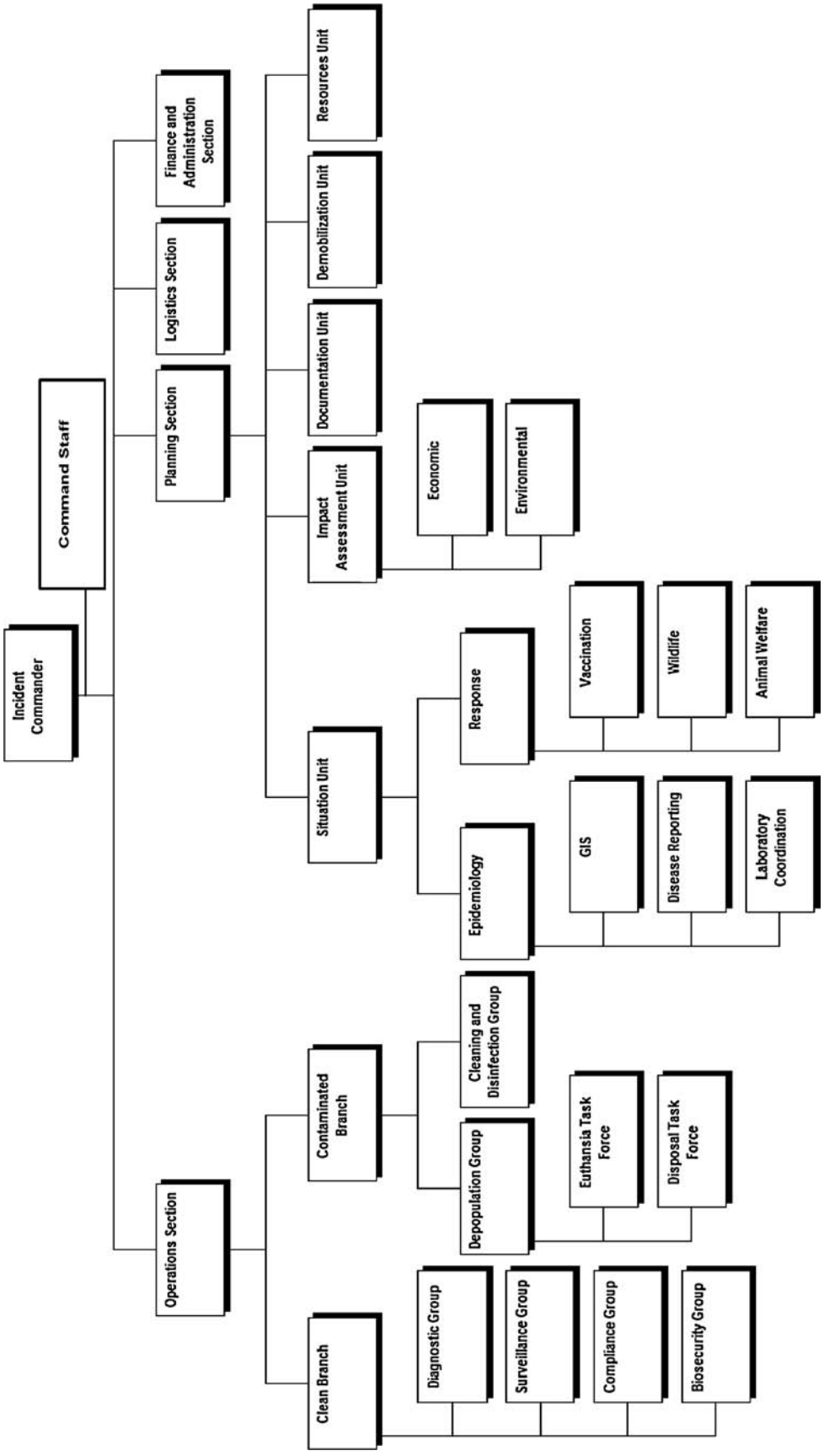

Figure 1. Transmissible/Foreign Animal Disease Outbreak ICS Organizational Chart[2,103]

