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THESIS

COLLABORATIVE RESPONSE AND RECOVERY FROM A FOOT-AND-MOUTH DISEASE ANIMAL HEALTH EMERGENCY: SUPPORTING DECISION MAKING IN A COMPLEX ENVIRONMENT WITH MULTIPLE STAKEHOLDERS

by

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13. ABSTRACT (maximum 200 words)

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The United States can strengthen its preparedness posture and can improve its ability to support effective decision making in responding to and recovering from a foot-and-mouth disease outbreak in the following three ways.

- Maintain Regional Multi-Stakeholder Partnerships
- Strengthen Data and Information Support to Decision Makers
- Understand the Complexity of the Situation and Approach Decision Making Accordingly

The first sets up an ongoing, regional, multi-stakeholder enabling structure that can be used to build trust by convening collaborative people from the multiple stakeholder groups. The second supports the provision of credible and rapid information upon which to make decisions. The third provides decision makers with a sense making framework for understanding and working in complex situations with multiple stakeholders.

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LIST OF ACRONYMS AND ABBREVIATIONS

AERT	Agriculture Emergency Response Team
AI	Avian Influenza
AHWBE	Animal Health and Welfare Board for England
APHIS	Animal and Plant Health Inspection Service
AVIC	Area Veterinarian in Charge
AVMA	American Veterinary Medical Association
CFSPH	Center for Food Security and Public Health
CIKR	Critical Infrastructure and Key Resources
DEFRA	Department for Environment, Food and Rural Affairs
EDEN	Extension Disaster Education Network
ESF-11	Emergency Support Function 11 (Agriculture and Natural Resources)
FA	Food and Agriculture
FAD	Foreign Animal Disease
FADPReP	Animal Disease Preparedness and Response Plan
FAZD	National Center for Foreign Animal and Zoonotic Disease
FDA	Food and Drug Administration
FERN	Food Emergency Response Network
FMD	Foot-and-Mouth Disease
GAO	Government Accountability Office
IVRRT	Iowa Veterinary Rapid Response Team
MAAEMA	Mid-Atlantic Agriculture and Animal Emergency Management Alliance
MSP	Multi-State Partnership for Security in Agriculture
NAHEMS	National Animal Health Emergency Management System
NAHERC	National Animal Health Emergency Response Corp
NAHLN	National Animal Health Laboratory Network
NASS	National Agricultural Statistics Service
NCAHEM	National Center for Animal Health Emergency Management
NCFPD	National Center for Food Protection and Defense
NIAA	National Institute for Animal Agriculture
OIE	World Organization for Animal Health

SAADRA	Southern Agriculture and Animal Emergency Disaster Response Alliance
SMS	Secure Milk Supply
SPS	Secure Pork Supply
UK	UK
USAHA	United States Animal Health Organization
USDA	United States Department of Agriculture
VS	Veterinary Services

EXECUTIVE SUMMARY

This thesis recommends ways to support decision makers who must operate within the multi-stakeholder complex situation of response and recovery from a major foot-and-mouth disease outbreak in the United States. This support is intended to assist decision making and response and recovery action execution. Recommendations are designed to assist in the accurate assessment of the initial infection zone and to garner situation awareness in support of implementing decisions that will limit the size and scope of the outbreak.

The thesis recommendations were formulated from a review of the decision support recommendations garnered from the 2001 and 2007 foot-and-mouth disease outbreaks in the UK. Additional information on working in complex situations with multiple stakeholders helped to formulate the recommendations. The recommendations were formulated within the context that a foot-and-mouth disease outbreak has not occurred since 1929. It would be considered a high consequence low probability event.

The findings indicate that decision support for a rare event that will impact many stakeholders should be built on a foundation of trusted relationships pre-event. This thesis recommends the following pre-event actions.

- Maintaining Regional Multi-Stakeholder Partnerships
- Strengthen Data and Information Support to Decision Makers
- Understand the Complexity of the Situation and Approach Decision Making Accordingly

The first sets up an ongoing regional multi-stakeholder enabling structure that can be used to build trust by convening collaborative people from the various stakeholder groups. The second supports the provision of credible and rapid information upon which to make decisions and the third provides decision makers with a sense making framework for understanding and working in complex situations with multiple stakeholders.

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I. INTRODUCTION

"Foot-and-mouth disease is a high consequence livestock disease due to its potential for rapid spread, severe trade restrictions and the subsequent economic impacts that would result" (Center for Food Security and Public Health 2008). Background information is provided to explain some of the factors that would make response and recovery following a foot-and-mouth disease outbreak in the United States especially challenging. This information supports two critical concepts of this thesis: the complexity of the response and recovery decision-making environment and the fact that multiple stakeholders would be involved with a foot-and-mouth disease response and recovery effort.

A. BACKGROUND

This section provides background about foot-and-mouth disease, how it is regulated to protect healthy animals from infection, and why it poses an economic threat to the United States. It explains why multiple regulators are involved, and why economic losses from the loss of animals and loss of international trade is anticipated in the event of an outbreak.

1. Regulatory Structure

Foot-and-mouth disease[1] (FMD) has not been detected in the United States since 1929 (United States Department of Agriculture 2013). Since the disease occurs in parts of

[1] Foot-and-Mouth Disease (FMD) importance as reported by the Center for Food Safety and Public Health, retrieved April 2013 from http://www.cfsph.iastate.edu/Factsheets/pdfs /foot_and_mouth_disease.pdf. Foot-and-mouth disease (FMD) is a highly contagious viral disease that primarily affects cloven-hooved livestock and wildlife. Although adult animals generally recover, the morbidity rate is very high in naïve populations, and significant pain and distress occur in some species. Sequelae may include decreased milk yield, permanent hoof damage and chronic mastitis. High mortality rates can be seen in young animals. Although foot-and-mouth disease was once found worldwide, it has been eradicated from some regions including North America and most of Europe. Where it is endemic, this disease is a major constraint to the international livestock trade. Unless strict precautions are followed, FMD can be readily re-introduced into disease-free livestock. Once this occurs, the disease can spread rapidly through a region, particularly if detection is delayed. Outbreaks can severely disrupt livestock production, result in embargoes by trade partners, and require significant resources to control. Direct and indirect economic losses equivalent to several billion US dollars are not uncommon. Since 1997, a PanAsia lineage virus has caused a series of outbreaks in Asia, Africa, the Middle East and Europe. Some outbreaks, particularly those in Taiwan and the UK, have been devastating.

Asia, the Middle East and South America the potential for introduction to the United States is ever present. Cloven-hoofed animals, including cows, pigs, sheep, goats, and deer, are susceptible to the virus (Center for Food Security and Public Health 2008)

Because of the highly contagious nature of the foot-and-mouth disease, it is a reportable disease in the United States under state statutes as illustrated by the Iowa Code 163 (Iowa Legislature 2013) and Iowa Administrative Code section 21–64.1 (163) Reporting Disease (Iowa Department of Agriculture and Land Stewardship 2013) and according to the World Organisation for Animal Health (OIE).

Foot-and-mouth disease is on the list of notifiable terrestrial and aquatic animal diseases, as determined by the World Organization for Animal Health (OIE). The World Organisation for Animal Health is the intergovernmental organization for improving animal health worldwide and is recognized as a reference organization by the World Trade Organisation (WTO). In 2013, it had 178 member countries (World Organisation for Animal Health n.d.).

“FMD is the first disease for which the OIE established an official list of free countries and zones with or without vaccination” (World Organisation for Animal Health n.d.). The categorization of a country or region sets limitations on the ability of that nation to trade live animals internationally. As described on the OIE website, Foot-and-Mouth-Disease portal, disease status categories include: FMD free without using vaccine (country or zone) and FMD free with use of vaccination (country or zone) (World Organization for Animal Health n.d.).

The OIE Guidelines for the Surveillance of Foot and Mouth Disease (OIE Terrestrial Animal Code) are followed by countries that wish to engage in international trade of live animals. Initial measures include early detection and warning systems and recommended prevention measures designed to minimizing the potential spread of the disease (World Organisation for Animal Health n.d.). The United States is a member country and would be subject to the OIE guidelines if a Food-and-Mouth Disease outbreak occurred in the U.S.

2. Economic Concerns

The UK outbreaks in 2001 and 2007 are the most recent examples of the extent of devastation that can be caused by an outbreak of foot-and-mouth disease in a country that had been disease free for 34 years (Anderson 2008). The economic impacts come from the cost of disease response and recovery, the economic disruption within the country as a result of the disease eradication methods causing disruptions in the animal production systems and the loss of export markets due to losing the FMD free designation (National Institute for Animal Agriculture 2013, 5).

> The 2001 outbreak of foot and mouth disease (FMD) in the UK decisively illustrated the devastation that this highly contagious animal disease can cause to a nation's livestock industry and other sectors of the economy. By the time the disease was eradicated, about 8 months later, the UK had slaughtered over 4 million animals to control the disease, and sustained losses of over $5 billion in the food and agricultural sectors, as well as comparable losses to is tourism industry. Before 2001, the UK had been FMD-free for 34 years; following the outbreak, the country was, until recently, generally restricted from participating in the international trade of live animals, and animal and other products that could transmit the FMD virus. (United States General Accounting Office 2002, 2)

Because the disease has not occurred in the United States since 1929, economic impact estimates are modeled based on the current animal production systems in the U.S. "Applying the National Interstate Economic Model (NIEMO), the total economic impacts across the United States is estimated at $23 billion to $34 billion. The overwhelming sources of the losses are due to domestic and international demand cuts" (National Institute for Animal Agriculture 2013, 5). An additional study of estimated economic losses from a foot-and-mouth disease outbreak in California indicated the following losses.

> Studies have estimated a likely national welfare loss of between $23–69 billion for an FMD outbreak in California, depending on delay in diagnosing the disease. The impact would come primarily from lost international trade, as well as costs directly associated with the eradication effort, including the expenses of depopulation, indemnity, carcass disposal, and cleaning and disinfection. In addition, there would be direct and indirect costs related to foregone production, unemployment, and losses in related businesses. The social and psychological impact on

> owners and growers would also be severe. (United States Department of Agriculture 2012, v)

This background information highlights the reasons why a foot-and-mouth disease outbreak in the United States would be complex and involve many stakeholders. Economic losses would increase if the outbreak was not contained and stopped by response actions. The economic losses would come from the destruction of animals to stop the spread of the disease per OIE guidance and the loss of international trade upon detection of the foot-and-mouth disease in the United States. Increased economic losses are anticipated with delays in diagnosing the disease.

The complexity of the situation is further highlighted by the multiple levels of regulatory oversight. Response and recovery actions must follow international, OIE, guidance in order to pursue the resumption of trade after a set period of demonstrating disease free status (World Organisation for Animal Health n.d.). In addition, within the United States, both federal and state regulations cover disease eradication efforts.

The Foot-and-Mouth disease virus can spread rapidly, if not detected. Response and recovery actions must work with the challenges of trying to stop the spread of a virus that is propagated through live animals within animal production systems. The economic impacts, multiple government regulatory layers and the contagious nature of the virus, taken together, complicate the decision making process in a response and recovery effort.

B. PROBLEM STATEMENT

Decision makers will face many challenges within this multi stakeholder complex environment of response and recovery from a major foot-and-mouth disease outbreak in the United States. Supporting decision makers in their efforts to make situational dependent, effective decisions is important, because poor decision making and uncoordinated response and recovery execution to a foot-and-mouth disease outbreak can lead to increases in the size and scope of the outbreak with associated increased economic costs. One illustration of this claim is the decision of where and how big to designate the quarantine areas of suspected infection. If the quarantine area is too small, the virus is not contained, and the extent of the outbreak can grow. If the quarantine area is too large,

capturing large numbers of uninfected animals, business disruption and associated economic losses that comes from the quarantine would have been unnecessary (Center for Food Security and Public Health 2013). An additional example of the consequences of decision making regarding quarantine is found in the Appendix. In one case, the Japan outbreak, “Slow detection and quarantine resulted in culling of 200,000 animals on 300 farms” (Maday 2013).

Decision makers have many resources that provide guidance during their response and recovery efforts. The Foreign Animal Disease Preparedness and Response Plan (FADPReP) defines what experts think should be done in a variety of outbreak situations of various sizes and scope (Center for Food Security and Public Health 2013). Implementation can bring its own challenges when responders and decision makers must take actions. When you have multiple stakeholders with different interests and control over various parts of the response and recovery process (National Institute for Animal Agriculture 2013, 27–31), the success in response and recovery from a Foot-and-Mouth disease outbreak is reliant not only on good plans, but on effective execution. Based on the thesis authors experience she has found that effective execution is reliant on good decision making and the acceptance of the decisions by the many stakeholders involved. In other words the various stakeholders need to follow through with what is asked of them.

The concern regarding whether animal producers would cooperate in disease eradication measures was expressed in a 2002 GAO report on foot-and-mouth disease .

> Finally, delays could occur during an FMD eradication effort, because producers—fearing that they might not be adequately compensated for the fair market value of destroyed animals, products, and materials as well as cleaning and disinfection costs—may not cooperate with responders. (GAO, Foot and Mouth Disease, To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding Issues 2002, 10)

This thesis will determine the challenges to decision making in a U.S. foot-and-mouth disease outbreak, and propose recommendations to further support decision makers in this potential foot-and-mouth disease outbreak situation.

C. RESEARCH QUESTION

What are some challenges decision makers are likely to face within a multi-stakeholder complex environment of response and recovery from a major foot-and-mouth disease outbreak in the United States? What is the 2013 multi-stakeholder preparedness posture and can it be improved to increase support to decision makers?

Since the United States has not experienced an outbreak of foot-and-mouth disease since 1929, can the review of the UK foot-and-mouth disease outbreaks provide recommendations that can be incorporated into the United States preparedness posture to support decision makers? And finally, can recommendations for working in complex environments provide additional measures that can support decision makers during the execution of response and recovery efforts to a major foot-and-mouth disease outbreak in the United States?

D. LITERATURE REVIEW

The literature review was intended to identify current knowledge about how to support decision makers in a major foot-and-mouth disease outbreak. This review involved identifying foot-and-mouth disease response and recovery literature and government resources. Once relevant resources were identified, the material was carefully read in order to identify and categorize recommendations that directly related to decision support. This categorization provided an organizing structure to conduct a qualitative comparative analysis from which to evaluate recommendations from past outbreaks, and make the thesis recommendations for a U.S. outbreak.

The following resources were determined to be the most relevant for this thesis. The after action reports from the UK's 2001 and 2007 response and recovery from their foot-and-mouth disease outbreaks provided a real response example. Reports and resources from the U.S. government and animal health associations were examined to identify who the stakeholders are, what the response and recovery challenges are anticipated to be, and what challenges decision makers may face in a U.S. Foot-and-Mouth-Disease outbreak. In addition, the author reviewed literature that made

recommendation on how to work successfully in complex environments with multiple stakeholders.

For this review, the literature has been grouped into three categories: 1) UK's Lessons Learned Reports; 2) U.S. Government and animal health association plans and guidance documents; and 3) professional literature on working with multiple stakeholders in complex situations.

The review of current and past literature reveals a significant amount of information from the UK foot-and-mouth disease reports related to how support to decision makers has been done, and how they recommend it be improved during a foot-and-mouth disease outbreak. Several magazine and newspaper articles discussed basic aspects of the foot-and-mouth disease outbreaks in Asia and the Middle East. These articles did not specifically discuss decision support. An article from John Maday provided a summary of the recent outbreaks, indicating the variability that a foot-and-mouth disease outbreak can take.

U.S. Government plans and guidance documents for Foot-and-Mouth disease preparedness, response, and recovery are abundant. Specifically, the need for good decision making is a theme throughout the documents. These documents provide a rich description of the many facets and variables that must be taken into consideration when responding and recovering from a foot-and-mouth disease outbreak. However, these resources lack specifics on how to overcome decision-making challenges in the complex environment of a foot-and-mouth disease outbreak. To meet this challenge, the author found a significant amount of literature about decision making in complex situations, although not specific to a foot-and-mouth disease outbreak.

1. UK's Foot-and-Mouth Disease 2001 and 2008 Lessons Learned Reports

The UK Lessons Learned reports provided an evaluation of, and recommendations for, future improvements to foot-and-mouth disease outbreaks. *Foot and Mouth Disease 2007: A Review and Lessons Learned,* issued March 11, 2008, reviewed the 2007 UK foot-and-mouth disease outbreak response and recovery, based on

the lens of the improvements recommended from the 2002 report on the 2001 outbreak of Food-and-Mouth Disease in the UK. These reports identified challenges and successes in the area of multi-stakeholder collaboration and support to decision makers that can provide insight to what may work in the United States. Relevant recommendations from the 2008 report included the creation of an Independent Advisory Committee on Animal and Emerging Infectious Diseases (Anderson 2007, 2008, 6–7), and a strategy that focuses on early detection complimented with rapid response and tight coordination (Anderson 2007, 2008, 14–17).

Nadav Morag in *Comparative Homeland Security, Global Lessons,* describes the UK communication strategy in major disasters. The system is designed to build trust with stakeholders and involves: 1) open communication; 2) transparency in decision making; 3) engagement of stakeholders to make the decision-making process more participatory; and 4) acknowledgement of the uncertainty of the situation (Morag 2011, 315–316).

Agricultural statistical data from the United States Department of Agriculture, National Agriculture Statistic Services, and England's Department for Environment, Food, and Rural Affairs, provides statistics on farm production. These statistics allow the comparison of the scope of animal production between the two countries. The U.S. geographical area is over 60 times as large as England. England finishes 3.7 million pigs, while Iowa (one U.S. state) finishes 25 million per year. This information is critical in trying to evaluate if additional measures may be needed in the United States due to the larger geographical area, or larger size of production.

The value from these resources comes from the ability to evaluate an actual outbreak response and recovery event, and use these findings to help understand what might be encountered in a major foot-and-mouth disease outbreak in the United States. The information on England's trust building communication strategy and the size of production systems help to portray any differences between the two countries. This information can help in conducting a qualitative comparative analysis in search of what recommendations may improve the current multi-stakeholder preparedness posture in support of decision makers during the execution of response and recovery actions during a major foot-and-mouth disease outbreak in the United States.

Literature resources were found for recent outbreaks in Asia and the Middle East. These sources consisted of magazine and newspaper reports of the outbreaks. The author determined that these resources could provide some insights to the varieties of forms that an outbreak can take. A summary of the outbreak lessons learned is attached in the Appendix for that purpose. However, the magazine articles did not provide ample information for review regarding decision support recommendations.

2. Government Reports and Guidance Documents

There are numerous government reports and guidance documents related to the challenges inherent in response and recovery to a foot-and-mouth disease outbreak. The 2002 GAO Report, *FOOT AND MOUTH DISEASE, To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding issues,* described the unresolved challenges that may impede an effective and timely response: 1) ensuring the rapid identification and reporting of an FMD incident; 2) enhancing cooperation, coordination, and communication between federal, state, and local agencies, private veterinarians, and the industry; 3) developing an adequate response infrastructure to outbreaks of animal diseases; and 4) establishing methods to identify and dispose of animals, and indemnify livestock producers (GAO 2002, 9–10).

The United States Department of Agriculture and relevant governmental partners have developed Foreign Animal Disease Preparedness and Response resources. "The FADPReP/National Animal Health Emergency Response System (NAHEMS) Guidelines provide the foundation for a coordinated national, regional, state, and local response in an animal health emergency. These guidelines are designed to be integrated into the preparedness plans of other Federal agencies, State and local agencies, Tribal Nations, and additional groups involved in animal health emergency management activities" (United States Department of Agriculture 2013). These sources of information provide resources and plans for many of the anticipated aspects of a major foot-and-mouth disease outbreak. They are tools for use however, their applicability to a given situation must be determined by the decision makers and the actual use of them by public and private stakeholders are not guaranteed.

The following list illustrates the large scope of resources available and the complexity of the topics that animal health professionals have determined are necessary for a foot-and-mouth disease outbreak response and recovery.

FADPReP is not just one, standalone FAD plan. Instead, it is a comprehensive U.S. preparedness and response strategy for FAD threats. This strategy is provided and explained in a series of different types of integrated documents, as illustrated and described below.

Strategic Plans—Concept of Operations

- *APHIS Framework for Foreign Animal Disease Preparedness and Response:* This document provides an overall concept of operations for FADPReP preparedness and response for APHIS, explaining the framework of existing approaches, systems, and relationships.
- *National Center for Animal Health Emergency Management (NCAHEM) Stakeholder Coordination and Collaboration Plan*: This plan describes NCAHEM strategy for enhancing stakeholder collaboration and identifies key stakeholders.
- *NCAHEM Incident Coordination Group Plan:* This document explains how APHIS headquarters will organize in the event of an animal health emergency.
- NAHEMS Guidelines

  These documents describe many of the critical preparedness and response activities, and can be considered as a competent veterinary authority for responders, planners, and policy-makers.
- Industry Manuals

  These manuals describe the complexity of industry to emergency planners and responders and provide industry a window into emergency response.
- Disease Response Plans

  Response plans are intended to provide disease-specific information about response strategies. These documents offer guidance to all stakeholders on capabilities and critical activities that would be required to respond to an FAD outbreak.
- Critical Activity Standard Operating Procedures (SOPs)

  For planners and responders, these SOPs provide details for conducting 23 critical activities such as disposal, depopulation, cleaning and disinfection, and bio-security that are essential to effective preparedness and response to an FAD outbreak. These SOPs provide operational details that are not

discussed in depth in strategic documents or disease-specific response plans.

- Continuity of Business Plans (Developed by public-private-academic partnerships)

  Secure Egg Supply (SES) Plan: The SES Plan uses proactive risk assessments, surveillance, bio-security, and other requirements to facilitate the market continuity and movement of eggs and egg products during an HPAI outbreak.
  Secure Milk Supply (SMS) Plan: Currently under development, the SMS plan will help facilitate market continuity for milk and milk products during an FMD outbreak.

- Outbreak Response Tools

  Case definitions, appraisal and compensation guidelines and formulas, and specific surveillance guidance are examples of important outbreak response tools.

- State/Tribal Planning

  State and Tribal planning is essential for an effective FAD response. These plans are tailored to the particular requirements and environments of the State or Tribal area, taking into account animal populations, industry, and population needs.

- Industry, Academic, and Extension Planning

  Industry, academia, and extension stakeholder planning is critical and essential: emergency management is not just a Federal or State activity.

- APHIS Emergency Management

  APHIS directives and Veterinary Services Memorandums provide critical emergency management policy. APHIS Emergency Management documents provide guidance on topics ranging from emergency mobilization, to the steps in investigating (United States Department of Agriculture 2011, iii–iv).

The FADPReP plans resources are valuable in an outbreak situation. The decision maker's challenge involves understanding the situational aspects of the given outbreak and deciding what actions to take. It is impossible to predict where Foot and Mouth Disease may be introduced in the United States.

Foot and Mouth Disease Technical Factsheets, found at the Center for Food Security and Public Health and USDA foot-and-mouth disease websites, explain why it is also difficult to be prepared with the appropriate vaccines, because the virus can present itself in 60 types of seven distinct serotypes. These location and virus type variables limit

the ability to plan for specifics in advance of an outbreak (Center for Food Security and Public Health 2007, 1). At the time of disease identification, rapid response and collaboration from multiple stakeholders with various interests is required to limit the spread of and effectively eradicate the disease (National Institute for Animal Agriculture 2013, 32). Uncertainty of which virus will need to be responded to limits the ability to pre-plan specific vaccines. This is one more element that leads to the complexity of a response and recovery effort that decision makers will have to manage.

An additional source of response and recovery plans, with a different primary focus of continuity of business, was located. The Secure Food Plans focus on keeping non-contaminated animals and animal products moving during an outbreak. The continuity of operations plans are being developed in a joint partnership between animal production associations and federal and state animal health professionals. These plans are developed under the Secure Food Supply Plans initiative. This collaborative project aims to facilitate the continuity of business during a foreign animal disease outbreak. USDA APHIS has partnered with industry, state governments, and academia to develop plans for the secure supply of eggs, turkey, milk, and pork (Center for Food Security and Public Health 2013). Both types of plans rely on the availability of accurate information on the disease status of individual animals to meet their objectives.

A White Paper, *Foot-and-Mouth Disease—Fostering a New Preparedness Paradigm: Facilitating a Conversation Among Public and Private Sector Stakeholders*, which includes information synthesized from April 17–18, 2013, foot-and-mouth disease Symposium in Louisville, KY., provided insights into the different foot-and-mouth disease preparedness stakeholders and their priorities (National Institute for Animal Agriculture 2013). The stakeholder groups included: producers and producer organizations; trade media and industry public relations; practicing veterinarians and public health veterinarians, state veterinarians and animal health and regulatory personnel; diagnosticians' priorities; and government personnel priorities (National Institute for Animal Agriculture 2013). The top priorities for producers included, FDM information sources, familiarization with current FMD response plans, bio-security on the farm/ranch, active disease surveillance program and producer education/awareness

materials. The top priorities of government personnel included diagnostics in field, significant focus on realistic scenarios, trade restrictions, public education and improved communications among local/State/Federal industry regarding roles during a response (National Institute for Animal Agriculture 2013, 27–29). This resource is significant to this thesis because the differences in priorities indicate potential conflicting priorities between stakeholders in the decision-making process during a foot-and-mouth disease Outbreak.

These government reports and guidance documents provide an animal health expert-vetted framework of concepts, and plans for how to structure a response to a foot-and-mouth disease outbreak. The reports and guidance document highlights some of the issues that make response and recovery from a major foot-and-mouth disease outbreak complex. This complexity comes from many factors, including but not limited to, the following: the highly integrated United States animal production systems; the highly infectious nature of the disease; the need for rapid availability of animal traceability data; and the inherent inability to know the full extent of the outbreak until a few days have passed and clinical signs have emerged (Center for Food Security and Public Health 2007).

The documents noted in this section of the literature review:

- Stress the need for rapid, coordinated, and collaborative responses (GAO 2002) (Center for Food Security and Public Health 2013).
- Note that actions deemed necessary by decision makers may be considered voluntary by various stakeholders (GAO 2002) (National Institute for Animal Agriculture 2013).
- State that reliable disease data and information is critical to successfully implement both the plans for response and recovery from the foot-and-mouth disease outbreak areas, and the plans to continue operations in proven disease free areas (GAO 2002) (Center for Food Security and Public Health 2013) (National Institute for Animal Agriculture 2013).

3. Literature Resources on the Topics of How to Work Effectively with Multiple Stakeholders in Complex Situations

The literature review provided several resources related to operating in complex systems or situations. It is the contention of this thesis that decision makers will be

working on a complex problem with multiple stakeholders. These resources can help explain why the systems are complex and how decision makers can work within these complex systems.

A 2012 Government Accountability Office (GAO) report, *Disaster Recovery, Select Themes for Effective Long-Term Recovery*, provided recommendations about themes for effective long-term recovery (GAO 2012) from other major disasters. From 2008 to 2010, the Government Accountability Office studied long-term disaster recovery. The three themes that were determined to be important to successful disaster recovery efforts included: 1) the need for clearly defined roles and responsibilities; 2) the importance of effective coordination and collaboration among recovery stakeholders; and 3) the value of periodic evaluation of, and reporting on, recovery progress (GAO 2012). Based on the recovery period of over a year from the 2007 foot-and-mouth disease outbreak in the UK (Anderson, Foot and Mouth Disease 2007: A Review and Lessons Learned 2008), it is anticipated that a major foot-and-mouth disease outbreak in the United States would fall into this category of long-term, and these recommendations should be relevant to the objective of this thesis.

A 2005 GAO report, *Results Oriented Government Practices That Can Help Enhance and Sustain Collaboration Among Federal Agencies* recommended practices to enhance and sustain collaborative efforts across multiple agencies that would be needed in an FMD response and recovery. These included: defining and articulating a common outcome; establishing mutually reinforcing or joint strategies to achieve outcomes; agreeing upon roles and responsibilities; establishing compatible policies, procedures, and other means to operate across agency boundaries; and developing mechanisms to monitor, evaluate, and report the results of collaborative efforts (GAO 2005). This report is a resource for recommendations for multi-agency collaboration; however, it is limited by focusing on only federal inter-governmental collaboration. In making recommendations for a foot-and-mouth disease outbreak decision support, it should be considered that both inter-governmental collaboration and collaboration between public, private, and academic partners will be required. This is noted in the FADPReP plans and resources discussed previously (United States Department of Agriculture 2013).

Leadership was critical to the effective response and recovery in the 2007 foot-and-mouth disease outbreak in the UK.

> Taken as a whole, the immediate response in Phase 1 made a significant contribution to the eventual containment of the disease. Officials and stakeholders at all levels were seized by the critical importance of speed. There was a sense of leadership and central control at political and veterinary levels. The effort on the ground was ramped up quickly. The COBRA crisis management mechanism worked well. Work started quickly to trace the potential spread of the disease. (Anderson 2007, 2008, 43)

In unsettling complex situations, leadership must instill trust in all parties that have a stake or opinion about how the disaster should be handled. Sir Brian Burridge describes, "The Seven Principles of Public Life," consisting of selflessness, integrity, objectivity, accountability, openness, honesty, and leadership (Burridge 2006, 8). Burridge contends that the strategic leader needs the ability to contend with ambiguity and chaos, be willing to tackle the hard problems, and must understand that they are more often at the mercy of the environment in which they operate.

> First, the difficulty in analyzing ambiguity which is frequently dynamic in nature rather than static; that is, the variables are not only in constant motion but they continually change in their order of importance. Secondly, this degree of ambiguity and chaos means that common interpretation between individuals is problematic. Thirdly, the need, intellectually, to stop this ever-varying kaleidoscope to identify patterns is a conceptual activity requiring much right brain thinking. Fourthly, there is significant difficulty in identifying the journey through these patterns in communicating the resultant plan in a way that is digestible to those who cannot conceptualize the problem in the same way. Lastly, all this has to be conducted in an environment in which there are high expectations over results. (Burridge 2006, 12)

Meta-leadership skills are recommended to influence multiple stakeholders to collaborate across multiple organizations, multiple jurisdictions and public/private interests when the stakeholders have only a few similar and many different goals and objectives. The skills of a meta-leader are: courage, curiosity, imagination, organizational sensibilities, persuasion, conflict management, crisis management, emotional intelligence, and persistence (Marcus, Dorn, and Henderson 2005, 48–53). Insights into

collaborative decision making are provided by Judith E. Innes and David E. Brooher in their book, *Planning with Complexity* (Innes and Brooher 2010). Both of these resources provide suggestions for how multi-stakeholder leaders can optimize managing the response and recovery decision making efforts during a foot-and-mouth disease outbreak.

Ruth Wageman describes common tripwires for cross-organizational leadership teams in her paper, *Building Great Leadership Teams for Complex Problems* (Wageman n.d.). This paper focuses on teams that choose to tackle a problem they have identified, given the time to engage the problem. Due to the fact that the foot-and-mouth disease virus will spread with inaction on the part of responders, the multi-stakeholder leadership will be required to engage the problem immediately (GAO 2002, 9). Wageman identifies the tripwires as "unclear purpose, the wrong people are convening, and meetings are a waste of time." The conditions to combat the trip wires include: "compelling direction, convening the right people, and creating enabling structures" (Wageman n.d.). These resources provide recommendations that can be applied to multi-stakeholder leadership for decision making in an outbreak.

Several academic journals provide resources for effective decision-making frameworks. Once you have the appropriate leadership skills attached to the foot-and-mouth disease outbreak, they need a decision-making framework in which to operate in the complex adaptive situation. Due to the fact that it is a disease situation, leaders may look at a "best science-based decision." Simon French and Carmen Niculae propose that scientific information should not be ignored, but that complex incidents also are greatly influenced by social, economic, and political inputs that are often hard to predict, and should not be ignored (French 2004). In a complex adaptive system, there may be many answers or legitimate courses of action that can be taken to resolve the situation. 'Best science-based decision' implies one correct answer that can be far more precise than the situation would warrant. French and Niculae suggest using David Snowden's Cynefin Model, discussed next, for knowledge management in a crisis response.

The Cynefin Model provides a framework for decision making in four distinct realms: simple, complicated, complex, and chaotic. The simple realm is where one can sense, categorize, and respond. The complicated realm is where one can sense, analyze,

and respond. The complex and chaotic realms are where a foot-and-mouth disease response and recovery would fit. In the complex and chaotic realms, you need to build partnerships and collaborate to provide a variety of perspectives on the issue. According to David Snowden and Mary E Boone, the complex system has a large number of interacting parts, the system is dynamic, and solutions cannot be imposed, but emerge from the circumstances. In complex systems, you have to probe, sense, and then respond. In chaotic systems, you must act, then sense, and respond (Snowden and Boone 2007). This thesis reviews the current animal production systems in the United States and the challenges in response to the FMD outbreak in the UK. Snowden's recommendations for operating in complex environments can provide a sense-making tool for use in the decision making efforts during a foot-and-mouth disease outbreak in the United States.

Animal production systems in the United States are marvels of just-in-time systems. A constant flow of animals from birth through growth stages, finishing and slaughter, keeps farmers, feed providers, truckers, meat packers, grocers, and various animal by-product businesses working. Disruptions in systems like this can have consequences throughout the system. An added complication results from the fact that the system must focus on the added consideration of keeping the animals alive during a disruption. Animal welfare issues will also have to be considered. Donella Meadows provides insights into basic principles of systems in her book, *Thinking in Systems: A Primer*. She states that "the systems-thinking lens allows us to reclaim our intuition about the whole systems and home our abilities to understand parts, see interconnections, ask "what-if" questions about possible future behaviors, and be creative and courageous about system redesign" (Meadows 2008). Because of the systems nature of animal production, decision makers in a foot-and-mouth disease outbreak should benefit from understanding these systems principles. This understanding can help to define the potential for unintended negative consequences from stopping the flow of animals and to managing the disease response and recovery. Animal welfare considerations, during disruptions of the flow of animals, are noted as a consideration in the Secure Pork Supply plans (Center for Food Security and Public Health 2011).

Snowden and Boone recommend that in order to manage effectively in a complex environment, you must open up the discussion, set barriers within which the various interests can self regulate, stimulate attractors and encourage the growth of positive ones, encourage dissent and diversity to explore more options and manage the starting conditions, and watch for emergence of what is acceptable for moving forward (Snowden and Boone 2007). In a foot-and-mouth disease outbreak the perceptions of consumer stakeholders will be just as important as the rational science-based decisions that may be proposed. The Cynefin framework helps decision makers to understand that different stakeholders will perceive the situation differently (Snowden and Boone 2007).

4. Conclusion

The literature revealed that the United States Department of Agriculture has extensive plans and guidance documents for recommending possible response and recovery actions for a foot-and-mouth disease outbreak. It is important to note that this guidance is voluntary. The plans and guidance documents are in line with the World Organisation for Animal Health internationally accepted recommendations. The plans and guidance documents provide guidance on response and recovery and state that cooperation and information sharing is critical (Center for Food Security and Public Health 2013). The following is from the FADPReP 2012 Draft, *foot-and-mouth disease Response Plan (The Red Book)*, and illustrates that the decision makers will have multiple options to consider in a given outbreak.

> Four key outbreak response strategies, which are not mutually exclusive, are detailed in this plan. These strategies are: stamping-out; stamping-out modified with emergency vaccination to slaughter; stamping-out modified with emergency vaccination to live; and emergency vaccination to live without stamping-out.
>
> During an FMD outbreak response effort, many activities—such as epidemiology, surveillance, bio-security, quarantine and movement control, and depopulation—must occur in a deliberate, coordinated fashion. In addition to providing strategic direction on these various activities, this plan explains the underlying Incident Command System structure, applying National Response Framework (NRF), and National Incident Management System (NIMS) principles and systems to eradicate

> an outbreak of FMD in domestic livestock. (United States Department of Agriculture 2012, iii–iv)

The resources state that multi-stakeholder cooperation will be required, but they do not explore the challenges of working in complex situations with multiple stakeholders. Because the plans have never been implemented—due to the absence of the disease in the United States since 1929—additional insights on decision support were sought from the UK's foot-and-mouth disease Outbreaks.

The 2002 and 2008 lessons learned reports on the two foot-and-mouth disease outbreaks in the UK, provide some decision support recommendations from actual response and recovery efforts. These recommendations include early detection, rapid response, and tight coordination with rapid access to accurate situation data and information to support decision makers. The UK reports support the claim that a response and recovery effort to a major foot-and-mouth disease outbreak in the United States would fit the definition of working in a complex system.

The literature review revealed the interests and roles of many relevant stakeholders including academic, state and federal animal health agencies, and animal producers and trade associations (United States Department of Agriculture 2012, v). The public and private stakeholders concerned with animal health emergencies are versed in prevention, preparedness, response, and recovery from minor animal health emergencies that they must address every day. They are staffed for this normal level of activity. While plans and guidance are available for the major Foot-and-Mouth disease outbreak, little information was found regarding how to overcome execution challenges, and specifically, how to support decision makers in a rare complex large-scale event with multiple stakeholders. These challenges involve meeting the increased staffing levels for field response activities, as well as data and information management activities.

Finally, the literature on how to work in complex situations provides recommendations relevant to improving decision making and execution in a foot-and-mouth disease outbreak.

E. ARGUMENT

In a major foot-and-mouth disease outbreak, decision makers will be faced with a complex situation where there will not be one right answer to many of the decisions that will have to be made. Reliable information and data throughout the continually evolving outbreak situation is critical to effective decision making in complex systems. Assuring the availability of an information and data management support system plugged into a sense making framework can help decision makers operate in a major multi-stakeholder, multi-jurisdiction event. The Cynefin decision-making framework and meta-leadership skills as presented in the literature can be adopted for use in a major animal health emergency situation. This would enhance the preparedness strategy for response and recovery from a foot-and-mouth disease outbreak.

F. SIGNIFICANCE OF THE RESEARCH

> The reason that everybody likes planning is that nobody has to do anything.
>
> –California Governor Jerry Brown

This thesis seeks to identify the challenges decision makers are likely to face during response and recovery to a high consequence low probability foot-and-mouth disease outbreak event. Recommendations for how to work in complex situations with multiple stakeholders can be used to mitigate some of those challenges. The goal is to support decision makers striving to limit the size of the outbreak and limit the economic losses. Plans, like FADPReP, for how to work in a complex major foot-and-mouth disease outbreak, are an essential starting point for formulating an effective response and recovery effort (United States Department of Agriculture 2013). Decision makers will choose what specific parts of the available plans and guidance they will implement in the particular outbreak scenario that emerges.

When the foot-and-mouth disease outbreak occurs, execution of the response and recovery effort comes with the additional challenges of requiring collaboration between

stakeholders, some of whom do not work closely together on a regular basis and normally have different interests and goals (National Institute for Animal Agriculture 2013, 27–29).