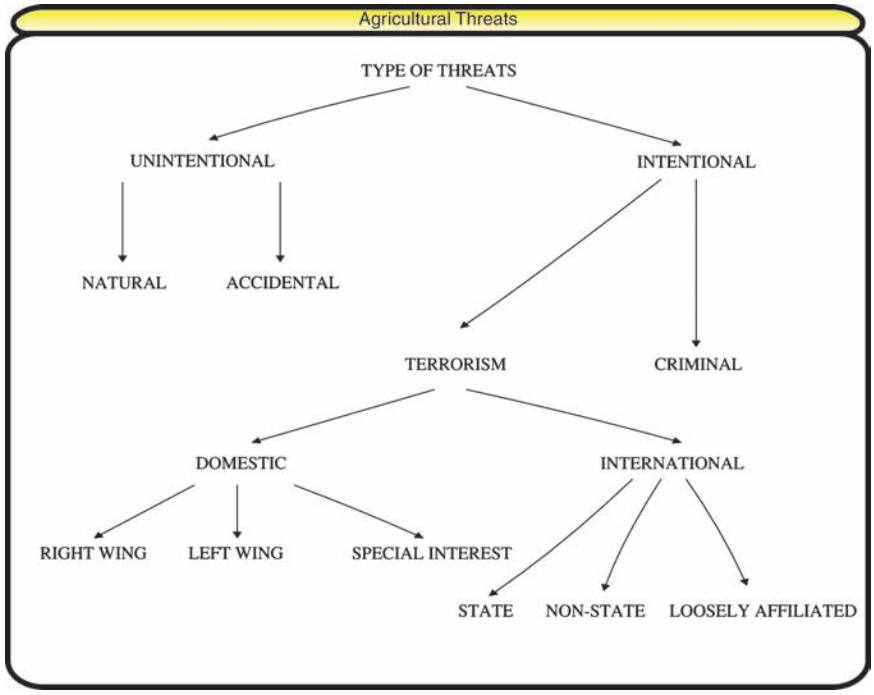

Figure 2. Types of Agricultural Threats

resulted in the loss of an estimated 763,000 cattle, 5.4 million sheep, and 432,000 pigs.[4,14,40,81-83]

Intentional Threats

Intentional threats are deliberate acts that are classified according to their origin as domestic or international. Those threats may be either *criminal* or involve *terrorism*. Criminal threats are often motivated by monetary gain, and the act itself not does address a political or social agenda.[11,84-87] However, criminal threats can have direct and indirect impacts similar to unintentional threats and acts of terrorism. In 1996, a cattle carcass containing chlordane was intentionally introduced into a Wisconsin animal rendering plant. An estimated 4,000 tons of animal feed and 500,000 pounds of animal fat by-product were contaminated and sold to more than 4,000 farmers throughout the Midwest.[25,28] In 1997, poultry feed at the same Wisconsin feed mill was contaminated with the fungicide Folpet; both incidents were contained before being fed to any animals.[14,28] The threat that domestic or international terrorism pose to agriculture is currently unclear, but the possibility for such events should not be ignored. In the U.S., domestic interest groups (eg, Earth Liberation Front [ELF], Animal Liberation Front [ALF]) have a history of arson, animal "liberation," assaults, extortion, firebombing, vandalism, and sabotaging of livestock and post-harvest production facilities.[13,14] Between 1998 and 2007, 58 acts of terrorism were attributed to ELF and 22 to ALF, resulting in more than $48 million in damages and production losses.[13,14,87,88] To date, there is no report of international terrorist groups such as al-Qaeda carrying out any form of anti-animal or anti-plant activities, but concern exists that such groups might engage in agroterrorism.[11,84-86,89-92]

Agroterrorism

Agroterrorism is an act of terrorism targeting the agricultural or agribusiness sector. There are 5 major reasons that agroterrorism may be appealing to terrorists.

First, animal targets are numerous and relatively easy to reach. The targeting of animals might be advantageous because of the spread and frequent long-distance movements of a large number of animals over wide geographical areas.[11,32,93,94]

Second, many transmissible/foreign animal diseases pose minimal health risk to humans. As discussed by Prempeh and colleagues,[86] pathogens such as foot-and-mouth disease virus have very limited zoonotic potential, causing mild or no symptoms in humans, but their socioeconomic impact can be significant.[40,58,81,94]

Third, the U.S. animal population is susceptible to many transmissible/foreign animal diseases (eg, foot-and-mouth disease, Nipah virus, avian influenza). The introduction of a new infectious agent in a susceptible population could lead to a serious epidemic. The potential for severe socioeconomic, health, and cultural impacts from such an event are of concern. If foot-and-mouth disease is introduced into the American cloven-hoof population (ie, cattle, sheep, pigs), the U.S. will not be able to export any cloven-hoof animals, meat, or animal products to any foot-and-mouth-

disease-free country for potentially 1 year past the last known case.[95] A worldwide ban was placed on the export of all livestock, meat, and animal products during the 2001 UK foot-and-mouth disease epizootic starting on February 21, 2001. The last case was on November 29, 2001 (more than 7 months later), and trade sanctions were imposed well into 2002.[82,83] The direct cost of the incident has been estimated at $50.5 billion,[4,58,81,96] and, indirectly, the British tourism industry lost between $6.5 and $7.8 billion.[82,83,97]

Fourth, unless responsibility for the event is claimed and/or publicized by the perpetrators, it can go undetected for a long time while it is spreading, making it difficult to differentiate from a naturally occurring event. It is believed that the index case of foot-and-mouth disease in the UK occurred on or around February 5, 2001, and the first case was not identified until February 19, 2001—14 days of unrestricted movement and secondary exposures.[82,83]

Fifth, transmissible/foreign animal diseases are easily accessible. Many of them are considered highly contagious and infectious, and they are endemic in many areas of the world, making them more accessible than CDC category A bioterrorism agents.[4]

Hazard Identification

The World Organization for Animal Health, formally known as the Office International des Epizooties/Epizootics (OIE), is recognized by the World Trade Organization (WTO) as the "international organization responsible for developing and setting animal health standards for conducting international trade."[98] The OIE maintains a list of significant "transmissible animal diseases" (transmissible/foreign animal diseases). Prior to 2006, the list was divided into 2 lists (A and B). The list classified pathogens according to criteria that were similar to the CDC's category A, B, and C lists of bioterrorism agents. However, the OIE categorized pathogens not only by their potential animal health outcomes, but also by their potential economic impact on international and domestic trade.