Realistically, decision makers do not have the option of inaction for a foot-and-mouth disease outbreak. The disease outbreak will not wait for a response to be initiated; it will spread until effectively countered. A recent introduction to the United States of Porcine Epidemic Diarrhea (PED) spread from two farms in April of 2013, to over 300 farms in fourteen states by July 7, 2013 (American Association of Swine Veterinarians 2013). While foot-and-mouth disease is a mandatory reportable disease, Porcine Epidemic Diarrhea is not. While not considered to be as devastating as foot-and-mouth disease, PED does illustrate how fast viruses can move from farm to farm in the 2013, integrated animal production systems. "PEDV is not a listed disease of the World Organization for Animal Health (OIE); is not considered a foreign animal disease in the United States; and there are currently no interstate trade restrictions pertaining to PEDV in U.S. swine. It is not a zoonotic disease, does not affect people, and is not a food safety concern" (American Association of Swine Veterinarians 2013). During this PED outbreak, any coordination on reporting of disease information was voluntary; however, cooperation in the absence of authority was encouraged by the National Pork Board (National Pork Board 2013).

The National Institute for Animal Agriculture, and the United States Department of Agriculture, contends that failure to successfully collaborate to meet the foot-and-mouth disease outbreak challenge will have negative economic impacts as more animals are infected. This would lead to the disruption of more animal production systems from the disease and from the methods used in the pursuit of disease eradication (National Institute for Animal Agriculture 2013, 32–33). "FMD outbreaks are usually controlled by quarantines and movement restrictions, euthanasia of affected and in-contact animals, and cleansing and disinfection of affected premises, equipment, and vehicles" (Center for Food Security and Public Health 2007, 5).

This thesis will recommend how to facilitate the decision-making process in a rare but potential foot-and-mouth disease outbreak. This research will provide the various

foot-and-mouth disease stakeholder groups with an understanding of the complexity of the decision-making environment and provide guidance on how to mitigate some of the decision making challenges. The significance of this greater understanding comes from its ability to help minimize the economic disruption of an outbreak, and limit the negative impacts to the animals, producers, and the United States economy.

G. METHOD

The goal of this research is to make a contribution to improve decision making in a U.S. foot-and-mouth disease outbreak. The UK Government requested an independent review of both the 2001 and 2007 foot-and-mouth disease outbreaks. These two formal reports were chosen for the authors' qualitative comparative analysis between the UK and the U.S. They will be reviewed to gather recommendations that were made to improve decision making and decision execution. These documents have the advantage of being a comprehensive independent review of a major outbreak in another democratic country.

The UK reports revealed the decision support recommendations from the UK outbreaks. In order to structure the comparison, the decision support recommendations were placed into three categories; organizational, legislative and communications. These categories were chosen based on where the UK decision support recommendations fit. This framework allowed the author to compare the UK recommendations in these categories with the 2013 situation within the U.S. in the same categories. This categorization process provided an organizing structure to conduct a qualitative comparative analysis from which to evaluate decision support recommendations from past outbreaks, and make the thesis recommendations for a U.S. outbreak.

This framework also allowed the differences between the two Country's animal production systems to be identified and accounted for in formulating decision support recommendations. To provide an understanding of the U.S. 2013 Foot-and-Mouth preparedness posture, a review was conducted of planning and resource materials related to foot-and-mouth disease preparedness, response, and recovery. These resources were accessed from UDSA, Animal, and Plant Health Inspection Service, National Institute for Animal Agriculture, World Organisation for Animal Health, Multi-State Partnership for

Security in Agriculture, and from the Center for Food Safety and Public Health. These documents provided an understanding of the current U.S. preparedness posture for foot-and-mouth disease response and recovery. These plans and guidance documents provided additional qualitative information for the comparison with the UK response and recovery and provided an understanding of the current likely decision support capabilities in the United States.

This initial research indicated that decision makers would be working in a complex environment with multiple stakeholders. To address this challenge research was conducted to compile recommendations for working in this type of situation. The literature on how to work in complex environments provided recommendations in two relevant areas. First, recommended practices to facilitate multi-stakeholder collaboration recognized as effective in other major complex response and recovery operations. Secondly, provide leadership and sense making framework recommendations for operating in complex systems. The thesis author will take the research findings in these two areas and describe how they could be applied in the context of improving decision making during a multi-stakeholder coordinated response and recovery effort during a major foot-and-mouth disease Outbreak in the United States

The formal government recommendations from the UK lessons learned reports, the author's recommendations from the UK and U.S. qualitative comparative analysis, and the complexity research provided the basis for the recommendations in this thesis. The author's recommendations for how to meet the challenges decision makers are likely to face in a high-consequence, low-probability major animal health emergency, are based on an envisioned, hypothetical, major FMD outbreak event. A major FMD outbreak has not occurred since 1929 in the U.S. Due to this fact, the author chose the qualitative comparative mode of analysis consisting of using information, reports, and guidance documents from experts in the animal health field, to review, compare, and contrast what is known from two major outbreaks in the UK with what the U.S. animal production system might face in an outbreak situation in 2013.

This method is limited by the uncertainty of where and how the foot-and-mouth disease might present itself and how the stakeholders will actually act in a foot-and-

mouth disease outbreak. It is impossible to predict the individual actions of many potential stakeholders in a future event. For this reason resources providing lessons learned from past major outbreaks in the UK and recommendations from other major U.S. disaster response and recovery efforts s were used to mitigate this uncertainty to the best of the author's ability.

1. Statement on Thesis Author Perspective

The Thesis author acknowledges her professional role from June 2010 to the present (2013), as a co-coordinator of the Multi-State Partnership for Security in Agriculture (MSP). This professional role brings insights to the thesis problem; however it has the potential to introduce bias toward the merits of the Multi-State Partnership for Security in Agriculture regarding their potential role in any recommendations made in this thesis.

H. OVERVIEW OF THESIS CHAPTERS

Chapter II looks at how the 2013 preparedness posture for a major foot-and-mouth disease outbreak in the United States came to be. A brief overview is presented of the current stakeholders and partnerships that are active in animal disease preparedness activities within the United States. This will provide context of how the current stakeholders, capabilities and strategy are positioned to switch from a preparedness posture to an active management posture in a multi-stakeholder response and recovery situation. This information will inform the UK and United States qualitative comparative analysis in Chapter III.

Chapter III provides an analysis of the 2001 and 2007 FMD outbreak in the UK (England). This comparative review looks at the recommendations for improving decision making and response and recovery execution from the recent outbreak in the UK. The analysis is framed in the three general categories of organizational, legislative and communications. The governing systems and animal production systems of the two countries are also compared to determine if these recommendations can be utilized in the United States.

Chapter IV provides an explanation as to why decision makers will be operating in a complex situation during the response and recovery efforts to a major foot-and-mouth disease outbreak. This information provides a base understanding from which to structure further decision support recommendations.

Chapter V provides an overview of current research based strategies that highlight the uniqueness of complex systems and why they need to be approached with a specific set of strategic and leadership skills. Specific collaboration recommendations from the literature are presented, which are documented as being helpful in past major response and recovery efforts.

Chapter VI compiles the insights from Chapters II–V, and provides recommendations for improving the decision-making capabilities needed for managing the response and recovery to a major foot-and-mouth disease outbreak in this complex system with multiple stakeholders. Challenges to implementation are discussed and recommendations for future research are suggested.

Chapter VII presents the thesis main conclusions.

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II. PREPAREDNESS STRUCTURE AND STAKEHOLDERS FOR A 2013 U.S. FOOT-AND-MOUTH DISEASE OUTBREAK

The year 2001 was quite a year of disruption. The September 11 attacks and the foot-and-mouth disease outbreak in the UK were two events that overwhelmed the normal response capabilities in their respective realms. The public's confidence in everyday life, going to work and a consistent food supply system, were upended. A foot-and-mouth disease outbreak is considered to be one of the most economically disruptive animal health emergencies that the United States would face (World Organisation for Animal Health n.d.).

During the beginning outbreak phase of the disaster attention cycle, people wanted to know why someone was not working on this foot-and-mouth disease problem (Bellavita 2005). How could this have happened? How will we address this threat moving forward? After the UK struggled with a major outbreak in 2001, inquiries began regarding how prepared the U.S. was to handle a foot-and-mouth disease crisis. Grants were provided to build the systems and programs to attempt to stop this from occurring in the U.S., and if it were introduced, be better prepared to respond to an outbreak. The goal was to build the capacity to stop an animal disease emergency from devastating the U.S. animal production system, and inflicting economic harm.

Several major events in 2001 paved the way for increased United States government investments in foot-and-mouth disease preparedness and response capacity. The Foot-and-Mouth disease outbreak in the UK in 2001 highlighted the potential costs of the threat. The terrorist attacks of September 11, 2001, the creation of the Department of Homeland Security, and the subsequent focus on infrastructure protection in the food and agriculture sector as directed in Homeland Security Presidential Directive-9 (Department of Homeland Security 2004), led to grant funding for the development of preparedness and response planning resources to address the foot-and-mouth disease threat (Center for Food Security and Public Health 2013).

In the past ten years, Federal, State, academic, and industry animal health professionals and emergency responders have made great strides in the promotion of bio-security measures to prevent the introduction of foot-and-mouth disease . Major improvements were made in the development of incident command based response strategies to coordinate in a complex response environment and improvements in foot-and-mouth disease vaccines that expand the response options in a foot-and-mouth disease outbreak (United States Department of Agriculture 2013). Due to this threat and the potential economic impacts of an outbreak, the United States Department of Agriculture and state departments of agriculture led the multi-agency collaborative efforts to developed response plans, guidelines, industry manuals, standard operating procedures, and other resources. These plans are conceptualize, based on animal health authorities and to what extent the government representatives intend on responding to, and working with, local governments and producers during an outbreak (United States Department of Agriculture 2012).

The plan and guidance documents for response and recovery of foot-and-mouth disease outbreak are readily available, along with expert vetted resources that set a framework from which to structure and approach a response and recovery effort to a foot-and-mouth disease outbreak. Use of the plans and guidance is voluntary. The bulk of these materials are located on the Center for Food Security and Public Health (CFSPH) website for easy access. "All of [the] materials developed by the CFSPH were written by veterinarians, reviewed by designated subject matter experts within and external to USDA APHIS, illustrated by professional graphic designers, and posted on the FADPReP Collaboration website for broad review and comment. Once finalized, the content is reviewed and approved by the USDA Legislative and Public Affairs (LPA) for wider distribution" (United States Department of Agriculture 2013).

These plan and guidance documents state that rapid response, availability of accurate disease data and information for decision makers, and multi-stakeholder collaboration in a major foot-and-mouth disease outbreak, are important to facilitating an effective response that limits the spread of the disease (United States Department of

Agriculture 2012). Due to the complexity of how this disease can present itself, decision makers must decide which actions are appropriate in a given outbreak situation.

A. THE 2013 ANIMAL PRODUCTION INDUSTRY PERSPECTIVE

The animal production industry acknowledges the threat from foot-and-mouth disease and has taken active steps to reduce the industry's vulnerability from an accidental introduction. Industry trade organizations have adopted and promoted improved bio-security measures at animal production facilities. The dairy industry in particular has worked with state and federal animal health officials and emergency managers to develop strategies for moving milk in the midst of a foot-and-mouth disease outbreak situation. It is called the "Secure Milk Supply Program" (Secure Milk Supply 2012). The pork industry is currently working on a Secure Pork program (Secure Pork Supply Program 2013). The dairy and pork industry have shown willingness to work on some preparedness measures with state and federal animal health agencies (Center for Food Security and Public Health 2013).

Animal agriculture industries have focused on how to assure continuity of business for those production systems that are not infected while the government is undergoing their eradication measures in the areas that are infected. Industry continues to advocate for federal investment in vaccination development and improvement (National Institute for Animal Agriculture 2013, 21–23).

The following industry priorities were reported at the 2013 foot-and-mouth disease Symposium. It should be noted that these priorities are limited to the opinions of the industry representative who were in attendance at the symposium sponsored by the National Institute for Animal Agriculture; however, they do indicate interests in congruence with animal health officials for effective response and recovery efforts.

Producers and producer organizations priorities include:

- FMD information sources
- Familiarization with current FMD response plan
- Bio-security on the farm/ranch

- Active disease surveillance program
- Producer education/awareness material—from how to identify FMD in their animals to bio-security measures that can be implemented before an event takes place
- Consumer education, including Secure Food Supply plans for all food animal species, developed
- Valid pre-harvest traceability system
- Communication protocols, including those who deliver messages to different entities
- Vaccination policy, including when vaccination should be used
- Identification of person/persons responsible for implementing a response plan, including vaccinations
- Animals in transport be allowed to continue to destination at the time an outbreak is announced
- Permitting during a disease event (National Institute for Animal Agriculture 2013, 27–28).

Reiterating the goals stated in the 2012 Draft of the USDA FADPReP foot-and-mouth disease Response Plan (The Red Book) the National Pork Board also cited the following goals of a foot-and-mouth disease response.

> (1) Detect, control, and contain FMD in animals as quickly as possible; (2) eradicate FMD using strategies that seek to stabilize animal agriculture, and protect public health; and (3) provide science- and risk based approaches and systems to facilitate continuity of business for non-infected animals and non-contaminated animal products. (Webb 2013)

The industry focus is on continuity of operations for non-infected animals and animal products; and on supporting consumer confidence in an outbreak. The animal production industry also wants to be assured that response plans and vaccination strategies are available if needed. The secure food supply programs are based on the notion of being able to differentiate the infected from the non-infected to facilitate continuity of operations for the non infected producer. This requires validated information to successfully operate this way.

B. Multi-state Partnership

Modern animal agriculture includes many large scale production systems that routinely cross both state and national boarders in the life cycle of the animals (MacDonald and McBride 2009). Seeing the need for regional collaboration, the Multi-State Partnership for Security in Agriculture (MSP) was formed in 2003 with seven member states in the upper Midwest. Today it boasts 15 member states (Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, South Dakota, and Wisconsin) (Multi-State Partnership for Security in Agriculture 2013).

Multi-state partnership participants are from each state's agriculture and animal health agencies, with coordination provided by the Iowa Homeland Security and Emergency Management Department. Recent coordination, planning, exercises, and project implementation has increased the preparedness of the local, state, and regional animal production systems to avoid animal health emergencies when possible, and address outbreaks when needed. These activities have been supported by Homeland Security grant dollars. This funding comes through the State Administrative Agent of each state that is willing to contribute a portion of their allocated State Homeland Security funds to the food and agriculture sector. Based on the thesis author's knowledge, the funding for this initiative will not be available from the Department of Homeland Security, through the state administrative agents, after the fiscal year 2012 grant.

While funding for food and agriculture multi-state partnerships are dwindling, the threats and the challenges to effectively respond to and recover from either a natural or intentional introduction of the FMD viruses have not been reduced. In the past ten years, animal production systems have trended toward larger and more integrated production systems that routinely cross both state and country borders (MacDonald and McBride 2009). At the same time, it is hard to justify funding for an event that has not occurred since 1929.

In 2013, the main stakeholders that will have some involvement with a major foot-and-mouth disease Outbreak include state and federal animal health officials, private animal producers, regional partnerships, animal health laboratory networks, animal health

and veterinary associations and academic research departments. Each stakeholder has a specific interest, role, and responsibility in the disease response and recovery effort (National Institute for Animal Agriculture 2013, 27–29).

Due to the highly infectious nature of foot-and-mouth disease, and the loss of export markets upon the identification of the disease in the United States, an outbreak at one producer premise is a concern for, and will impact, all producers within the U.S. If foot-and-mouth disease is introduced to the United States, producers and state and federal animal health regulators will have to cooperate to eradicate the disease.

> To manage the risk and have an effective emergency management plan in place ready to activate requires cooperation among all levels of government, the private sector and the community. Other response agencies include health and conservation departments, local government, police, emergency services and volunteer organizations. (National Institute for Animal Agriculture 2013, 6)

B. CHAPTER SUMMARY

The multiple stakeholders understand that cooperation between the private and public sector, and the community, will be required in an outbreak situation. Multi-state partnerships have been formed to facilitate regional collaboration however funding is ending for these partnerships. Resources and plans have been developed to meet the challenges of response and recovery from an outbreak. The planning focus of public entities is primarily on stopping the spread of the disease, while private industry has expressed a strong interest in maintaining continuity of business around the outbreak zones.

The preparedness structure in 2013 consists of multiple stakeholders with various interests within a complex environment. The one goal they all have in common is to detect, control, and contain the foot-and-mouth disease in animals as quickly as possible. This requires accurate situational awareness for decision makers.

The remaining chapters will explore this complex environment and look for ways to improve decision making within it.

III. WHAT CAN THE U.S. LEARN FROM THE UK FOOT-AND-MOUTH DISEASE RESPONSE AND RECOVERY EXPERIENCES IN SUPPORT OF DECISION MAKING?

A. UK'S FOOT-AND-MOUTH DISEASE PREPAREDNESS, RESPONSE, AND RECOVERY POSTURE IN 2013

The UK has experienced two outbreaks of Food and Mouth Disease (FMD) in the first decade of the twenty-first century. The 2001 outbreak response resulted in the culling (killing) of over 4 million sheep and cattle, lasted 8 months, and resulted in over $ 10 billion in agriculture and tourism losses to the UK economy (GAO 2002, 2). A second outbreak in 2007 resulted in an improved response that benefited from the lessons learned from a review of the 2001 outbreak (Anderson 2008, 6).

In 2001, the UK learned firsthand how economically devastating an outbreak of foot-and-mouth disease can be (Anderson 2002). This impact was felt by animal producers who lost animals in the course of disease eradication, and by the local economy within the impacted area. Although all parts of the UK were impacted by the foot-and-mouth disease outbreaks, this analysis will focus on what actions England took to meet future decision support challenges.

England learned that it is important to keep a watchful eye open for early detection, support rapid and coordinated response and recovery efforts, provide scientific data to policy decision makers, and use open communications with both the general public and animal producers (Anderson 2008, 14–19).

Today, the UK's strategy to combat potential future outbreaks of foot-and-mouth disease relies on the dual focus of early detection and rapid response, in concert with tight coordination by all stakeholders. In support of this strategy, the following nine areas of recommended practices were presented for future foot-and-mouth disease response and recovery efforts as determined by England's official government review of the 2007 outbreak requested by the Prime Minister and the Secretary of State for the Environment. (Anderson 2008, 14–19):

- Maintain vigilance
- Be Prepared
- React with Speed and Certainty
- Explain policies, plans and practices
- Respect local knowledge
- Apply risk assessment and cost benefit analysis
- Use data and information management systems
- Have a legislative framework
- Base policy decisions on the best available science

Based on the decision support scope of inquiry for this thesis, recommendations will come from the UK's foot-and-mouth disease outbreak review (Anderson 2008), and the United States foot-and-mouth disease Strategy documents (Center for Food Security and Public Health 2013). This thesis will focus on early detection, rapid response and tight coordination by all stakeholders in the comparison of decision support lessons learned from the England outbreaks, to the current U.S. animal production situation. This analysis will be grouped into three areas: organizational structure, legislative structure, and the communication strategy that England currently utilizes to monitor and manage the threat of major foreign or emerging animal diseases.

1. UK's Animal Health Emergency Organizational Structure and Animal Production Systems

To improve the nation's capabilities to respond to and recover from a major animal health emergency, the Department for Environment, Food, and Rural Affairs (DEFRA) was created in 2001. The creation was in part brought about by the perceived lack of coordination between relevant governmental agencies during the first foot-and-mouth disease outbreak in 2001.

In 2013, according to the DEFRA website, the Department for Environment, Food, and Rural Affairs (DEFRA) is a government department in the UK that sets policies and legislation, and works with others to deliver policies such as:

- the natural environment, biodiversity, plants and animals
- sustainable development and the green economy
- food, farming, and fisheries
- animal health and welfare
- environmental protection and pollution control
- rural communities and issues

Although DEFRA only works directly in England, they work closely with the devolved administrations in Wales, Scotland, and Northern Ireland, and generally lead on negotiations in the EU and internationally (Department for Environment, Food and Rural Affairs n.d.). England takes an integrated approach to food and environmental issues.

The DEFRA staff includes approximately 10,000 workers in 2010. Of this, a small portion works on animal health issues. DEFRA covers animal health policy implementation for a population of 5.4 million cattle 3.7 million pigs, 14.6 million sheep and lambs, and 118 million types of poultry. The total land in agricultural production in England was 8.9 million hectares in 2012 (DEFRA 2012). England's agricultural workforce was at 307,000 in 2012, resulting in 0.57 percent of the overall population. England covers 50,350 sq miles (130,400 km^2), with a population 53 million people.

When the 2007 outbreak was identified, coordination was implemented from the highest level of government to the local level.

> At national strategic level, the response was overseen and steered by the Cabinet Office Briefing Room (COBR), the government's central crisis management committee. COBR met first at 21.00 on Friday 3 August and regularly thereafter (and in the early days was often chaired by the Prime Minister). It brought together all the main departments and agencies involved in responding to the disease, including representatives from the Scottish Executive and the Welsh Assembly. (Anderson 2008, 8)

The knowledge of the devastation that an unchecked outbreak could wreak instilled the support at all levels of government and with producers, to treat the situation seriously and respond quickly. Ministers, officials, and stakeholders at all levels were seized by the critical importance of speed. There was a certainty and clarity in the DEFRA response that was absent six years ago (Anderson 2008, 15).

2. Creation of a Technical Advisory Board

During the preparedness phase, The Animal Health and Welfare Board for England (AHWBE) was created to bring together animal health and welfare experts. The Board is tasked with making recommendations to DEFRA on setting policy priorities, assessing the risk of threats from animal disease and how to manage them and reviewing and developing contingency plans for dealing with new disease outbreaks (DEFRA 2013). This board is aligned with the concept that, "The increasing movement of people and goods as a result of globalization, together with the advance of climate change, contribute to the growing risks to this country from the introduction of exotic diseases" (Anderson 2008, 6). The board fulfills an advisory role with final decisions on policy made by the government Ministers.

The UK has made improvements from the 2001 outbreak. This ability to gather data, assess risk, and implement eradication measures that are appropriate in scope to the outbreak situation, is valuable (Anderson 2008, 75). If decision makers underestimate the scope of the infected area, the disease will spread. If decision makers overestimate the scope, expensive resources will be wasted, and more people will be disrupted than necessary. A miscalculation either way may result in loss of confidence from the public that the situation is being handled appropriately. This risk of losing public confidence based on poor decisions was illustrated during the 2007 outbreak, where after the first phase was declared by DEFRA to be over on September 8, a second phase with five other cases followed on September 12. "In Phase 1, the mood of the farming community was supportive, co-operative, and confident. By Phase 2, the mood was impatient and ready to challenge and question. DEFRA's authority had been weakened" (Anderson 2008, 13).

3. Animal Traceability and Data Management Capabilities

Since the 2001 outbreak, England has passed strict rules for animal identification, farm premise identification, and database tracking of the health and movements of animals within the Nation. An ID tag was applied to all pigs that contained the date of movement and a location that was electronically entered into the BPEX movement

recording system. This system provided the data necessary for situational awareness in a disease outbreak (Department for Environment, Food and Rural Affairs 2013).

The response in 2007 was swift and targeted, and was assisted by the availability of everyday movement data available for all susceptible animals (Anderson 2008, 8). New tracking laws allowed for the rapid trace back of potential disease exposure when it was identified. The availability of information and data increased the chances of making appropriate science-based decisions.

> The lessons from 2001 were largely applied in 2007. There was recognition within DEFRA that science needed to drive many of the policy decisions. Scientific input was central to the development of detailed contingency plans. It was also central to the way in which the FMD outbreak was managed, both in the putting in place specific control and surveillance strategies, and in providing the evidence necessary to demonstrate to the EU and OIE that the disease had been eradicated. (Anderson 2008, 83)

This was an improvement over the 2001 response, where lack of data resulted in the culling of larger numbers of animals, due to the uncertainty from the lack of trace-back tools (Anderson 2008, 66).

4. England's Legislation Impacting Decision Making in a Foot-and-Mouth Disease Outbreak

In 2004, the Civil Contingency Act was passed, which provided the legal framework to respond to emergency situations like, terrorism, flooding, or animal disease outbreaks. Forty-seven local resiliency forums were created to provide a framework for civil protection at the local level.

> The Act also repealed out-of-date legislation (including the Emergency Powers Act 1920) and allowed special temporary legislation to be passed, which might be needed to deal with a serious emergency. The Act allows for the use of emergency powers on a regional or devolved administration basis. Emergency powers remain a reserved matter, although the devolved administrations are consulted. (Anderson 2008, 77)

In addition to legislatively backed improvements to manage the emergency, new legislation specific to actions necessary to control and eradicate the foot-and-mouth disease were passed in the 2006 FMD Orders under the Animal Health Act of 1981.

The Orders set out the legal powers around:

- Notification, suspicion, and investigation of disease (including the establishment of a temporary control zone and movement control zone).
- Measures following confirmation of disease (including tracing work, slaughter and implementing PZs and SZs).
- General and supplementary provisions (such as the production of licenses and duties of local authorities).
- The Animal Health Act 2002 amended key areas of the 1981 Animal Health Act to allow further powers—notably around rights to slaughter, testing, and vaccination (Anderson 2008, 79).

As noted in the organizational section, the UK has passed laws that prescribe a unified system of animal identification, farm premise identification, and electronic reporting and tracking of animal health and movements within the Nation. This system is designed to provide improvements in collecting the data necessary for situational awareness in any future disease outbreaks. Reliable data is an asset for assisting decision makers in a foot-and-mouth disease outbreak (Anderson 2008, 66–75). While the data management was better in 2007 than 2001, calls for further improvements still continued to be made.

> Good data management and information systems—including GIS—are needed for the effective management of an outbreak of exotic animal disease such as FMD. The 2002 Report made this clear and stressed the importance that Defra should attach to this task. However, in 2007, Animal Health was still operating a confusing network of incompatible systems which processed incomplete and inaccurate data on livestock registration and movements.
>
> It is disappointing to record that so little has been achieved over the past six years. This is a lesson not yet applied from the 2001 epidemic. (Anderson 2008, 75)

The legislative actions strengthened the decision makers' ability to gather and utilize data and information for continual situational awareness throughout the outbreak.

5. England's Communications in a Foot-and-Mouth Disease Outbreak

England's open communications policy for a potential foot-and-mouth disease outbreak was to explain policies, plans, and practices openly to both animal producers and the general public. In addition: the DEFRA website would provide up-to-date situational awareness of any incident; new media tools would be utilized to assure that the farmers and general public were aware of the situation; and farmers or the general public would be made aware of any measures they may have to take. "Livestock keepers have a responsibility to stay informed during an outbreak and are advised to register to receive AHVLA test alerts in advance" (DEFRA 2011). Messages were already being prepared for signs and symptoms, appropriate bio-security, and control measures.

6. Building Trust and Cooperation through Open Communications

This strategy of open communication was designed to maintain trust and facilitate cooperation of all stakeholders involved throughout the disease eradication process. The British Government utilizes Six Guiding Principles of a Communication Strategy that is more inclusive.

> The British government has changed its strategic communications approach to incorporate more openness about the nature of risks and the uncertainties of some situations, more transparency regarding decision-making process in government, and more engagement with stakeholders and the broader public at an early stage in order to make decision-making process more participatory. (Morag 2011, 316)

All strategies are designed to build trust with the public. Disease outbreaks by their inherent nature of virus propagation from host-to-host are fluid and it is difficult to know all the facts at any given point of time. For these reasons, open communications must acknowledge this uncertainty. The UK demonstrates that they understand this concept of being clear about the realities of any FMD response situation.

> The delivery of public messaging should also be consistent, allow people to know what they need to do to protect themselves, stick to the facts and avoid speculation, and avoid over optimistic assessments regarding the return to normalcy. (Morag 2011, 318)

In summary, the main goal of the open communication strategy that acknowledges uncertainty is to build trust with the consumer and the animal producers. This trust is invaluable when you must rely on the actions of different stakeholders in an outbreak situation.

B. U.S. FOOT-AND-MOUTH DISEASE PREPAREDNESS, RESPONSE, AND RECOVERY POSTURE IN 2013

This section looks at the foot-and-mouth disease issues that are stated to be of concern to the public and private stakeholders in 2013. This first section provides context regarding the concerns of the main stakeholders in a foot-and-mouth disease outbreak.

The qualitative comparative analysis shows that the United States animal production systems are larger with animals moving greater distances throughout their lifespan. The United States animal producers have the added regulatory level of state animal health governance, as well as federal governance. And the understanding of the need for coordinated communications to the general public and between stakeholders is acknowledged by both England and the United States.

1. Stakeholder Understanding of Lessons Learned–2013

In April 2013, The National Institute of Animal Agriculture brought together public, private, and academic stakeholders to discuss a new preparedness paradigm for foot-and-mouth disease in the United States (National Institute for Animal Agriculture 2013). The lessons learned from outbreaks around the world, including the UK outbreaks, are noted below:

> Additional lessons the United States can learn from these outbreaks and outbreaks that have occurred during the past three years in Japan, Bulgaria, Turkey, Israel, and Egypt include:
>
> - Early recognition, reporting and detection are keys to controlling the outbreak.
> - Effective bio-security helps minimize the spread of the disease.
> - When necessary, early implementation of vaccination is critical to success.

- The issues that can have the biggest impact should receive top priority.
- The United States must have the ability to scale up and quickly prepare large numbers of FMD vaccines.

The experiences of USDA-APHIS with foreign animal diseases underscore further lessons (National Institute for Animal Agriculture 2013, 11–12):

- State-Federal-Tribal-industry planning should respect local knowledge.
- Unified Command goals should be clearly defined and attainable.
- Action should be taken quickly and with certainty.
- Science- and risk-based approaches should be employed.
- Guidelines, strategies and procedures need to be communicated and understood by responders and stakeholders.
- Early detection and rapid tracing are essential for the effective and timely control of an outbreak.
- High expectations for successful outcomes may require the rapid scale-up of resources and trained personnel.
- Communication is vital

This summary indicates the issues that public and private stakeholders in the U.S. consider important for Foot-and-Mouth disease preparedness and response in 2013. Additional information on the various serotypes of foot-and-mouth disease and specific lessons learned from the various disease eradication efforts were undertaken in individual outbreaks are available in the Appendix. This overview of past outbreaks highlights the variability in species impacted, the serotype involved, response action limitations, and the consequences, sometimes negative, of various response actions chosen by decision makers (Maday 2013). Due to this variability, each outbreak will have unique circumstances that decision makers must understand so that response and recovery decisions and actions can be tailored accordingly.

2. U.S. Animal Health Emergency Organizational Structure and Animal Production Systems

This section describes the structure of animal production systems and animal health regulatory oversight in the United States. This is done to compare the United States and UK animal production and regulatory production systems. This qualitative comparison will be used to evaluate and recommend if any UK foot-and-mouth disease decision support recommendations should be adopted in whole, modified, or rejected.

The continental United States covers 3,119,884 square miles of geographic area. This is 60 times larger than the UK, and contains 50 states with distinct animal health emergency statutes, and animal health departments (National Association of State Departments of Agriculture 2013). This geographical connection results in a shared governance situation for a foot-and-mouth disease outbreak if it crosses state lines. At the Federal level, The United States Department of Agriculture Animal and Plant Health Inspection Service have the responsibility "to protect and improve the health, quality, and marketability of our nation's animals (including various wildlife species), animal products, and veterinary biologics" (USDA APHIS 2012).

Each state has laws regarding animal disease detection, control, and available eradication measures the state can take. In Iowa, the law is found in CHAPTER 163 INFECTIOUS AND CONTAGIOUS DISEASES AMONG ANIMALS (Iowa State Legislature 2013), and the administrative rules are found in Chapter 65 (Iowa Department of Agriculture and Land Stewardship 2013). Identification of foot-and-mouth disease starts with the reporting of clinical signs by the producer. Identification of FMD in the U.S. will have immediate impact on trade by closing all exports of sheep, hogs, and beef, and potentially other products from the U.S (World Organisation for Animal Health n.d.).

Due to the overlap of state and federal authorities for animal health emergencies, both state and federal governments have jurisdiction in a multi-state outbreak. The decision making, strategy development, and coordination structure during an outbreak will involve many states, as well as the U.S. Department of Agriculture. This is acknowledged in the various FADPReP documents. According to the foot-and-mouth

disease Preparedness Plans, state and federal agricultural officials should work together to eradicate the disease (Center for Food Security and Public Health 2013).

It is the contention of this thesis author that the fine points of exactly how a specific outbreak response and recovery will be executed in a real situation is unknown until animal health officials and impacted producers can evaluate the exact foot-and-mouth disease outbreak situation they are presented with, and the reality of the available resources. The plans provide a great starting point, and are very valuable in sorting out difficult policy issues prior to an outbreak; however, the FADPReP author' acknowledges that they are only guidance documents.

> While best efforts have been used in developing and preparing the *FMD Response Plan*, the U.S. Government, U.S. Department of Agriculture and the Animal and Plant Health Inspection Service and other parties, such as employees and contractors contributing to this document, neither warrant nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information or procedure disclosed. The primary purpose of this *FMD Response Plan* is to provide strategic guidance to those government officials responding to a FMD outbreak. It is only posted for public access as a reference. (United States Department of Agriculture 2012)

The animal production systems in the United States are more integrated and larger than in the UK. In the United States, animal production is typically large scale and integrated (MacDonald and McBride 2009). It is not uncommon for pigs to be born in North Carolina or Canada, and be shipped at 5–6 weeks of age to Iowa or another Midwestern state for finishing. Pigs can then be shipped to slaughter in another state (MacDonald and McBride 2009). The U.S. produces approximately 100 million hogs annually, and large operations with more than 5,000 or more head, account for 4.5 percent of all operations, but produce over 61 percent of the total inventory (United States Department of Agriculture 2010).

These large production systems rely on the uninterrupted flow of live animals. The systems are not designed or equipped to operate in a stop movement environment (National Pork Board 2013). The system is lean without extra carrying capacity at the various stages of the 6–7 month lifespan of the hog should movement not be allowed

(MacDonald and McBride 2009). This is relevant to the thesis problem, because one tool for disease eradication is a "stop movement order" for animals. Due to the large number of animals on the road on any given day, and limited carrying capacity at animal production facilities, animal welfare concerns will have to be considered in the decisions regarding how to manage a given outbreak (National Institute for Animal Agriculture 2013, 32). In a stop movement situation the animals on the road have to be housed and fed even if their trip is interrupted.

Organizationally, the UK is similar to the United States in their strategy to stamp out a foot-and-mouth disease outbreak without the use of vaccination, if possible. The United States' animal production systems are different from the UK in size of operations, greater distances traveled by the animals and the additional layer of state government regulation. Each of these aspects adds a layer of complexity that can impact the decision makers' ability to implement their chosen actions.

3. U.S. Legislation Impacting Decision Making in a Foot-and-Mouth Disease Outbreak

The commerce clause in the U.S. Constitution, Section 8 states that Congress shall have the power to regulate commerce with foreign nations, and among the several states, and with the Indian Tribes. In the area of animal health, oversight authority states have authority over animals that are born, raised, and slaughtered within one state, and the USDA has some additional authorities over restricting movement of diseased animals that cross state lines.

> The Secretary may prohibit or restrict:
>
> (1) the movement in interstate commerce of any animal, article, or means of conveyance if the Secretary determines that the prohibition or restriction is necessary to prevent the introduction or dissemination of any pest or disease of livestock; and
>
> (2) the use of any means of conveyance or facility in connection with the movement in interstate commerce of any animal or article if the Secretary determines that the prohibition or restriction is necessary to prevent the introduction or dissemination of any pest or disease of livestock. (United States Code 2012 Title 7 n.d.)

This law gives the Secretary of Agriculture the authority to order a stop movement, and to set up quarantine zones.

4. Animal Traceability and Data Management Capabilities

Recommendations from the UK's foot-and-mouth disease outbreaks noted the importance of the ability to identify individual animals, and to know on what farms the individual animals have been located over the last month or two when a disease outbreak occurs. This was considered crucial to rapidly and accurately provide decision makers with the data needed to make decisions. This ability to trace back locations is required, because animals can spread the disease for a few days to a week prior to any signs of any apparent infection (Center for Food Security and Public Health 2007, 2).

Premise ID is a unique identifier for a single farm location. When used in combination with animal identification, the location and movement of individual animals can be tracked. In the United States, the registering of individual farms with a premise ID is voluntary in many states, and mandatory in other states. Indiana and Wisconsin have adopted state laws requiring mandatory registering of standardized premises IDs. Recognizing the importance of their dairy industry, Wisconsin has taken the stance that this will help them to maintain continuity of business in a disease outbreak situation (Wisconsin Department of Agriculture, Trade, and Consumer Protection 2013).

A universal animal identification system is another key component that assists decision makers in a FMD outbreak. After several years of effort, a USDA final rule on implementation of an animal disease traceability system for livestock moving interstate has been approved by the United States Department of Agriculture. The rule was modified after a comment period and the adopted rule included flexibility in the system to meet local needs.

Under the final rule, unless specifically exempted, livestock moved interstate would have to be officially identified and accompanied by an interstate certificate of veterinary inspection or other documentation, such as owner-shipper statements or brand certificates.

After considering the public comments received, the final rule has several differences from the proposed rule issued in August 2011. These include:

- Accepting the use of brands, tattoos and brand registration as official identification when accepted by the shipping and receiving States or Tribes
- Permanently maintaining the use of backtags as an alternative to official eartags for cattle and bison moved directly to slaughter
- Accepting movement documentation other than an Interstate Certificate of Veterinary Inspection (ICVI) for all ages and classes of cattle when accepted by the shipping and receiving States or Tribes
- Clarifying that all livestock moved interstate to a custom slaughter facility are exempt from the regulations
- Exempting chicks moved interstate from a hatchery from the official identification requirements (United States Department of Agriculture 2013).

The adoption of a rule with flexibility acknowledges local issues and reduces day-to-day costs of animal production systems. The final rule favors ease and cost efficiency in the day-to-day operations and movement of animals through the animal production systems. After the risk-based analysis, a uniform system that everyone electronically reports to was not adopted. It should be noted that the additional cost of a more robust system, like UK adopted, would likely be more costly in the United States, due to the larger size of our production systems.

Each state can have their own rules for animal identification covering livestock that enters their state. For example in Iowa, except for swine going directly to slaughter, all swine entering the state must be moved in accordance with an approved swine production health plan, and must be accompanied by a Certificate of Veterinary Inspection (CVI) (Code of Iowa 2013). Cattle that are raised and remain in one state, even if they spend some time in a large feed lot with over 100,000 other cattle, do not need uniform identification that stays with the animal their whole life.

The size and interconnectedness of the U.S. animal production systems and the additional governance layer at the state level add to the complexity of decision making in a foot-and-mouth disease outbreak.