As of January 2006, the diseases have been placed into a single consolidated list divided by hosts: multi-species diseases, cattle diseases, sheep and goat diseases, swine diseases, equine diseases, avian diseases, fish diseases, bee diseases, mollusc diseases, crustacean diseases, lagomorph diseases, and "other" diseases. There are 4 inclusion criteria to identify significant animal diseases (Figure 3):

1. Potential for international spread, proof of international spread on 3 or more occasions, OR presence of more than 3 countries with populations of susceptible animals free of the disease or facing impending freedom;[93,97]
2. Potential for significant spread within a naïve population(s) and presence of significant mortality, OR morbidity at the level of a country or compartment;[93,97]
3. Zoonotic potential, with proof of transmission to humans (with exception of artificial circumstances), AND presence of death or prolonged illness in humans.[93,97] Currently, 31 diseases listed are *zoonotic*;[4,11,20,21,23]
4. Presence of an emerging disease, a newly recognized pathogen, or a known pathogen behaving differently.[93,97]

Transmissible/Foreign Animal Disease Outbreak Response

Transmissible/foreign animal disease outbreaks pose a different set of response concepts from those experienced in other types of emergency response incidents, such as wildfires, natural disasters (eg, hurricane, tornadoes), or nonbiological terrorist attacks. When preparing for and responding to a transmissible/foreign animal disease, the potential *size*, *scope*, and *duration* of an event must be considered.[93,94] Transmissible/foreign animal disease events are generally not single focal points (ie, a single farm) or a focal point restricted to a single defined area. Depending on the pathogen and the length of time that it goes undetected, the event has the potential to encompass multiple states. The 2002-03 exotic Newcastle disease outbreak included California, Arizona, Nevada, New Mexico, and Texas. The California epizootic lasted approximately 11 months, covered over 46,000 square miles, and involved more than 1,000 responders at a cost of over $160 million.[100-102]

Transmissible/foreign animal disease response tasks include:

- increased biosecurity;
- the establishment of *control zones*, *infected zones*, and *buffer-surveillance zones*;
- farm or installation quarantine;
- movement restriction of exposed animals;
- culling and depopulation of affected animals;
- carcass disposal; and
- cleaning and disinfecting of the infected premises, depopulation and carcass disposal equipment, and contaminated vehicles, feed trucks, and response equipment.

These tasks are integrated into the ICS Operational, Planning, and Logistics sections (Figure 1).[2,103]

Nonfinancial Implications

Implications for transmissible/foreign animal disease events can be described by their direct and indirect effects. Zoonotic diseases are the primary reason to educate traditional and nontraditional first responders, including public health professionals, on their roles and responsibilities in the event of a transmissible/foreign animal disease outbreak. However, concerns about the indirect effects of zoonotic