5. U.S. Communications in a Foot-and-Mouth Disease Outbreak

Animal Industry representatives for cattle, sheep, and pigs have created a tri-species communication group to coordinate messaging on FMD, should it be found in the U.S. The tri-species communication group is part of a communications working group for the Secure Pork Supply Plan (Center for Food Security and Public Health 2013). The need to understand the capabilities and reach of social media has been acknowledged by due to the experiences like the depiction of lean fine textured beef as “pink slime” (Boffey 2012). The pink slime, or fine textured lean beef controversy, highlighted the challenges of discussing science-based issues versus public sentiment. In the pink slime case, consumers boycotted the product in spite of science based assurances of safety.

Along with industry, regional food and agriculture security groups, like the Multi-State Partnership for Security in Agriculture, have promoted risk and crisis communications training for state animal health and emergency management officials (Multi-State Partnership for Security in Agriculture 2013). Message maps have been developed for use in the onset of disease outbreak (Multi-State Partnership for Security in Agriculture 2013). A message map is only a starting point and the messages used in an outbreak must be continually managed as the facts of the situation unfold.

At the federal level, USDA APHIS produced a Fact Sheet in 2007 with basic information about the disease, and stressed that producer participation in early detection and testing was vitally important (Center for Food Security and Public Health 2007). The National Center for Animal Health Emergency Response under USDA APHIS develop strategies and policies for effective incident management and help coordinate incident responses and ensure that USDA Veterinary Services emergency management policies, strategies, and responses are current with national and international standards (United States Department of Agriculture 2012).

USDA APHIS has also standardized many of the guidance documents regarding preparedness and response for Foreign Animal Diseases that include FMD. The documents are called FADPReP (Foreign Animal Disease Preparedness and Response Plan). These documents are a compilation of standardized and

academically/industry/governmental approved documents (Center for Food Security and Public Health 2013). The goal in developing these documents was to standardize guidelines, industry manuals, standard operating procedures, and other resources.

Communications plans and tools, vetted by subject matter experts, have been developed, and are ready to be utilized by disease response and recovery practitioners. The remaining challenge is interpreting these technical concepts to the general public in an understandable way. The USDA, State Departments of Agriculture and Animal Production Trade Associations all support messaging coordination in an outbreak situation as stated in the Secure Food Plans (Center for Food Security and Public Health 2013).

C. CONCLUSIONS

Having experienced the economic devastation wrought from a slow and uncoordinated initial response to a foot-and-mouth disease outbreak in 2001, the UK has improved the legal framework and the support from the producers and public on the need for rapid detection and response The UK has institutionalized standardized premises and animal identification, electronic movement tracking, and standard practices in farm isolation and movement protocols that minimize the spread of disease prior to its detection. These improvements helped limit the scope of the outbreak in 2007, and additional improvements since 2007 are part of the response tools to aid decision makers in any future outbreak (Anderson 2008).

The UK has the advantage of dealing with smaller geographical areas, smaller numbers of animals per farm, and the fact that many animals remain locally for their entire lives. A single governing body with an accepted command and control structure helps to simplify command and control and messaging and increase the effectiveness of both the response and the communication strategy.

The U.S. choice to not have standardized premise and animal identification may slow the information and data collection process that decision makers will rely on in a foot-and-mouth disease Outbreak. As stated earlier in this thesis this impact will be situational dependent on where an outbreak occurs and how far the virus spreads.

This level of animal identification requirements in the U.S. was based on an extensive rule-making process that weighed the cost, benefits, and practical application of various animal traceability options (United States Department of Agriculture 2013). The additional cost of daily operations from more robust traceability systems should be balanced against the expected benefits in a situation that is considered rare.

This thesis author recommends that traceability systems for employment, only within the foot-and-mouth disease outbreak, should be developed with the goal of providing improved data and information for decision makers. This is also the recommendation from the National Institute for Animal Agriculture 2013 foot-and-mouth disease Symposium, "robust information management (Information Technology–IT) systems are needed to manage permitting in the context of a large-scale outbreak response, and these IT systems need to be in place prior to an event" (National Institute for Animal Agriculture 2013, 21).

The traceability system is needed because U.S. large-scale animal production systems routinely cross state and international borders, and cohabitate thousands of animals in singular locations (MacDonald 2009). With a disease identification latency period of up to two weeks, many animals can be exposed before a problem is even noticed (Center for Food Security and Public Health 2007). The uncertainty that comes from the high-mobility and latency period should be mitigated with accurate data of animal location, and in association with other animals within the latency exposure period.

Command and control of a response and recovery effort would require voluntary cooperation between the animal production industry, several state governments, and the federal government, due to our highly-integrated and mobile animal production systems. Continued improvements in the command, control, and communication aspects between these stakeholders should continue along the lines of the FADPReP efforts. By acknowledging the challenges and vulnerabilities in the U.S. animal production system, these stakeholders can pre-plan how to work together effectively.

D. RECOMMENDATIONS FROM QUALITATIVE AND COMPARATIVE ANALYSIS OF THE UK AND U.S.

From this case study review, two areas have emerged where the U.S. should strengthen its decision-making posture in preparedness, response, and recovery from a FMD outbreak. The first improvement comes from developing a standardized ID and tracking system to be implemented during a foot-and-mouth disease outbreak. This respects the cost concerns of producers during normal operations while acknowledging the need for more information during a foot-and-mouth disease outbreak. However, it should be noted that it will not address the concerns that have been expressed about burdens to small farmers and regarding privacy rights as illustrated by Patrice Lewis in her article, *Animal disease traceability*. "In reality, of course, the implementation was a nightmare, both logistically and in terms of property rights and privacy. Additionally, it was clear from the start that the major beneficiaries were the large producers, and that small farmers and ranchers would be unfairly impacted" (Lewis 2012).

While you cannot predict the future, the author speculates from past experiences, that a more accurate traceability system will be required in a foot-and-mouth disease outbreak in order to continue operations along the lines of the Secure Food Supply Program efforts (Center for Food Security and Public Health 2013). Taking a pre-developed and stakeholder approved course of action would allow for a more inclusive and thoughtful process in developing a foot-and-mouth disease traceability system that is more likely to be effectively used when needed.

The second improvement comes from developing trusted data and information sharing mechanisms pre-outbreak among the private, state, academic, and federal stakeholders. This effort will increase the decision maker's knowledge base for situational awareness during an outbreak situation. The first improvement will improve the situational accuracy of animal movement data used by decision makers to develop the appropriate strategy to eradicate the disease and the second will improve the information sharing between stakeholders and with the general public leading to more trust and acceptance of the strategies that are implemented. All of these were lessons learned from the UK 2007 Outbreak (Anderson 2008).

Chapter IV will expand on the complexity theme that has emerged in this thesis, and will use the literature about complexity and a discussion of the various variables decision makers may have to consider in an outbreak situation to determine some challenges decision makers will face. Chapter V will use the previously identified literature to suggest ways to operate in this complex situation.

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IV. RESPONSE AND RECOVERY FROM AN ANIMAL HEALTH EMERGENCY WILL BE COMPLEX

To paraphrase the first step of many 12 step programs, "you must first admit you have a *complex* problem." This can also be applied to an approach to response and recovery from a major FMD outbreak.

A. RARE EVENT

There is only so much that can be done cost-effectively to identify and begin to work on preventing the out of the ordinary major foot-and-mouth disease outbreak. A foot-and-mouth disease outbreak can emerge unexpectedly, and would be unique and highly situational dependent (Center for Food Security and Public Health 2007, 1). It is impossible to determine an incident in advance or to factor how many resources to devote or what specific actions would provide cost-effective risk reduction for a Black Swan event. There are too many unknowns to allow for pre-positioning of potential, specific response and recovery resources like vaccines, personal protective equipment, or sampling kits. Adding to the uncertainty, the disease can emerge anywhere and in many different variations (Center for Food Security and Public Health 2007, 1).

What we call a Black Swan (and capitalize it) is an event with the following three attributes.

> First, it is an *outlier*, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence *after* the fact, making it explainable and predictable. (Taleb 2007)

It is difficult to predict the actual scope of a" black swan event" in an emergent disease situation. The most effective response actions in any given situation are not cut and dry. For these reasons we should be prepared to operate in a complex environment to meet the challenges of an animal health emergency.

B. COMPLEX SYSTEMS

Response and recovery will have to manage many issues simultaneously. Animal welfare, supply chain disruptions, euthanasia, and disposal considerations for large numbers of animals, landfill capacity, the need for quarantine with movement constraints, and disinfection requirements, to name a few of the issues (Center for Food Security and Public Health 2013). According to David J. Snowden and Mary E. Boone in their 2007 Harvard Business Review article,

A complex system has the following characteristics:

- It involves large numbers of interacting elements
- The interactions are nonlinear, and minor changes can produce disproportionately major consequences.
- The system is dynamic, the whole is greater than the sum of its parts, and solutions can't be imposed; rather they arise from the circumstances. This is frequently referred to as *emergence*.
- The system has a history, and the past is integrated with the present; the elements evolve with one another and with the environment; and evolution is irreversible.
- Though a complex system may, in retrospect, appear to be ordered and predictable, hindsight does not lead to foresight, because the external conditions and systems constantly change.
- Unlike in ordered systems (where the system constrains the agent), or chaotic systems (where there are no constraints), in a complex system the agents and the system constrain one another, especially over time. This means that we cannot forecast or predict what will happen. (Snowden and Boone 2007, 3)

In a chaotic system, the first objective is to establish order. For an animal disease emergency, this would be accomplished by the establishment of quarantine zones (Figure 1) when a contagious disease outbreak has been confirmed. These quarantine zones will inconvenience every industry or resident that happens to fall within the zone. Movement controls and disinfection requirements will be required when trying to exit the zone.

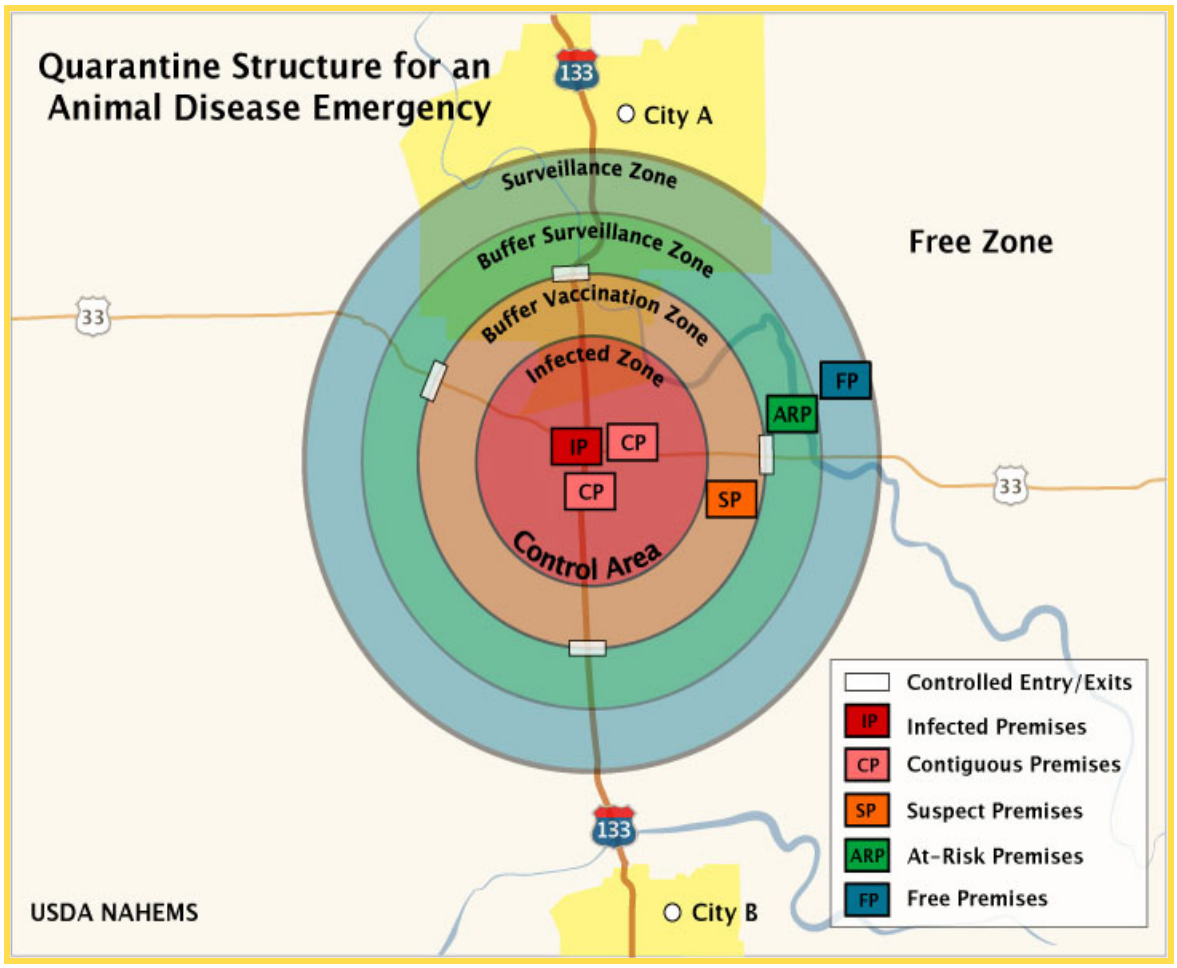

Figure 1. Control zone (approximately 6.2 mile diameter) (From Center for Food Secuity and Public Health 2008)

C. LARGE-SCALE AND COMPLEX SCOPE

Once stakeholders understand that they are faced with a foot-and-mouth disease outbreak, response strategies will be undertaken to manage the complex situation. Figure 2 indicates the scale of response anticipated for a foot-and-mouth disease outbreak in the United States. This scope is indicative of a large-complex system. It is estimated that a Food-and-Mouth Disease outbreak will require 500–1000 operations personnel per day.

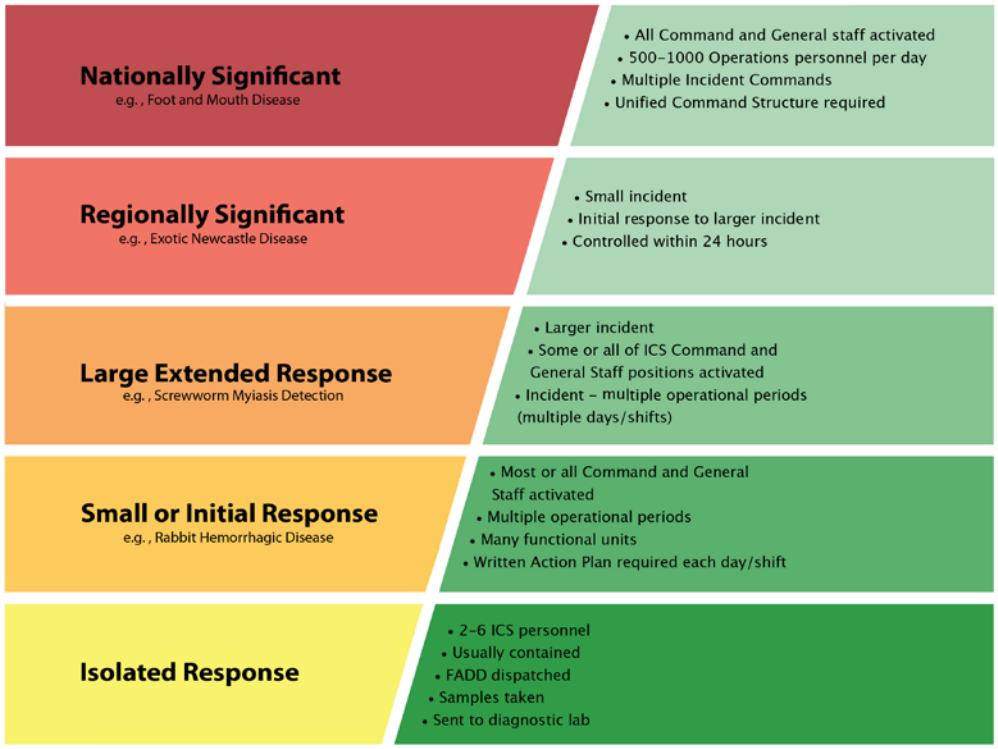

Figure 2. Type of animal health emergency and anticipated Incident Command System (ICS) response needs (From Center For Food Secuity and Public Health 2008)

The response and recovery will remain in the realm of the complex, due to the fact that many stakeholders are involved. Each stakeholder has their own interests and objectives (National Institute for Animal Agriculture 2013, 27–29). Every stakeholder can exhibit control over their part but have limited control over the actions of the other stakeholders.

Due to the infectious nature of this situation, actions by one stakeholder may impact other stakeholders. Movement of animals by one person may infect other stakeholder's animals. This may be intentional or unintentional, if the animals are contagious but not showing symptoms yet. Animal agriculture production systems may need to modify how they operate, even if the disease is detected in only one location. Due to the infectious nature of the diseases and the high levels of animal transport

inherent in the animal production systems (MacDonald and McBride 2009) uncertainty of the extent of the outbreak will be high until surveillance and traceability data can be gathered and analyzed.

Animal production systems have evolved to their current interconnected state over the past couple of decades (MacDonald and McBride 2009). Vulnerabilities of these integrated animal production systems to the spread of highly infectious animal diseases are illustrated by the rapid spread of Porcine Epidemic Diarrhea in the 2013 outbreak (American Association of Swine Veterinarians 2013). Production disease was discovered in the U.S. for the first time in April 2013, and has spread to over 347 premises in fourteen states by July 7, 2013. This illustrates how far and how fast animal diseases can spread in today's integrated animal production system (National Animal Health Laboratory Network 2013).

Risk of rapid transmission for foot-and-mouth disease comes not only from animal production systems, but can result from the virus infecting feral swine or wild or captive deer populations (Center for Food Security and Public Health 2007).

> Free-ranging populations of feral swine (also called feral hogs and wild pigs) in the United States are located in at least 35 States. Some experts estimate their numbers at over 5 million, with the largest populations located in California, Florida, Oklahoma, and Texas. This species causes extensive damage and disease threats to public property, native ecosystems, livestock health, and human health. (United States Department of Agriculture 2013)

This is why wildlife control agencies are one of the stakeholders in a response and recovery effort.

According to Peter Schwartz in his book *LEARNINGS from the Long View*, systemic crisis is a result of our societal complexity and interconnection. Many of the animal production systems have evolved into large-scale integrated systems (MacDonald and McBride 2009). When these animal production and distribution systems work well, they are invisible and go unnoticed by the general public. "When the very rendering of infrastructure services as virtually ubiquitous and utterly ordinary takes place, it means that their use can become taken for granted and normalized as an essential, but largely

invisible, support to modern urban life" (Graham 2010, 6). However, when disturbed, these systems can produce unexpected and sometimes far-reaching problems. The seven factors in Figure 3 influence this vulnerable systemic crisis situation (Schwartz 2011, 36–39), and illustrate why close monitoring and caution must be taken into account when implementing disease eradication methods in a major foot-and-mouth disease outbreak.

FACTOR		Peter Schwartz Explanation	Animal Production System in a Major FMD Outbreak
1.	Interconnection	"More and more systems are connected internally and externally. More and more things affect more and more other things" p-36	A quarantine zone for FMD will disrupt the movement of all industries caught within its borders.
2.	Scale	"All of these systems now operate on a much, much larger scale than before. We're getting larger agglomerations of institutions." p-37	Dairy's have over a thousand cows. Feed lots house over 10,000 cattle and hog confinement units' house over 10,000 hogs routinely.
3.	Speed	"Computer trading, global logistics and mobile communications are perpetual. We are always connected, always available, always on." p-38	News and speculation of all aspects of an outbreak any response or recovery measures will be instantaneous. Social media will debate the issues 24/7
4.	Diversity	"This system is hardly homogenous. It contains many different kinds of actors. Even in the supposedly monolithic public sector, diversity is rampant. We have states, cities, counties, and regions pitted against each other." "The same is true of companies, industries, NGOs and non-profits." p -38	The states and federal government both have regulatory oversight in a disease outbreak. You will be working with multiple producers and other industries that are impacted. Wildlife (deer and feral hogs) are also susceptible to the disease.
5.	Complexity	"When these four factors come together, the result is the fifth factor: complexity. Complexity means that the link between cause and effect is not simple." Systems have become too complex for anyone to manage or even understand." "Small changes now can produce very large changes downstream." p - 38	A disruption in one part of the animal production chain has ripple effects up and down the line. Example: Slaughter facilities will have to lay off people if the flow of animals is stopped.
6.	Incoherence	"When humans attempt to respond to problems within these complex systems, we get the sixth factor: incoherence. The recent financial crisis is a perfect example. We saw an incredibly interconnected financial system, a shadow economy on a massive scale, events that were happening with tremendous speed and many actors within the system with different views on how to fix it. Yet the complexity was so great that no one understood exactly what effect a fix would have." p - 39	You will have to monitor the various effects of any measures you undertake to eradicate the disease. Due to the interconnections unintended consequences may emerge.
7.	Out of Control	"No one is in charge. That doesn't mean that individual actors can't nudge and influence the system. We all influence the system in significant ways. But no one actor dominated the stage." p - 39	Producers, state and federal officials, consumers and trading partners all have the ability to influence the response and recovery.

Figure 3. Seven factors that influence a vulnerable systemic crisis situation (FMD outbreak) (From Schwartz 2011; FADPReP 2011)

D. INDEPENDENT VARIABLES IN A FOOT-AND-MOUTH DISEASE OUTBREAK

This section outlines additional factors that can contribute to the complexity of an animal health emergency and may have to be considered in the decision making process.

1. Consumer Sentiment and Purchasing Power

Consumer opinions and actions, including their purchasing choices in this environment, will have economic impacts. Their reaction to the major event will be influenced by media coverage, in both traditional and social media. Risk and crisis communications, and the influences of public perceptions and reactions to the various aspects of a foot-and-mouth disease response and recovery effort, are important to understand. Lucinda Parker explored challenges in this area in her 2005 Naval Postgraduate School Thesis (Parker 2005). She identified the following three factors that must be taken into consideration, as well as seven rules for effectively communicating with the public.

- Recognition that the communication of risk about food carries with it specific challenges
- The public's level of trust in government will affect how it perceives and accepts risk messages
- Americans' post-September 11, 2001 fear associated with terrorism alters perception of risk (Parker 2005, v).

Seven rules for effectively communication risk to the public as proposed by Vincent Covello (Covello 1989) and elaborated by Lucinda Parker (Parker 2005, 29–35).

- Accept and involve the public as a legitimate partner
- Plan carefully and evaluate performance
- Listen to your audience
- Be honest, frank, and open
- Coordinate and collaborate with other credible sources
- Meet the needs of the media
- Speak clearly and with compassion

These seven rules have been incorporated into USDA recommendations regarding crisis communication. "The Cross-Species FMD Communications Team was formed to

create a unified FMD crisis response plan, share FMD messaging, and form government partnerships to ensure a coordinated response. This Cross-Species Team has developed messaging for FMD, which can be found at www.FootAndMouthDiseaseInfo.org (Center for Food Security and Public Health 2013). Risks and crisis communications must now contend with social media and the abundance of smart phone and other mobile recording capabilities. The influence that social media can have over public sentiment in contrast to scientific fact was illustrated in the public reaction to calling lean fine textured beef pink slime (Boffey 2012). Social media is another tool for potential misinformation or hijacking of the messaging about a foot-and-mouth disease response and recovery effort.

2 Political, Social, and Economic Considerations

Political, social, and economic considerations will be interwoven throughout the complex systems of animal production and disease era and should be taken into considered. The political reality of making decisions in disaster situations is described by Jeffery Rosen.

> Before World War II, people understood that life was fraught with risk, and presidents like Lincoln and Roosevelt could challenge the public to be brave in the face of uncertainty and danger. Today, by contrast, we have come to believe that life is risk-free and that, if something bad happens, there must be a government official to blame. (Rosen 2008)

Simon French and Carmen Niculae "believe that in the handling of major risk events and crises, the context will almost inevitably pass into the complex domain. Thus, crisis response should anticipate that social, political and economic issues may increase in importance, become major drivers in the decision making process" (French 2004, 11).

UK's response to the 2007 outbreak cited the success of leadership at the political and veterinary levels. The rapid response and coordination of these decision makers helped the effort to contain the disease (Anderson 2008, 15). Teaming with a communications effort that manages public expectations can help in explaining the difficulty of decision making in a major FMD animal health emergency. Public expectations can be managed by acknowledging that response and recovery efforts will

be fluid, and decisions may need to be changed as more information is gathered, or the situation evolves in unexpected ways.

3. Regulation Limits

Regulations for animal health will only cover some of the actions that decision makers may determine are required to attain disease eradication. The main authorities available to state and federal animal health officials include the authority to quarantine and stop movement of suspected infected animals. Their statutory mandates are to confine the infected animals to protect the health of other animals. Decision makers may determine that other activities or actions may be helpful as an outbreak unfolds. Producer or other stakeholder cooperation on determined eradication measure will depend on voluntary cooperation (GAO 2002, 10).

4. Cost Recovery

Federal reimbursement for culled animals can be complicated. It involves a verification and authorization process (United States Department of Agriculture 2012). When the federal government determines that a particular group of animals must be killed to try and stop the spread of FMD, the animals are appraised, the federal government buys the animals, and after positioning, the animals are destroyed. At the same time that infected animals are being indemnified and destroyed, it is likely that just the presence of the disease has closed export markets, resulting in the loss of value for all animals. A potential problematic situation would arise if infected animals are worth more than healthy animals.

5. Inter-state and International Coordination

An outbreak may involve multiple states. State to state as well as state to federal coordination will have to be managed. Any state can close their borders to transport of animals resulting in rerouting of animals from original routs. In a large outbreak coordination will also take place between Canada and Mexico (Center for Food Safety and Public Health 2013).

6. Disposal Issues

Disposal and transportation of infected animals poses challenges.

> During an animal disease outbreak, there is a very high likelihood of generating massive amounts of contaminated biomass which can have a severe impact on public health. During the 2001 FMD outbreak, the UK (UK) found unlined burial to have unacceptable public health risks. Therefore, due to potential negative risks to public health associated with improper burial, it is imperative that carcass FADPReP/NAHEMS Guidelines: Disposal (2012) disposal decisions be made by qualified waste disposal experts who are familiar with livestock industry concerns as well as State/local environmental concerns. State-level environmental and animal health agencies will need to be consulted and must approve large-scale animal disposal plans. (United States Department of Agriculture 2012)

Where burial on site is not possible, precautions must be taken to safely transport animals to disposal areas. Landfill capacity and cost issues must be considered. The sheer volume of animals to be processed can be overwhelming if an outbreak is in a large feed lot with over 100,000 animals.

7. Laboratory Capacity

Demands on the laboratory system will greatly increase in a Foot-and-Mouth disease outbreak. The laboratories will handle both samples to confirm the disease and will likely receive many requests to confirm that producer's animals are free of disease.

8. Vaccination Strategies

Vaccination is utilized as a part of a disease eradication strategy in countries where foot-and-mouth disease is endemic and the country knows they will be constantly battling the disease. Countries that are designated as foot-and-mouth disease free without vaccination have preferred trade status (World Organisation for Animal Health 2013). Vaccinations used prior to 2013 could not be distinguished from animals that have the disease. This inability to distinguish between the two is a deterrent to using vaccination as an eradication strategy (Center for Food Security and Public Health 2007).

> Vaccination may be used to reduce the spread of FMDV or protect specific animals (e.g., those in zoological collections) during some outbreaks. The decision to use vaccination is complex, and varies with the scientific, economic, political and societal factors specific to the outbreak. (Center for Food Security and Public Health 2007)

This policy toward vaccination will evolve depending on the size of the outbreak if we encounter an outbreak in the U.S. (United States Department of Agriculture 2013). New advances in vaccinations are occurring that may solve some of these issues (Homeland Security News Wire 2012). If vaccinations are used, decision makers will have to contend with issues of production volume, who gets the limited supplies, and how to effectively distribute them.

E. CHAPTER SUMMARY

This chapter highlighted the many complex issues decision makers must take into consideration in implementing a response and recovery effort to a major foot-and-mouth disease outbreak. Animal production systems are interwoven within the social and economic systems and can cause unintended and unforeseen disruptions in other industries when they are disrupted with eradication measures like quarantine and controlled movement of animals. Many options for response actions are available to the decision makers. Some of the options include, to vaccinate or not, how large of a quarantine to set up; appropriate disposal methods, and how to manage the laboratory sampling loads (Center for Food Security and Public Health 2013). Each stakeholder has control over only parts of the disease response and recovery efforts, and due to the system nature of animal production actions by one individual stakeholder, may impact the other stakeholders.

Decision makers charged with eradicating any foot-and-mouth disease will have to operate in a complex response and recovery environment where knowledge and the ability to take individual action are distributed among many stakeholders. The foot-and-mouth disease will continue to spread in the absence of actions designed to stop its spread. Due to the complex situation, decisions may need to be made with limited data. As the situation evolves and new data is available, decisions may need to be changed.

Chapter V will discuss recommendations for how to operate in complex environments. These insights will help in the development of further recommendations to support decision makers in the management of response and recovery to a major animal health emergency with multiple stakeholders, limited, disjointed authority, and areas of control.

V. HOW TO OPERATE IN COMPLEX ENVIRONMENTS

A. MANAGING COMPLEXITY

Based on the determination that response and recovery from a major FMD outbreak would involve working with complex systems, this chapter recommends sense-making frameworks and collaboration strategies to improve the success of decision makers in this complex situation. These tools will help to manage and guide the emergence of workable solutions to the unique foot-and-mouth disease situation. Snowden and Boone explain complex contexts as the domain of emergence.

> Most situations and decisions in organizations are complex because some major change – a bad quarter, a shift in management, a merger or acquisition – introduces unpredictability and flux. In this domain, we can understand why things happen only in retrospect. Instructive patterns, however, can emerge if the leader conducts experiments that are safe to fail. That is why, instead of attempting to impose a course of action, leaders must patiently allow the path forward to reveal itself. They need to probe first, then sense, and then respond. (Snowden and Boone 2007, 5)

This continual process of probing, sensing, and responding can be utilized by decision makers in a foot-and-mouth disease outbreak. Once situational data is provided to the foot-and-mouth disease response and recovery decision makers they can use this sense making method to act then sense with further data gathering and then respond to the feedback. This process of acting, gathering more data then reevaluate the situation and determine the next actions will be an ongoing process throughout the response and recovery efforts. This is a continual loop of activities designed to maintain current situational awareness in a fluid complex environment. Data and information management is essential to the success of this type of effort (Anderson 2008, 75).

Snowden and Boone's tools for managing in complex context include:

- **Open up the discussion** – Complex contexts require more interactive communication than the other domains (Simple, Complicated, Complex and Chaotic)
- **Set barriers** – Barriers limit or delineate behavior. Once the barriers are set, the system can self-regulate within those boundaries.

- **Stimulate attractors** – Attractors are phenomena that arise when small stimuli and probes (whether from leaders or others) resonate with people. As attractors gain momentum, they provide structure and coherence.
- **Encourage dissent and diversity** – Dissent and formal debate are valuable communication assets in complex contexts because they encourage the emergence of well-forged patterns and ideas.
- **Manage starting conditions and monitor for emergence** – Because outcomes are unpredictable in a complex context, leaders need to focus on creating an environment from which good things can emerge, rather than trying to bring about predetermined results and possibly missing opportunities that arise unexpectedly (Snowden and Boone 2007, 7).

In complex situations, leadership must instill trust in all parties that have a stake or opinion about how the disaster should be handled (Burridge 2006). The facilitation of trust between the stakeholders will provide a foundation from which the multi-stakeholder decision makers can make tough decisions in a complex environment where the ability to manage ambiguity and chaos and build trust is needed. A trusted leader or leaders is essential to garnering buy-in from stakeholders to work for a common purpose and to maintain consumer confidence in the undertaking (Anderson 2008, 39). Both of these sources stress the importance of leadership to facilitate multi-stakeholder coordination in disasters.

Decision makers working the foot-and-mouth disease outbreak need support from a decision making framework in which to operate in the complex situation. Due to the fact that it is a disease situation, leaders may look to a "best science based decision making." Science-based decision making is a good place to start; however, it is only one consideration in a complex major foot-and-mouth disease outbreak. Simon French and Carmen Niculae propose that scientific information should not be ignored, but that complex incidents are also greatly influenced by social, economic, and political inputs, and are often hard to predict; however, those non-scientific inputs should not be ignored (French 2004, 9). In a complex system, there may be many answers or legitimate courses of action that can be taken to resolve the situation. 'Best science-based decision' implies one correct answer that can be far more precise than the situation would warrant (French 2004, 9). For a foot-and-mouth disease outbreak decision makers will have many options

in how they approach the disease eradication measures and they should consider social, economic, and political issues as well as the science part of disease eradication.

French and Niculae suggest using David Snowden's Cynefin Model for knowledge management in a crisis response (Figure 4).

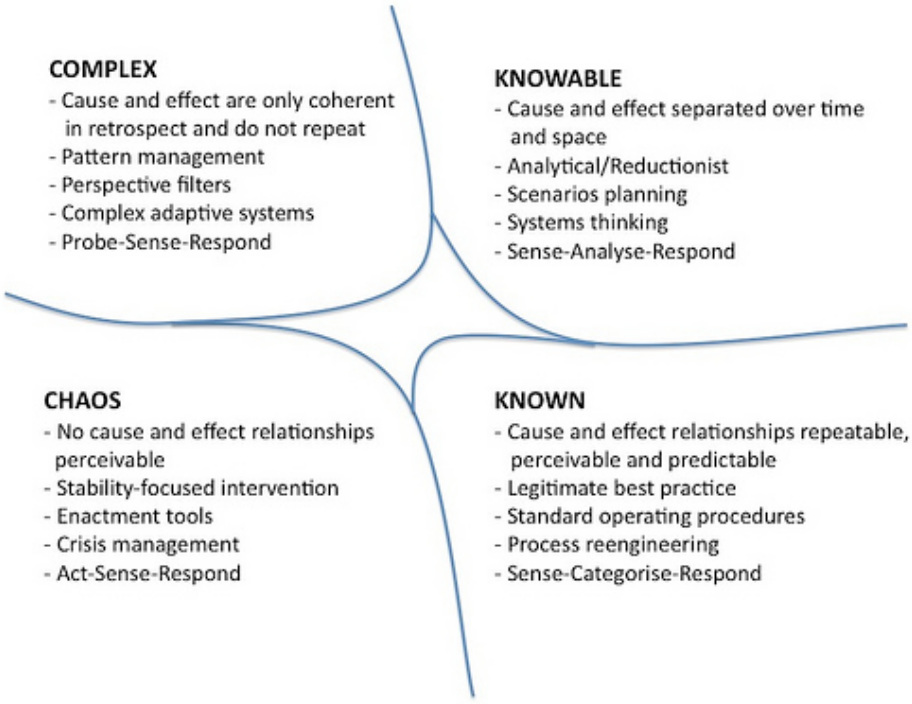

Figure 4. Cynefin domains (From Kurtz and Snowden 2003)

The initial response efforts to a foot-and-mouth disease outbreak will be working with large amounts of uncertainty about the extent of the outbreak until sampling can be conducted and data can be compiled and analyzed.

"Looking at historical outbreaks, when the first case of FMD is diagnosed, it's not usually the first case. Normally, when the first case is announced, infected animals have already moved, and FMD has already spread. The "first case" diagnosed is a time and place within the epidemic" (National Institute for Animal Agriculture 2013, 32).

> The Cynefin Framework helps leaders determine the prevailing operative context that they can make appropriate choices. Each domain requires different actions. Simple and complicated context assume an ordered

> universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on facts. Complex and Chaotic contexts are unordered–there is no immediate apparent relationship between cause and effect, and the way forward is determined based on emerging patterns. (Snowden and Boone 2007, 6)

As the situation unfolds, modifications of the initial response and recovery coordinated efforts may be necessary to minimize the negative, and foster the positive outcomes that emerge from the complexity of the outbreak. The emergence of unexpected outcomes may indicate the value of creating new partnerships to manage the unique animal health emergency situation. Any potentially useful partnerships will not be known until the decision makers see and evaluate the extent and characteristics of the individual outbreak the decision makers are dealing with.

The Cynefin Model provides a framework for decision making in the following four distinct realms: simple where one can sense, categorize and respond; complicated, where one can sense, analyze, and respond; and complex and chaotic realms where a foot-and-mouth disease response and recovery would fit. In the complex and chaotic realms, you need to build partnerships and collaborate, to provide a variety of perspectives on the issue. According to David Snowden and Mary E Boone, the complex system has a large number of interacting parts, the system is dynamic and solutions cannot be imposed but emerge from the circumstances. In complex systems, you have to probe, sense, and then respond. In chaotic systems, you must act, then sense, and respond (Snowden and Boone 2007, 7).

The Cynefin framework helps to illustrate that different stakeholder will perceive the situation differently (Kurtz and Snowden 2003, 464). To harness the diversity of perspectives within the complex environment, Judith Innes and David Booher suggest creating collaborations to tackle these complex adaptive systems.

> Complexity thinking suggests that as policy professionals we need to operate at the system scale rather than focus piecemeal on individual fixes. To do this we need the insights of critical theory, pragmatism, communicative planning, and deliberate policy analysis. The insights of complexity science added to these suggest that we need to build dispersed intelligence, linked together through networks and dialogue among diverse

> players, searching out many types of knowledge, if we are to have a hope of operating effectively in our complex, uncertain and constantly changing world. (Innes and Booher 2010, 33)

B. RECOMMENDATIONS FROM PAST MAJOR DISASTER RESPONSE AND RECOVERY COLLABORATIONS

Building on the recommendation of harnessing the dispersed intelligence of multi-stakeholder collaborations, the following government reports highlight recommendations for response and recovery that have come out of the review of past major disasters and factors that facilitate collaboration. This information can be used to address the expected issues that will come from a foot-and-mouth disease outbreak. Finally, an example of a 2013 public/private/academic foot-and-mouth disease collaborative effort is highlighted as an example of these practices in action.

From 2008 to 2010, the Government Accounting Office studied disaster recovery. Three themes emerged.

> The …work highlighted themes that are important to successful disaster recovery efforts. Three of these key themes are: (1) the need for clearly defined recovery roles and responsibilities; (2) the importance of effective coordination and collaboration among recovery stakeholders; and (3) the value of periodic evaluation of, and reporting on, recovery progress. (GAO 2012, 1)

All three of these recommendations are also indicated in the 2005 GAO recommendations for interagency collaboration between federal agencies. The 2005 report identified the following eight key practices to enhance and sustain collaborative efforts.

1. Defining and articulating a common outcome
2. Establishing mutually reinforcing or joint strategies to achieve outcomes
3. Identifying and addressing needs by leveraging resources
4. Agreeing upon agency roles and responsibilities
5. Establishing compatible policies, procedures, and other means to operate across agency boundaries
6. Developing mechanisms to monitor, evaluate, and report the results of collaborative efforts

7. Reinforcing agency accountability for collaborative efforts through agency plans and reports
8. Reinforcing individual accountability for collaborative efforts through agency performance management systems.