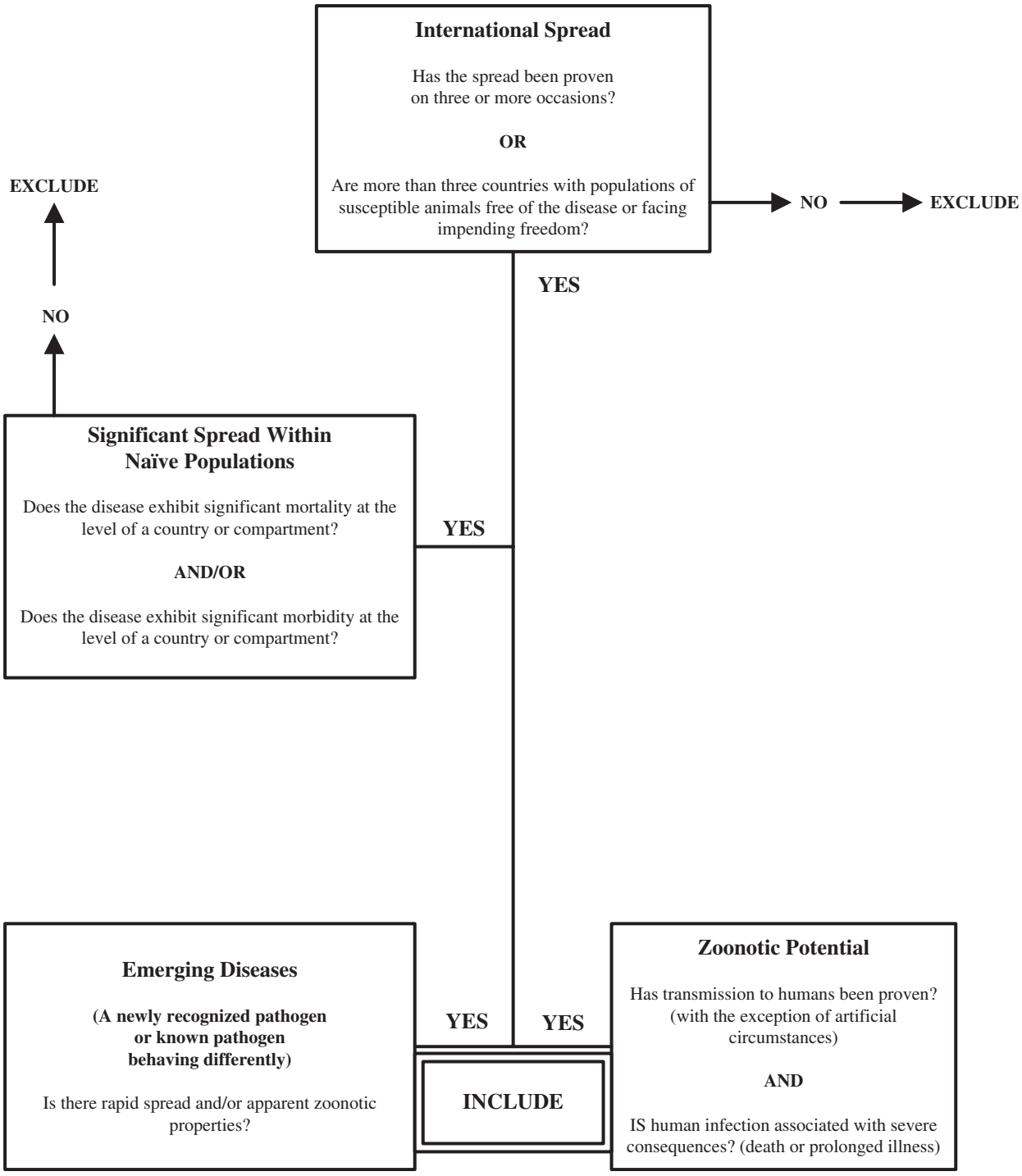

Figure 3. A decision tree that shows how the 4 main inclusion criteria for OIE-listed diseases are applied

Source: Published in Ryan JR, Glarum JF. *Biosecurity and Bioterrorism: Containing and Preventing Biological Threats.* Copyright 2008 Elsevier. Reprinted with permission.

and nonzoonotic agents are not as well described from an emergency response point of view.

An agriculture emergency can indirectly affect human health outcomes (physical and mental), as well as the social and cultural networks of farms involved in an incident. Individual farms owned by multigenerational family units comprise the vast majority of farming units in the U.S. (98%);[104] 91% of all farms in the U.S. are classified as "small farms" (less than $250,000 in sales per year) and they comprise more than 27% of all U.S. agricultural output, with the other 9% accounting for 59% of the U.S. agricultural output.[104]

Farming families are facing multiple stressors including lack of cash flow, long working hours, and extreme environmental working conditions.[11,105,106] Before the 2001 UK foot-and-mouth disease epizootic, farmers had the highest suicide rate among all occupations in England and Wales.[40] During and immediately after the outbreak, the suicide rate increased, with 85 reported suicides associated with the incident.[77] Farming is considered a lifestyle in which livestock are an integral part of the community.[11,40,72,106] In the 2001 UK foot-and-mouth disease outbreak, many of the slaughtered animals had unique breeding pedigrees and were a source of pride. These feelings were destroyed after the depopulation. Several studies reported that farmers and their families felt guilty and ashamed of not being able to save their livelihoods.[11,40,72] The farmers expressed a sense of helplessness, compounded by anger, denial, and grief as a result of mass depopulation of healthy animals in order to mitigate the spread of the disease.[32,72,106] Another study described reports of individuals suffering from respiratory problems stemming from the large pyres used to dispose of the carcasses,[40] feelings of community ostracization, lack of normalcy, and feelings of self-imposed punishment because of the government-imposed quarantines.[11,40,72,106] During the 1995-1999 Australian (Ovine) Johne's Disease epizootic, responders involved in the depopulation suffered from extreme traumatic and mental health problems. The Australian government suspended the program in 1999 because of open hostilities, sheer exhaustion, and responders' burn-out.[72]

Conclusions

This review has briefly described preharvest livestock agricultural emergencies and their link with public health emergency planning, response, and mitigation. Drawing on those examples, we have identified reasons that concern about agriculture emergencies should extend beyond veterinary health practitioners to include traditional and nontraditional first responders. Attention should encompass not only the zoonotic potential of agriculture emergencies, but also the issues surrounding their mitigation. Past events demonstrate that socioeconomic impacts can be substantial in the short term and may expand in the longer term, depending on the event and agent used. In addition, the mental health effects on the farming community, responders, and surrounding communities are under-studied and under-described. These gaps need to be filled, because the occurrence of natural, accidental, or intentional agriculture emergencies is inevitable.

The melamine contamination of food products from China (2006-2009), which was first recognized in pet and pig feed and was recently found in infant formula, serves as an excellent example of food product contamination occurring abroad. The initial event was identified after the deaths of cats and dogs in the U.S. and Canada.[107-109] This has brought to light many "holes" in the food supply "veil of protection."[110] The event has demonstrated that any country that imports food products or byproducts is vulnerable because of the large volume of imports and small number of inspectors.

Similarly, recent cases of salmonella contamination (serrano peppers in 2008, peanut butter in 2009), although not attributable to animals or animal byproducts, has exposed the difficulty of tracing product origination. The Bioterrorism Law of 2002, Section 306, provided direction for the FDA to institute better food industry records. However, the law does not require all components of the "farm to fork" to maintain records (eg, farm of origination, restaurants), and it does not provide the FDA with the authority to enforce industry compliance. This lack of product continuity and lack of enforcement powers has been a crucial stumbling block in recent salmonella outbreaks.[111] For preharvest livestock traceability, the USDA began implementing the National Animal Identification System in 2003; the program was scheduled to be fully implemented by 2009. However, implementation of an effective and comprehensive tracking system has met major resistance from producers, stemming primarily from concerns about potential impacts on producers and the inability of the USDA to assuage those concerns.

Given both the potential impacts of agriculture emergencies and the likelihood of such events happening, this article underscores the need for public health and emergency response professionals to proactively plan, prepare, and train with an all-hazards approach to include mitigation, planning, and response to an agriculture emergency. In order to plan and prepare for an agriculture emergency, it is essential to first educate both traditional and nontraditional responders about the nature and definition of an agriculture emergency, its implications, and their roles in facing such event. Particular emphasis should be placed on the indirect effects of the event. Looking toward the future, as public health and other nontraditional responders adopt and implement the NIMS Incident Command Structure, it is inevitable that this will begin to happen.

In parallel, it is essential to educate the public about how they could potentially be affected and what they can do to help prevent agriculture emergencies and to avoid unwarranted panic. To be effective, any public awareness and education campaign designed to improve understanding of the impact of agriculture emergencies needs to be targeted. In addition to the general public and producers, such campaigns should also include importers, shippers, international travelers, and anyone else who could potentially bring contaminated materials (eg, fruits, vegetables, animal byproducts) into the U.S. from foreign countries. Ultimately, the foundation for successfully preventing, preparing for, or responding to an agriculture emergency is grounded in enhancing the level of awareness and understanding of the first responders, the public, and the associated industries.

Acknowledgments

Portions of this research were supported by the Defense Threat Reduction Agency and the Air Force Research Laboratory under Cooperative Agreement FA8650-05-2-6523 and the Centers for Disease Control and Prevention, Cooperative Agreement U90/CCU624198-01. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the U.S. government. Support for Mr. Gilpen was provided by the NIH F31 AI058915-02S1 Predoctoral Fellowship.

References

1. Noah DL, Grayson JK, Caudle LC 3rd. Ten great veterinary public health/preventive medicine achievements in the United States, 1901 to 2000. *J Am Vet Med Assoc* 2000;217(12):1834-1836.
2. United States Animal Health Association [USAHA], Committee on Foreign Animal Diseases. Critical foreign disease issues for the 21st century. In: *Foreign Animal Disease: The Gray Book.* 7th ed. St. Joseph, MO: United States Animal Health Association; 2008:17-18.
3. United States Animal Health Association [USAHA], Committee on Foreign Animal Diseases. Critical foreign disease issues for the 21st century. In: *Foreign Animal Disease: The Gray Book.* 6th ed. St. Joseph, MO: United States Animal Health Association; 1998.
4. Carabin H, Perez D, Gilpen J, Greenfield RA. Animal diseases as a possible consequence of biological attack. In: Greenfield RA, Bronze MS, eds. *Biodefense: Principles and Pathogens.* Norfolk: Horizon BioScience; 2005:737-791.