The 2005 GAO study stated that agencies can strengthen their commitment to work collaboratively by articulating their agreements in formal documents, such as a memorandum of understanding, interagency guidance, or an interagency planning document, signed by senior officials in the respective agencies (GAO 2005, 1).

The factors of leadership and trust are necessary elements for the collaborative working relationships noted above. These factors are established, sustained, and reinforced through that relationship, thereby fostering a collaborative culture (GAO 2005). Ruth Wageman recommends three conditions to facilitate effective cross-organizational leadership teams. She recommends: defining a compelling direction by identifying interdependencies, and convening the right people by looking for systems thinkers; recomposing people over time, and assessing participants for empathy and integrity; and create an enabling structure by creating interdependent tasks, establishing ground rules, and doing midcourse reviews and revise norms (Wageman n.d., 2).

These recommendations can be used to foster collaboration in the multi-stakeholder relationships within a foot-and-mouth disease outbreak. The next section describes some 2013 partnerships that have utilized these recommendations.

1. Secure Food Supply–Public/Private/Academic Partnership

For a foot-and-mouth disease outbreak the United States Department of Agriculture has indicated its desire to work collaboratively with nonfederal partners, key clients, and stakeholders by their involvement in the development of the FADPReP plans and guidance documents and the Secure Food Programs. The major animal agriculture trade associations have begun a partnership with the Center for Food Safety and Public Health. The associations are collaborating to develop strategies for continuation of operations in the event of a major event. These efforts include the Secure Egg Supply, Secure Milk Supply, Secure Pork Supply, and Secure Turkey Supply (Center for Food Security and Public Health 2013).

The Center for Food Security and Public Health (CFSPH) at Iowa State University, in collaboration with a number of partners, is leading the development of Secure Food Supply Plans for eggs, turkeys, milk and pork. These Secure Food Supply Plans are designed to provide business continuity in the face of a foreign animal disease outbreak.

The overall goals of the Secure Food Supply projects include:

- Avoid interruptions in animal/animal product movement to commercial processing from farms with no evidence of infection during a foreign animal disease outbreak
- Provide a continuous supply of safe and wholesome food to consumers
- Maintain business continuity for producers, transporters, and food processors through response planning

This work is funded by USDA-APHIS National Center for Animal Health Emergency Management (NCAHEM), and is a collaborative effort between the Center for Food Security and Public Health at Iowa State University, the Center for Animal Health and Food Safety at the University of Minnesota, the University of California at Davis, federal and state government personnel, and industry. All Secure Food Supply Plans are drafts that may be modified in an actual disease outbreak (Center for Food Security and Public Health 2011).

The secure milk supply program is the most advanced program. It has included education and outreach to emergency managers. This outreach is intended to increase collaboration and understanding before an event occurs.

> The national SMS Plan has made significant strides in the development of a framework and support tools to facilitate decision making and timely permitting for raw milk movement during an FMD outbreak response. However, the national proposed bio-security performance standards for raw milk movement to processing still need to be tailored to specific states and regions, socialized and agreed upon by those responsible for decision making at that level, and optimally incorporated into FMD response plans. (Secure Milk Supply 2013)

The plans for continuity of operations and suggestions for collaboration are still under development in the other sectors. It is impossible to know exactly how individual animal production and processing entities will work with state and federal government during a "major event." Beyond the "letter of the law" industry may find that other actions on their part would be economically beneficial in the joint public/private goal of disease eradication. These appropriate response actions are unknown at this time and will be one of the things that will emerge in the complex response and recovery environment.

These "secure" programs are examples of attempts to improve multi-stakeholder preparedness efforts. The programs attempt to foster public/private partnerships to address the issues anticipated in a major FMD outbreak. At this time, only the Secure Milk Supply Program (Secure Milk Supply 2013) and the Secure Pork Program (Secure Pork Supply Program 2013) are far enough along to be a viable tool for consideration as part of the response and recovery strategies for a major event. The list of the coordinators, funding, and planning team members shows the extent of the multiple stakeholders involved in this collaborative effort.

Plan Development Team

> *Coordinators* – Center for Food Security and Public Health (CFSPH) – Iowa State University, Center for Animal Health and Food Safety (CAHFS) – University of Minnesota
>
> *Funding* – USDA-APHIS National Center for Animal Health Emergency Management (NCAHEM) and the National Pork Board (NPB)
>
> *Planning* – CFSPH, CAHFS, NCAHEM, NPB, National Pork Producers Council, American Association of Swine Veterinarians, Federal and State animal health officials, and individuals from academia and industry. (Secure Pork Supply Program 2013)

The author contends that this collaborative approach would also benefit the decision-making process during an outbreak.

C. CHAPTER SUMMARY

These recommendations of probing, sensing, and responding to the unknowns within the complex situation, and including stakeholders as partners in knowledge management, affirm the recommendations from the UK outbreaks regarding the need for tight coordination by all stakeholders discussed in Chapter III. This ability to bring different stakeholder perspectives and knowledge of the various part of the situation together, improves the ability of decision makers to manage the complex situation. And finally the secure food programs provide an example of multi-stakeholder collaboration that can be used as an example in the development of a collaborative decision support strategy.

Chapter VI will propose a decision support strategy based on the thesis research findings.

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VI. DECISION SUPPORT STRATEGY PROPOSAL

Chapter II provided an understanding of the 2013 preparedness posture for a foot-and-mouth disease outbreak in the United States. Chapter III provided a qualitative comparative analysis of decision support between the FMD outbreaks in the UK and a potential outbreak in the U.S. Recommendations were provided for supporting decision makers during an actual response and recovery effort should a major foot-and-mouth disease outbreak occur in the U.S. In Chapter IV, it was determined that decision makers would be dealing with a Black Swan complex system with the challenges of maintaining preparedness and response capabilities for a rare event, and in Chapter V, we looked at sense making strategies to help decision makers manage in the complexity of response and recovery from a foot-and-mouth disease outbreak with multiple stakeholders.

Taking the information from the previous chapters this chapter will propose a strategy to enhance support to decision makers charged with managing a foot-and-mouth disease outbreak in the United States.

A. RECOMMENDATIONS TO SUPPORT DECISION MAKERS

1. Organizational Overview

a. Rapid Deployment of Information, Data Gathering, and Management Staff

When an animal health emergency develops in the U.S., major stakeholders, including federal and state animal health professionals, large and small animal agriculture industries, regional partners, academic institutions, laboratory support services, and the peripheral state and federal agencies involved in animal transport and disposal, must collaborate, communicate, and fight the spread of disease together (United States Department of Agriculture 2013).

These core groups of informed and trained animal health emergency professionals are a valuable resource. This group can be the foundation upon which a response and recovery effort is undertaken. The numbers of individuals who work in these areas are small compared to the numbers of production animals. The State of Iowa

is provided as one example to illustrate this point. State Animal Health Departments and State Veterinarians provide the state regulatory structure and authority in an animal health emergency. Iowa has a state veterinarian, an assistant state veterinarian, and five regional state veterinarians. There are seven people for a state with approximately 92,400 farms, 3,900,000 cattle and calves, 19,000,000 hogs and pigs, 200,000 sheep and 209,000 milk cows in 2010 (USDA NASS 2011).

Seven state veterinarians in Iowa represent the staffing levels for preparedness activities, keeping partnerships active pre-event, and for response to smaller animal health events like chronic wasting disease (Iowa Department of Agriculture and Land Stewardship n.d.). This core group will provide the enabling structure from which the cross-organizational leadership team will be formed. However, in a major event, projected to require 500–1000 operations staff per day, (Center For Food Secuity And Public Health 2008) this small group of animal health professionals will rapidly require additional staffing support to provide the data and information coordination required to make sense of the complex situation and support decision makers. This rapid support will allow the decision makers to react with speed and certainty as recommended from the UK outbreaks (Anderson 2008, 37–43), and in the FADPReP guidance from USDA (Center for Food Security and Public Health 2013).

This support is required to gather and manage the data and information that is used to make sense of the complex situation as the response and recovery evolve. Inter-stakeholder communications and collaborations will be vital to success in this complex environment (National Institute for Animal Agriculture 2013, 23–25). These support teams should be brought in rapidly to support the animal health professional staff with technology tools to facilitate a large scale multi-state response. This support staff can facilitate communications, logistical tracking and manage data and information for decision makers. This support would be a force multiplier when used to support the animal health emergency professional.

Due to the value of rapid response to an animal health emergency pre-event contracts should be in place for the initial support services that will be needed. This can help with managing the starting conditions and improve coordination and collaboration. This type of arrangement leads to what Donald Kettl said we need in Homeland Security. "Our hope lies in nimble organizations capable of flexible response. We need organizations that can rise to the challenge of the problems we face." (Kettle 2007, 80) Rapid response was also a recommendation from the reviews of the UK foot-and-mouth disease Outbreaks (Anderson 2008, 15).

The challenge to implementing this recommendation is fiscal. It can be argued that it is not fiscally prudent to put excessive resources into a high consequence but low probability event. However, it is not prudent to ignore the possibility either, especially when rapid response has been shown to be critical key to an effective response and recovery that limits the scope of the outbreak (Anderson 2008, 15). This is a case where planning is valuable as a risk-management tool.

Funding to reimburse this type of staffing support has not been identified. The lack of a dedicated funding source for this type of administrative assistance would limit the ability to rapidly support decision makers with this capability. The author recommends further investigation into funding options to support this capability under emergency protective measures of the Stafford Act or under United States Department of Agriculture emergency authorities.

b. Regional Animal Health Emergency Partnerships

Regional Partnerships of state animal health professionals, animal production representatives, and academic institutions help facilitate the use of local and regional knowledge about response and recovery limitations and needs in a specific region. The Multi-State Partnership for Security in Agriculture has used regional state collaboration to develop preparedness and response tools and strategies for animal health emergencies. These regional collaborations are efficient ways of pooling preparedness

resources, maintaining critical relationships prior to an outbreak, and provide a localized structure to meet the rapid response necessity that has been indicated as a key element throughout this thesis.

This thesis proposes that many of the pieces that are needed to coordinate and collaborate on the response and recovery challenges posed by a major FMD outbreak have been developed. The availability of regional collaborative structured like the Multi-State Partnership for Security in Agriculture provide a workable sized unit to focus on these issues. This is the glue that keeps the vital regional stakeholders concerned with animal health emergencies connected in preparation for use in a rare outbreak situation. These multi-state partnerships also provide a platform to coordinate with other agriculture emergency response structures that focus on all hazards that impact the food and agriculture sector.

This thesis proposes that the Multi-State Partnership for Security in Agriculture is likely too large—at the current 15 states—to effectively support the animal preparedness and response issues within the 15 state regions. This is based on the recommendations for management span of control in the range of 5–7 from the USDA National Incident Management System guidance documents (United States Department of Agriculture 2013, 2), and on the recommendation that the groups should align with regional animal production systems.

The Multi-State Partnership for Security in Agriculture is an example of a regional collaborative organization that has added states beyond a reasonable span of control. It has been the author's experience that under the current funding situation, Homeland Security Grants, it was easier for a new state to join the already formed Multi-State Partnership for Security in Agriculture, rather than for a group of similar states to initiate a new organization. This is a case where the ultimate form of the Multi-State Partnership for Security in Agriculture has not entirely followed function. The Partnerships evolution has been influenced by the path of least resistance within bureaucratic and fiscal constraints. A dedicated funding source to sustain multiple

regional partnerships would eliminate this clustering effect and would support smaller regions aligned with regionally connected animal production systems and animal health issues.

These partnerships can provide an environment for experimentation within each partnership area and idea sharing between the several partnerships. These partnerships provide a structure for administrative support for individual states for a black swan event, without overtaxing the agriculture and veterinary expertise at the local and state level. These partnerships will have local knowledge of how the animal production systems are interconnected within their region. "As our world continues to change rapidly and become more complex, systems thinking will help us manage, adapt, and see the wide range of choices we have before us" (Meadows 2008, Loc 184). These regional partnerships would be tasked with incorporating local and regional knowledge into formulating a preparedness posture and in support of decision makers formulating response and recovery actions.

These regional partnerships should continue to work with academia and the animal production industries to advance innovations in vaccines, early detection capabilities, and industry best practices to minimize the effects of an outbreak. It is the thesis author's opinion that because both the government and private animal industry have interests in disease prevention eradication the costs for these partnerships should be shared.

c. Public-Private-Academic Partnerships for Leadership and Coordination

By focusing on a Public-Private-Academic partnership for crisis planning and operations, you inherently recognize that the industry and government both have an interest in approaching an animal disease outbreak in a collaborative way. The focus should be on risk-based decisions, transparency with the consumer and on voluntary efforts as well as regulatory mandates that will help in a given outbreak situation. All three of these recommendations were made in the official Review of the 2007 UK outbreak (Anderson 2008). A trusted group from these various stakeholder groups can

fulfill the strategy development and leadership role in an outbreak situation, similar to the trusted apolitical role the Animal Health and Welfare Board for England fulfilled in the 2007 UK FMD outbreak (Anderson 2008, 6–7).

To provide technical support to the decision makers in an outbreak, a response and recovery technical advisory body should be developed. This governing body should have representatives from animal production industry, academia, non-profit animal health organizations; relevant local, state, and federal departments, as well as consumer representatives. This technical advisory body can provide leadership and a trusted collaborative forum to work on the multi-faceted issues that will come up during a complex response and recovery to a major FMD outbreak. Due to the rapid response that is required in a FMD outbreak, this governing or advisory body should be created prior to an outbreak. By convening this group in the preparedness phase, trusted relationships have time to be built, and collaborative strategies have time to be vetted and accepted by the stakeholders. This technical governing body would be a similar entity and fulfill a similar role that the Animal Health and Welfare Board for England fulfilled during the 2007 FMD outbreak.

The advisory body would be an apolitical group that can help to diffuse some of the political pressures on governmental decision makers in a major animal health emergency. The governing body would be a source of connectivity between the various stakeholders. Decisions by the board are more likely to be accepted by the various stakeholders if each of the stakeholders has a represented on the board. As explained by Snowden and Kurtz, in a complex situation better decisions can be made by utilizing input from the various perspectives of the many stakeholders (Kurtz and Snowden 2003, 464–471).

Following Wageman's recommendation of establishing ground rules, the coordinated stakeholders should set common agreed upon policies and procedures by which they will operate. Mechanisms should be developed to monitor and evaluate the progress and setbacks in the system. Over time, this will allow the stakeholders to identify attractors to solidify the positive outcomes that emerge as well as the negative

outcomes that need to be dissuaded. Transparency of decision making and reporting of progress, both positive and negative will help to bolster the trust of the consumers (Wageman n.d.).

The definition of accepted roles and responsibilities is crucial to effectively working together in a highly complex and politically charged situation (GAO 2005). The goals of disease eradication and continuity of business for non-infected animals are shared by both government regulators and the animal agriculture industry. The stakeholders should acknowledge that it is a complex situation with several ways to address it. Strategies may be modified as the situation progresses. Actions taken at one location may not be the best approach in another location. Decisions taken in one area may impact other parts of the complex food processing system. Because of these complex system realities, collaboration of all stakeholders and strong leadership is very important (Burridge 2006).

Leadership is what facilitates working across the complex boundaries of government agencies. It also convinces private industry to collaborate beyond the letter of the law when it is in the interest of multiple stakeholders. Leadership in both the public and private arenas will allow for the setting of roles and responsibilities, the required coordination, and collaboration, and the ability to evaluate and change course as needed throughout the complex response and recovery from a major animal health emergency. If the stakeholders cannot work this way, they may lose the confidence of the consumers (Anderson 2008, 51).

2. SENSE MAKING IN THE COMPLEX SITUATION

Chapter IV showed how animal production systems are interwoven within the social and economic systems of the United States. Due to the systems aspects of animal production; human health, environmental and animal health impacts should be viewed together to give a total picture of the situation. If you separate the foot-and-mouth disease outbreak from the environmental context in which it emerges, you will not be able to effectively manage the outbreak, and your chosen eradication measures may cause more harm than good to other economic interests within the given environmental context. This

recognition that you must look at the whole system or context is the philosophy behind the One Health Initiatives. The One Health Initiatives mission involves,

> recognizing that human health (including mental health via the human-animal bond phenomenon), animal health, and ecosystem health are inextricably linked, One Health seeks to promote, improve, and defend the health and well-being of all species by enhancing cooperation and collaboration between physicians, veterinarians, other scientific health and environmental professionals and by promoting strengths in leadership and management to achieve these goals. (One Health Initiative 2013)

a. Systems Thinking and the Cynefin Sense-Making Framework Can Help Decision Makers in a Major Foot-and-Mouth Disease Outbreak

A system is a set of things-people, cells, molecules, or whatever-interconnected in such a way that they produce their own pattern of behavior over time. The system may be buffeted, constricted, triggered, or driven by outside forces. But the system's response to these forces is characteristic of itself, and that response is seldom simple in the real world (Meadows 2008, Loc 206).

Animal production systems are highly dependent on just-in-time flow of their systems. Living creatures are very susceptible to disruptions in the life support systems that sustain them. Animals must move to slaughter so the new piglets can move in to replace them. Economic losses are incurred when system movement is interrupted. "Resilience is a measure of a system's ability to survive and persist, within a variable environment" (Meadows 2008, Loc 1376). Large animal production systems are not very resilient. The animal production systems are susceptible to disruption because they are based on a just-in-time movement of large numbers of animals throughout the various stages of their life. Stopping movement for any great length of time, will back up the system causing other problems. These problems may include finding additional housing, feeding animals while stopped, and the loss of animals going to slaughter facilities.

In making response and recovery decisions, decision makers will have to probe, sense (gather data and information), and respond in a repeated cycle throughout the response and recovery. Because you cannot predict exactly what effect a given action will have on the interconnected parts of the animal production systems, decision makers

must continually evaluate to make sure that the choices they make do not result in unintended negative consequences as they interact with the complex production systems.

The David Snowden and Mary E. Boone Cynefin framework for sense making (Chapter V) can help the decision makers manage within the complex situation. The next recommendation will provide the data support for this cyclic process of probing, sensing, and responding that is undertaken throughout the response and recovery to a major Foot - and - Mouth Disease outbreak.

b. Stakeholders Acceptance for Sharing Critical Data and Information on a Standardized Trusted Platform

The U.S. animal production systems are marvels of continuous process improvement. Large integrated systems for the production of beef and pork move animals from state-to-state throughout their lifespan with just-in-time precision. A constant flow from birth through growth, finishing, and slaughter, keep farms, feed providers, truckers, meat packers, grocers, and various animal byproduct businesses profitable (MacDonald and McBride 2009).

These systems provide high quality protein to the American public, as well as to our trading partners across the globe. In addition to the beef and pork products, cows are used by dairies, large and small, to produce milk and dairy products. For these dairies, milk has to move on a regular basis, because you cannot tell the cows to stop producing (Secure Milk Supply 2013). These products help the U.S. in their balance of trade efforts. The system works when everything moves appropriately. This is an example of infrastructure systems working well with little attention from the consumer other than being able to purchase a wide variety of products at the market.

Problems occur when this movement is interrupted. An outbreak of foot-and-mouth disease within the United States will cause extensive disruption to these systems. Due to the integrated and mobile animal production systems in the U.S., a foot-and-mouth disease outbreak has the potential to spread quickly. The spread can get a jump on response measures, because you are not aware of its presence for a while, due to the fact that animals can shed the virus and infect other animals up to 10 days prior to

showing visible signs of infection. This is a feedback delay of information that is critical. “Because of feedback delays within complex systems, by the time a problem becomes apparent, it may be unnecessarily difficult to solve” (Meadows 2008, Loc 236). For this reason, early detection and accurate records regarding infected animals and their past locations and intermingling with other animals is critical to effective response and recovery efforts.