5. U.S. Department of Agriculture. *Process for Foreign Animal Disease Status Evaluations, Regionalization, Risk Analysis, and Rulemaking.* Washington, DC: APHIS-USDA; 2004.
6. Cupp OS, Walker DE II, Hillison J. Agroterrorism in the U.S.: key security challenge for the 21st century. *Biosecur Bioterror* 2004;2:97-105.
7. Harl NE. US agriculture, food production is threatened by bioterrorism attacks. *Ag Lender* 2002;10-11.
8. U.S. Department of Homeland Security. *Homeland Security Presidential Directives.* http://www.dhs.gov/xabout/laws/editorial_0607.shtm. Updated August 21, 2008. Accessed May 29, 2009.
9. Fine A, Layton M. Lessons from the West Nile viral encephalitis outbreak in New York City, 1999: implications for bioterrorism preparedness. *Clin Infect Dis* 2001;32:277-282.
10. U.S. Government Accountability Office. *West Nile Virus Outbreak: Lessons For Public Health Preparedness.* Washington DC: GAO; 2000.
11. National Association of State Departments of Agriculture Research Foundation. *The Animal Health Safeguarding Review: Results and Recommendations.* Washington, DC: NASDARF; 2001.
12. American Veterinary Medical Association. *Disaster Preparedness and Response Guide.* Schaumburg, IL: AVMA; 2001.
13. Ackerman GA. It is hard to predict the future: the evolving nature of threats and vulnerabilities. *Rev Sci Tech* 2006;25:353-360.
14. Ackerman GA, Giroux J. A history of biological disasters of animal origin in North America. *Rev Sci Tech* 2006;25:83-92.
15. Alibek K. The Soviet Union's anti-agricultural biological weapons. *Ann N Y Acad Sci* 1999;894:18-19.
16. Becker KM. An epiphany: recent events highlight the responsibilities, roles, and challenges that veterinarians must embrace in public health. *J Vet Med Educ* 2003;30:115-120.
17. Cain S. *Agroterrorism.* West Lafayette, IN: Purdue Extension Educators; 2001.
18. Cheek P. Factors impacting the acceptance of traceability in the food supply chain in the United States of America. *Rev Sci Tech* 2006;25:313-319.
19. Davies FG. Kenya, Mau Mau and bioterrorism. *Rev Sci Tech* 2006;25:149-151.
20. Davis RG. The ABCs of bioterrorism for veterinarians, focusing on Category B and C agents. *J Am Vet Med Assoc* 2004;224:1096-1104.
21. Davis RG. The ABCs of bioterrorism for veterinarians, focusing on Category A agents. *J Am Vet Med Assoc* 2004;224:1084-1095.
22. Domaradskij IV, Orent LW. Achievements of the soviet biological weapons programme and implications for the future. *Rev Sci Tech* 2006;25:153-161.
23. Dudley JP, Woodford MH. Bioweapons, bioterrorism and biodiversity: potential impacts of biological weapons attacks on agricultural and biological diversity. *Rev Sci Tech* 2002;21:125-137.
24. Fitzpatrick AM, Bender JB. Survey of chief livestock officials regarding bioterrorism preparedness in the United States. *J Am Vet Med Assoc* 2000;217:1315-1317.
25. Foxell JW. Current trends in agroterrorism (antilivestock, anticrop, and antisoil bioagricultural terrorism) and their potential impact on food security. *Studies in Conflict & Terrorism* 2001;24:107-129.
26. Furmanski M. Misperceptions in preparing for biological attack: an historical survey. *Rev Sci Tech* 2006;25:53-70.
27. Groves MG. Public health education of veterinarians and veterinary students for the future. *J Am Vet Med Assoc* 2000;217:1831-1833.
28. Heath B. Homeland security in America's dairyland. *Nonproliferation Review* 2002;9(3)117-134.
29. Heath SE. Challenges and options for animal and public health services in the next two decades. *Rev Sci Tech* 2006;25:403-419.
30. Hugh-Jones M. Distinguishing between natural and unnatural outbreaks of animal diseases. *Rev Sci Tech* 2006;25:173-186.
31. Hugh-Jones M. Biological disasters of animal origin: the role and preparedness of veterinary and public health services. *Rev Sci Tech* 2006;25:421-427,429-444.
32. Hugh-Jones M, Brown CC. Accidental and intentional animal disease outbreaks: assessing the risk and preparing an effective response. *Rev Sci Tech* 2006;25:21-33.
33. King LJ. Veterinary medicine's role in biodefense and public health. *J Vet Med Educ* 2003;30:161-163.
34. Kohnen A. *Responding to the Threat of Agroterrorism: Specific Recommendations for the United States Department of Agriculture.* BCSIA Discussion Paper 2000-29, ESDP

Discussion Paper ESDP-2000-04. Cambridge, MA: Harvard University; 2000.
35. Kosal ME, Anderson DE. An unaddressed issue of agricultural terrorism: a case study on feed security. *J Anim Sci* 2004;82:3394-3400.
36. Kroschewski K, Kramer M, Micklich A, Staubach C, Carmanns R, Conraths FJ. Animal disease outbreak control: the use of crisis management tools. *Rev Sci Tech* 2006;25:211-221.
37. Lubroth J. International cooperation and preparedness in responding to accidental or deliberate biological disasters: lessons and future directions. *Rev Sci Tech* 2006;25:361-374.
38. Lutz BD, Greenfield RA. Agroterrorism. *J Okla State Med Assoc* 2003;96:259-263.
39. McEwen SA, Wilson TM, Ashford DA, Heegaard ED, Kournikakis B. Microbial forensics for natural and intentional incidents of infectious disease involving animals. *Rev Sci Tech* 2006;25:329-339.
40. Mort M, Convery I, Baxter J, Bailey C. Psychosocial effects of the 2001 UK foot and mouth disease epidemic in a rural population: qualitative diary based study. *BMJ* 2005;331:1234.
41. Neher NJ. The need for a coordinated response to food terrorism: the Wisconsin experience. *Ann N Y Acad Sci* 1999;894:181-183.
42. Noah DL, Crowder HR. Biological terrorism against animals and humans: a brief review and primer for action. *J Am Vet Med Assoc* 2002;221:40-43.
43. Nolen RS. Bioterrorism expert says U.S. agriculture vulnerable to attack. *J Am Vet Med Assoc* 2002;221:756-757.
44. Nolen RS. Though better prepared after 9/11, America still vulnerable to bioterrorism. *J Am Vet Med Assoc* 2003;223: 163-164.
45. Nolen RS. Veterinary medicine a key component of Bush's new policy defending U.S. agriculture from terrorism. *J Am Vet Med Assoc* 2004;224:809-810.
46. O'Rourke K. National pet health surveillance system in the works. *J Am Vet Med Assoc* 2003;222:1335-1336.
47. Orriss GD. Animal diseases of public health importance. *Emerg Infect Dis* 1997;3:497-502.
48. Pearson GS. Public perception and risk communication in regard to bioterrorism against animals and plants. *Rev Sci Tech* 2006;25:71-82.
49. Ridge T. *National Incident Management System.* Washington, DC: Department of Homeland Security; 2004.
50. Rushton J, Upton M. Investment in preventing and preparing for biological emergencies and disasters: social and economic costs of disasters versus costs of surveillance and response preparedness. *Rev Sci Tech* 2006;25:375-388.
51. Shears P. Communicable disease surveillance with limited resources: the scope to link human and veterinary programmes. *Acta Trop* 2000;76:3-7.
52. Steele JH. The history of public health and veterinary public service. *J Am Vet Med Assoc* 2000;217:1813-1821.
53. Stern KS. *A Force Upon the Plain: The American Militia Movement and the Politics of Hate.* New York: Simon & Schuster; 1996.
54. Tauxe RV. New approaches to surveillance and control of emerging foodborne infectious diseases. *Emerg Infect Dis* 1998;4:455-456.
55. Thurmond MC, Gibbs EP, Brown CC, Wagner GG, Wilson TM, Lautner BA. Educational preparedness of veterinarians for foreign animal diseases. *J Am Vet Med Assoc* 2003;222:1352-1357.
56. Vallat B, Pinto J, Schudel A. International organisations and their role in helping to protect the worldwide community against natural and intentional biological disasters. *Rev Sci Tech* 2006;25:163-172.
57. Van Bredow J, Myers M, Wagner D, Valdes JJ, Loomis L, Zamani K. Agroterrorism. Agricultural infrastructure vulnerability. *Ann N Y Acad Sci* 1999;894:168-180.
58. Zinsstag J, Weiss MG. Livestock diseases and human health. *Science* 2001;294:477.
59. Burton F, Stewart S. Placing the terrorist threat to the food supply in perspective. *Right Side News* 2008.
60. Capua I, Alexander DJ. Animal and human health implications of avian influenza infections. *Biosci Rep* 2007;27:359-372.
61. Presidential Decision Directive 63: Critical Infrastructure Protection. 1998. http://fas.org/irp/offdocs/pdd/pdd-63.htm. Accessed May 28, 2009.
62. Executive Order 13228: Order establishing the Office of Homeland Security and the Homeland Security Council. http://www.fas.org/irp/offdocs/eo/eo-13228.htm. Accessed May 28, 2009.
63. P.L. No. 107-188: Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Bioterrorism Act). 2002.
64. U.S. Department of Homeland Security. *National Bio and Agro-Defense Facility.* http://www.dhs.gov/xres/labs/editorial_0762.shtm. Accessed May 28, 2009.
65. P.L. No. 107-17: Farm Security and Rural Investment Act of 2002 (Farm Bill).
66. Tran N. Existing federal system for addressing animal diseases: white paper. In: Committee on Assessing the Nation's Framework for Addressing Animal Diseases, National Research Council. *Animal Health at the Crossroads: Preventing, Detecting, and Diagnosing Animal Diseases.* Washington, DC: National Academies Press; 2005:179-254.
67. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. The New APHIS Emergency Operations Center. *APHIS Fact Sheet* 2003. http://www.aphis.usda.gov/publications/aphis_general/content/printable_version/fs_aheoc.pdf. Accessed May 28, 2009.
68. U.S. Department of Homeland Security, Center for Domestic Preparedness. *Agro-Security Awareness Information Paper.* Anniston, AL: Center for Domestic Preparedness; 2004.
69. Annelli JF. The national incident management system: a multi-agency approach to emergency response in the United States of America. *Rev Sci Tech* 2006;25:223-231.
70. U.S. Department of Agriculture. Standard Operating Procedures for National Response Plan Activations Emergency Support Function #11 Agriculture and Natural Resources. Washington, DC: USDA; 2006.
71. Veterinary Medical Assistance Teams. http://www.vmat.org/about.htm. Accessed May 28, 2009.
72. Hall MJ, Ng A, Ursano RJ, Holloway H, Fullerton C, Casper J. Psychological impact of the animal-human bond in disaster preparedness and response. *J Psychiatr Pract* 2004;10:368-374.
73. Lanciotti RS, Roehrig JT, Deubel V, et al. Origin of the West Nile virus responsible for an outbreak of encephalitis in the northeastern United States. *Science* 1999;286:2333-2337.

74. Malkinson M, Banet C, Weisman Y, et al. Introduction of West Nile virus in the Middle East by migrating white storks. *Emerg Infect Dis* 2002;8:392-397.
75. Malkinson M, Weisman Y, Pokamonski S, King R, Deubel V. Intercontinental transmission of West Nile virus by migrating white storks. *Emerg Infect Dis* 2001;7:540.
76. Nash D, Mostashari F, Fine A, et al. The outbreak of West Nile virus infection in the New York City area in 1999. *N Engl J Med* 2001;344:1807-1814.
77. Petersen LR, Roehrig JT. West Nile virus: a reemerging global pathogen. *Emerg Infect Dis* 2001;7:611-614.
78. Tyler KL. West Nile virus encephalitis in America. *N Engl J Med* 2001;344:1858-1859.
79. Control of communicable diseases; restrictions on African rodents, prairie dogs, and certain other animals. Interim final rule; opportunity for public comment. *Fed Regist* 2003;68:62353-62369.
80. Dyckman LJ. *Foot and Mouth Disease: To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding Issues.* Washington, DC: Government Accountability Office; 2002.
81. Prempeh H, Smith R, Muller B. Foot and mouth disease: the human consequences. The health consequences are slight, the economic ones huge. *BMJ* 2001;322:565-566.
82. Lavender A, Mitchell T. *The Report of the Chief Veterinary Officer: Animal Health 2001.* Department for Environment, Food and Rural Affairs. London: DEFRA Publications; 2001. http://www.defra.gov.uk/animalh/cvo/pdf/2001report.pdf. Accessed May 28, 2009.
83. Scudamore JM. 2002. *Origin of the UK Foot and Mouth Disease Epidemic in 2001.* Department for Environment, Food and Rural Affairs. London: DEFRA Publications; 2002. http://www.defra.gov.uk/animalh/diseases/fmd/pdf/fmdorigins1.pdf. Accessed May 28, 2009.
84. United States Institute of Peace. *Teaching Guide on International Terrorism: Definitions, Causes, and Responses.* Washington, DC: United States Institute of Peace; 2005. http://www.usip.org/etc/tools_resources/guides/terrorism.pdf. Accessed May 28, 2009.
85. *Terrorism: An Introduction.* Washington, DC: Council on Foreign Relations; 2004.
86. *Types of Terrorism.* Washington, DC: Council on Foreign Relations; 2004.
87. *Terrorism 2000/2001.* Washington, DC: U.S. Department of Justice; 2002.
88. Dandow D. Animal terrorism. *Washington Times* 2005.
89. U.S. Department of Homeland Security. *Incident Response to Terrorist Bombings.* Washington, DC: U.S. Department of Homeland Security; 2006.
90. *Al-Qaeda (Afghanistan, Islamists).* Washington, DC: Council on Foreign Relations; 2004.
91. *Muslim Militant Extremists?* Washington, DC: Council on Foreign Relations; 2004.
92. Hoffman B. *Inside Terrorism.* New York: Columbia University Press; 1998.
93. Ryan JR, Glarum JF. Biological threat to agriculture. In: *Biosecurity & Bioterrorism: Containing and Preventing Biological Threats.* New York: Butterworth-Heinemann; 2008:155-184.
94. Ryan JR, Glarum JF. 2008. Recent animal disease outbreaks and lessons learned. In: *Biosecurity & Bioterrorism: Containing and Preventing Biological Threats.* New York: Butterworth-Heinemann; 2008:185-206.
95. World Organisation for Animal Health (OIE). *Terrestrial Animal Health Code.* Paris: OIE; 2008.
96. Barnett PV, Carabin H. A review of emergency foot-and-mouth disease (FMD) vaccines. *Vaccine* 2002;20:1505-1514.
97. Whiting TL. Foreign animal disease outbreaks, the animal welfare implications for Canada: risks apparent from international experience. *Can Vet J* 2003;44:805-815.
98. World Organisation for Animal Health (OIE). *The OIE.* Paris: OIE; 2009.
99. Vallat B. *Criteria for Listing Diseases. Terrestrial Animal Health Code.* Paris: OIE; 2008.
100. Nolen RS. Emergency declared: exotic Newcastle disease found in commercial poultry farms. *J Am Vet Med Assoc* 2003;222:411.
101. Nolen RS. Exotic Newcastle disease strikes game birds in California. *J Am Vet Med Assoc* 2003;221:1369-1370.
102. U.S. Department of Homeland Security. *WMD Basic Agriculture Emergency Response Training (AgERT).* Washington, DC: U.S. Department of Homeland Security; 2006.
103. Roberts JE, Holley RD, Floyd CL, Team OVIM. *Foreign Animal Disease (FAD) Emergency Response Guide.* Oklahoma City: Oklahoma Department of Agriculture Food and Forestry; 2002.
104. U.S. Department of Agriculture. *Structure and Finances of U.S. Farms: 2005 Farm Report/ EIB-12.* Washington, DC: USDA-ERS; 2005.
105. Davies C. The rural stress information network. *Stress News* 2002;14:1-5.
106. Osborne S. Farming and mental health outreach. *Mental Health Nursing* May/June 2001;21(3):10-12.
107. Melamine adulterates component of pellet feeds. *JAVMA News* 2007;231:17. http://www.avma.org/onlnews/javma/jul07/070701d.asp. Accessed May 28, 2009.
108. Burns K. Events leading to the major recall of pet foods. *Am Vet Med Assoc* 2007;230:1600-1620.
109. U.S. Food and Drug Administration. *Melamine Contamination in China.* Washington, DC: U.S. Food and Drug Administration; 2009.
110. Nucci ML, Dellava JE, Cuite CL, Hallman WK. *The U.S. Food Import System: Issues, Processes and Proposals.* New Brunswick, NJ: Food Policy Institute; 2008.
111. Levinson DR. *Traceability in the Food Supply Chain.* Washington, DC: U.S. Department of Health and Human Services; 2009.

Manuscript received August 19, 2008;
accepted for publication April 30, 2009.

Address correspondence to:
Professor Johnnie Lee Gilpen
Redlands Community College
Homeland Security and Emergency Preparedness
1300 South Country Club
El Reno, OK 73036

E-mail: jgilpen@gmail.com