The more accurate and rapid the availability of information and data about a particular outbreak, the easier it is for decision makers to safely manage continuity of operations during an outbreak. Dr. Patrick Webb, Director, Swine Health Programs at the National Pork Board, stated in his recent presentation at the National Institute for Animal Agriculture 2013 Conference, that the number one thing needed in an outbreak is “good and accurate information” (Webb 2013).

Academic institutions like the FAZD CENTER,[2] have developed web-based and geo-located tools for managing the data of animals and infection distribution that will be vital in providing situational awareness for decision makers. The FAZD Center has done their job in developing the tool but do not have the staff to use the tool. It has not been determined who will train on it and fulfill the needed data management role. Currently, in 2013, no one is designated to use the AgConnect tool, although the National Pork Board has expressed interest for tracking their industry products in an outbreak situation. While encouraging and moving in the right direction based on the recommendations from the UK outbreak review (Anderson 2008) this is only one small piece of the response and recovery puzzle.

The need for rapid and accurate information is critical to aid decision makers. Good information can help decision makers to choose appropriately sized responses and recovery efforts that cover the infected area without wasting resources or

[2] The National Center for Foreign Animal and Zoonotic Disease Defense (FAZD Center) performs research and develops products to defend the nation from high-consequence foreign animal and zoonotic diseases. Founded in April 2004 as a Department of Homeland Security (DHS) Science and Technology (S&T) Center of Excellence (COE), the FAZD Center leverages the resources of multiple major universities, Minority Serving Institutions, national laboratories, and partners in state and federal government.

causing undue economic disruptions to non-infected areas. Well-handled response and recovery efforts in turn instill confidence in the general public (National Institute for Animal Agriculture 2013, 14–15).

B. CHALLENGES TO IMPLEMENTATION OF PUBLIC-PRIVATE-ACADEMIC COORDINATION

Whether an accidental or an intentional terrorist introduction were to occur, the challenges to work together toward disease eradication will be many. The various stakeholders include, but are not limited to, animal producers, animal production, transportation, processing industries; animal health officials at the federal and state level, environmental waste management officials, local impacted communities, and in a peripheral way, consumers (National Institute for Animal Agriculture 2013, 14–15).

In some pairings, like animal producers and environmental officials, not only do they not normally work together collaboratively, but the groups may have an adversarial relationship during normal business operations over issues like waste management. The producers can find the environmental regulations too burdensome and the environmental officials are charged with identifying those producers who may disregard their regulations. This is not a conductive climate for trusted information sharing. However, in a disease management situation the stakeholders will have to collaborate on environmentally sound disposal methods for large numbers of infected animals (United States Department of Agriculture 2013).

Each of the stakeholders comes to the response effort with their own ingrained organizational biases and primary focus on protecting their interests in any disease management strategy. "Social identity that promotes the power of one organization over another produces two social outcomes during complex incidents" (Pfeifer 2007, 207). First, it leads to positive bias to the in-group and negative bias to the out-group. This results in sharing more information with the in-group. Second when under stress there is even less inclination to share information with the out-group members. This tendency to close ranks within the in-group, at the time that a complex multi-stakeholder collaborated response is required, should be understood and mitigated prior to a major foot-and-mouth

disease outbreak. Unified command structure is recommended to mitigate the negative impacts of organizational bias during complex incidents (Pfeifer 2007, 213).

Stress can come from the fact that the normal routines and responses to everyday animal production systems will not work in the complex crisis situation. "New interpretive frameworks are needed to manage events that fall outside the realm of routine emergencies" (Patton 2007, 235). The following factors will be stressful to animal producers by radically shifting and expanding the trusted circle in which information must be shared, and to effectively manage the response and recovery from a major FMD outbreak.

- They will be asked to work with and trust groups that they may consider adversarial in normal operating situations.
- They may be asked to cull (kill) large numbers of animals for disposal, where their normal responsibility is to care for and raise them sell them to others who so slaughter for the good purpose of feeding people.
- The identification of foot-and-mouth disease in the United States will shut down international markets negatively impacting animal product prices for the entire industry and disease eradication efforts are sure to lead to financial hardships for those directly impacted by the disease (World Organization for Animal Health 2013).
- Some choices of how to handle the disease eradication on their farm will be determined by others. This takes control away from them at a time of great financial losses and uncertainty. This limiting of options for effective actions increases stress (Patton 2007, 235).

Pre-event education for all the various stakeholder groups would be beneficial to gain acceptance for any unique situation that would require working under a different framework where collaboration, coordination, and communication are required to meet the challenges of the extraordinary complex animal health emergency. Respected leaders from each stakeholder group must forge pre-event working relationships about how they will jointly operate a unified command structure in a major event. These leaders must pre-condition their stakeholder groups to the critical need for developing acceptable collaboration, coordination, and communication operational structures. This tells the in-group when it is acceptable to switch operational gears for the more critical purpose of disease eradication. This sanctioning of a different-than-the-norm behavior by leaders of

the stakeholder group will reduce the stress of acting out of normal in-group behaviors and will improve the collaborative response and recovery efforts. These leaders "must accept the value of collaboration (e.g., the need for diverse perspectives) if they are to understand and manage complex problems" (Patton 2007, 238).

Stakeholder groups will feel less stress knowing that someone representing their group is part of the unified command structure. Each stakeholder group can be assured that their viewpoint and concerns will be represented as the response and recovery strategy is developed, continually assessed, and modified to meet emergent issues. Along with a multi-stakeholder command structure, stakeholder groups need pre-developed policies to work together to provide meaningful and timely operational and situational awareness information to support the decision makers.

C. RECOMMENDATIONS FOR FUTURE RESEARCH

Research at academic institutions has made great strides in vaccination improvements. "Our molecular knowledge of the seven serotypes of FMD virus has grown exponentially in the past 20 years, and there are now many sophisticated and sensitive diagnostic assays available for field and laboratory use and knowledge of the components of an effective vaccine" (Lubroth 2011, 235). These advancements provide additional options in a response and recovery strategy. However, the creation of vaccine production capabilities within the U.S. is not economically feasible in the absence of the disease.

Because of the lack of disease within the U.S., stockpiling to meet a potential need is further hindered because you do not know what strain of the virus you are dealing with until an outbreak occurs, and you test to find out what serotype you are dealing with. Then when mass numbers of vaccines are needed in an outbreak, you do not have the capacity built up to produce them. Research to improve the capabilities to produce effective vaccines rapidly when needed should be pursued.

The anticipated costs associated with response and recovery activities from a major FMD outbreak are conceivable before the fact. Future research should be conducted to explore insurance risk-management tools to cover this risk. An insurance

product should be considered as a means to cover the significant costs required for the response and recovery actions that may be required. This can include support for producers who cull their herds to save the overall industry.

A risk management tool may provide additional certainty regarding financial losses to producers, due to eradication efforts. Swift action in the early stages of an outbreak should not be hindered by local or state level administrative fears about not being reimbursed for the response activities. A funding pool, based on shared risk within the animal production industry, can provide the funding source for the rapid response needs in a major FMD outbreak.

VII. CONCLUSIONS

Chapter IV illustrated the complex nature of a foot-and-mouth disease outbreak and Chapter V recommended using a sense making framework and the use of trust and leadership in multi-stakeholder collaboration to overcome the challenges of working in complex systems. The challenges inherent in the 2013 preparedness posture were identified as disjointed authorities, interests, capabilities, and expectations of the various stakeholders. Each stakeholder can react according to the authorities they have in the case of governments, the control of their animals they have in the case of producers and in the emotional reaction without regard to scientific facts as the consumers tend to do in response to disruptions to their food sources. Individual reactions by multiple people involved in the outbreak situation cannot be predicted ahead of time.

In this situation, it is challenging to manage a response and recovery process that needs to sort structure from complexity through the logical gathering of information and implementation of measures within a continual feedback loop. Without coordination and collaboration from the public and private stakeholders the response and recovery efforts are more likely to find themselves lurching from crisis to crisis. Because animal production industries have an economic threat in a foot-and-mouth disease outbreak, they should undertake a leadership role in developing and supporting collaborative structures pre-event that will allow for the needed collaboration to minimize the impacts of a foot-and-mouth disease outbreak.

The need for this collaborative structure is based on the main themes that have emerged throughout this thesis.

- Support early detection mechanisms
- Support rapid and coordinated response and recovery efforts
- Provide scientific data to decision makers
- Use open communication with both producers and the general public

A response and recovery effort to a major foot-and-mouth disease outbreak in the United States will benefit from technical data gathering and modeling support and voluntary collaboration between industry, academia, governmental entities, media, and

consumers. Effective engagement of these recommendations will provide the support for the decision maker's use of unique sense-making strategies like the Cynefin model (Snowden and Boone 2007).

The United States can strengthen its preparedness posture and can improve its ability to support effective decision making in responding to and recovering from a major animal health emergency in the following three ways. The first sets up an ongoing regional multi-stakeholder enabling structure that can be used to build trust by convening collaborative people from the multiple stakeholder groups (Innes 2010) (Wageman n.d.). The second supports the provision of credible and rapid information upon which to make decisions (Anderson 2008). The third provides decision makers with a sense-making framework for understanding and working in complex situations with multiple stakeholders (Snowden and Boone 2007).

A. MAINTAIN REGIONAL MULTI-STAKEHOLDER PARTNERSHIPS

The research indicated that trust and leadership help to facilitate coordination and cooperation between multi-stakeholder groups (Wageman n.d.). Multi-stakeholder partnerships provide the structure where diverse intelligence can be dispersed and linked together to make sense of the complex situations (Innes 2010) and strengthen the understanding of the group. Relationships build prior to an outbreak can help to mitigate some of the organizational biases that each stakeholder has based on their individual interests during normal disease free times (Pfeifer 2007, 214).

To meet these needs, regional multi-stakeholder partnerships should be maintained to provide the collaborative structure of trusted relationships to facilitate information and data sharing during a major animal health emergency. The size of the regional partnerships should align with major regional animal production systems. These are the regional groups that can come to agreements between all the stakeholders of how response and recovery actions will be undertaken initially and how locally and regionally appropriate actions will be determined as an outbreak evolves. "As societies, we must come to some understanding of what we are facing, and in times of relative tranquility, organize ourselves and debate what we will do if a catastrophe came to pass" (Bobbitt

2009, 425). These groups provide the framework for maintaining the local and regional multi-stakeholder relationships that agree on the plans, train to the plans and exercise the plans to find workable local and regional solutions for effectively operating together in a foot-and-mouth disease Outbreak.

B. STRENGTHEN DATA AND INFORMATION SUPPORT TO DECISION MAKERS

The UK learned how economically devastating an outbreak of foot-and-mouth disease (FMD) can be. This impact was felt not only by the animal producers who lost animals in the course of disease eradication, but also to the economy of the area impacted by the disease. England's animal health officials and producers learned that it pays to keep a watchful eye open for early detection, support rapid and coordinated response, provide scientific data to policy decision makers, and operate with open communications with the public and animal producers.

From the comparison of the UK foot-and-mouth disease outbreak and the United States animal production structure, the Thesis author proposes two ways to strengthen the United States posture for information and data support to decision makers in a foot-and-mouth disease Outbreak. The first is the development of a standardized animal identification and tracking system to be implemented during a disease outbreak. These increased capabilities in animal traceability and data management will help both in the eradication effort and in the continuity of operations efforts. To manage this data and information, current animal health preparedness capabilities will have to be rapidly augmented with communication, and technical and logistical support staff to scale up to meet the needs of collecting, organizing, and analyzing the vast data needed to provide continuous situational awareness in a fluid response and recovery situation.

The second is in facilitating the commitment of the various stakeholders to utilize trusted communications and information sharing platforms. Both actions will improve the accuracy of situational awareness by increasing the accuracy of the information and data used by decision makers in their development of appropriate strategy to eradicate the

disease. The regional multi-stakeholder partnership is a structure where these improvements can be formulated, accepted by all the stakeholders and can be maintained.

C. UNDERSTAND THE COMPLEXITY OF THE SITUATION AND APPROACH DECISION MAKING ACCORDINGLY

The Cynefin model (Snowden and Boone 2007) of sense making in complex situations can help decision makers by setting a framework from which to operate in the anticipated complex response and recovery environment. Snowden and Boone recommend that, in order to manage effectively in a complex environment, you must open up the discussion, set barriers within which the various interests can self regulate, stimulate attractors and encourage the growth of positive ones, encourage dissent and diversity to explore more options, and manage the starting conditions and watch for emergence of what is acceptable moving forward (Snowden and Boone 2007, 7).

H.L. Mencken said "For every complex problem there is an answer that is clear, simple, and wrong." In an animal health emergency there will be many answers that could be right for many of the issues that will have to be managed in the response and recovery phases. Each decision will have ramification to other parts of the system. No one decision will be the silver bullet answer to solve the problem. Difficult choices will have to be made. "All these endeavors require one to stay wide awake, pay close attention, participate flat out, and respond to feedback" (Meadows 2008, Loc 3171). Due to these realities, the multi-stakeholder effort must acknowledge the complex environment they are working in, and be prepared to utilize the best tools for that environment. These tools will include:

- Defining roles and responsibilities and establishing mutually reinforcing or joint strategies to achieve outcomes in partnership with all stakeholders.
- Set barriers and stimulate attractors. Guide efforts toward what is working well. Manage the starting conditions and look for emergence.
- Develop mechanisms to monitor, evaluate, and report on a regular basis. This will allow for transparency with all stakeholders and consumers. It will also allow for a feedback loop to identify where adjustments should be made.

It is important that decision makers understand that they are working in a complex environment during a major FMD outbreak. If the various stakeholders understand this concept prior to an outbreak situation the response and recovery actions can be supported through a continual sense making process. The data management support recommendation will provide the decision makers with the data and information needed to apply the sense making tools of the Cynefin model.

All of these recommendations are designed to mitigate the challenges of working with multiple stakeholders in a complex environment by meeting the situational awareness needs of decision makers. By maintaining trusted relationships between public, private, and academic stakeholders; collaboration, coordination, and information sharing will be facilitated. This will support decision makers, with the goal of disease eradication while minimizing economic disruptions.

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APPENDIX. LESSONS FROM RECENT OUTBREAKS

A. DROVERS CATTLE NETWORK SUMMARY OF DR. PAM HULLINGER'S 2013 NIAA PRESENTATION ON LESSONS LEARNED FROM RECENT FMD OUTBREAKS

Following are excerpts taken from the Drovers Cattle Network of lessons learned from recent FMD outbreaks. These excerpts were summarized in Dr. Pam Hullinger's 2013 NIAA presentation.

John Maday, Managing Editor, Drovers Cattle Network | Updated: 04/19/2013

As the United States plans and prepares for the possibility of an outbreak of foot and mouth disease (FMD), we have the benefit of knowledge gained from outbreaks around the world in recent years. During last week's annual conference of the National Institute for Animal Agriculture, University of California-Davis veterinarian Pam Hullinger described what went right and what might have been done differently in several FMD outbreaks.

Taiwan, 1997

The strain involved in this outbreak only caused clinical signs in pigs, which resulted in early misdiagnosis. Delays in detecting the virus, a heavy concentration of hogs in the area, slow implementation of vaccinations and a shortage of vaccine once implemented resulted in a large impact. The country killed 74 million hogs, 38 percent of the total population, from over 6,000 farms, resulting in $2 billion per year in export losses alone.

UK, 2001

The index farm did not report problems as they appeared, and ended up shipping infected sheep well after the outbreak began. Early in the outbreak, farmers did not have adequate information and bio-security practices were inadequate. The country depopulated 10,000 farms, resulting in economic disruptions that continue today. UK officials depopulated uninfected farms adjacent to infected farms, a practice Hullinger says probably was not necessary.

Uruguay, 2001

In contrast to the UK, Uruguay culled very few animals. Animal health officials quickly recognized the rapidly spreading outbreak, which infected herds on 28 farms in the first five days. They initially implemented a “ring-vaccination” program, vaccinating animals in areas surrounding the outbreak, but within seven days, with 131 farms infected, switched to a national vaccination program. In cooperation with the government, farmers administered two rounds of over 12 million doses of the vaccine to susceptible animals across the country. Only 7,000 animals were destroyed, and Uruguay’s beef exports resumed within one year. The country was rated FMD-free by May 2003, but the national vaccination program continues today.

UK, 2007

A relatively small outbreak occurred with the virus apparently escaped from a vaccine-manufacturing facility. The disease was well established in a small herd before it was detected, but there was little movement of animals from the site and the outbreak was quickly contained.

Japan, 2010

The outbreak began in a small cattle herd and spread to 10 farms before being detected. Two months after detection, the government implemented a vaccination program, with animal-health officials controlling and administering the vaccine. Slow detection and quarantine resulted in culling of 200,000 animals on 300 farms.

South Korea, 2011

The virus was detected in swine in October 2010, and the strain was difficult to detect in cattle and farmed deer. The country implemented culling, quarantines and 2,500 disinfection stations. Inhumane culling practices made international news in some cases. The country began emergency vaccinations in January 2011, distributing 30 million doses of vaccines. Widespread culling resulted in food shortages and high food prices in South Korea.

Bulgaria and Turkey, 2011

Animal health officials detected FMD in a hunter-killed wild boar along the border between Bulgaria and Turkey. Testing of wildlife in the area suggests a low rate of transmission. Hullinger says this and other research indicate wild pigs, deer or other wildlife probably would not play a major role in spreading the virus in a U.S. outbreak.

Israel, 2011

Israel routinely vaccinates livestock for six strains of the FMD serotype that occurs there. The strain in this outbreak was similar to three strains in the vaccine, but not an exact match. Virtually all infected animals had been vaccinated, but those vaccinated within two weeks prior to the outbreak did not show evidence of the virus. Hullinger says this experience shows there is a lot yet to learn about vaccinating for FMD.

Hullinger lists these common threads that influence success in controlling outbreaks:

- Early recognition, detection and reporting
- Effective bio-security in response to the disease and good routine bio-security overall
- When necessary, early implementation of vaccination

We now have the benefit of better understanding of the disease and better diagnostics than in the past, Hullinger says. We also face challenges due to the high concentration of livestock in some areas of the United States and the high rate of movement of livestock through markets and between operations. Past experience shows the value of investing in preparedness.

For more information, see: http://www.bovinevetonline.com/news/Learning-from-FMD-outbreaks-203839431.html?view=all#sthash.SexQNkfl.dpuf (Maday 2013).

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LIST OF REFERENCES

American Association of Swine Veterinarians. "ASSV Quick Facts–Porcine Epidemic Diarrhea." *American Association of Swine Veterinarians.* May 23, 2013. Accessed July 21, 2013, http://www.aasv.org/aasv%20website/Resources/Diseases/PED/PED--AASVQF052313.pdf.

Anderson, Dr. Ian. *Foot and Mouth Disease 2001: Lessons to be Learned Inquiry Report.* Inquiry into Government Actions, London: The Stationary Office, 2002.

———. *Foot and Mouth Disease 2007: A Review and Lessons Learned.* Foot and Mouth Disease 2007: A Review and Lessons Learned, London: The Stationary Office, 2008, 1–139.

Bellavita, Christopher. "Changing Homeland Security: The Issue-Attention Cycle." *Homeland Security Affairs* I, no. 1 (2005).

Bobbitt, Philip. *Terror and Consent.* New York: Anchor Books, 2009.

Boffey, Philip M. "What if It Weren't Called Pink Slime." *The New York Times*, May 12, 2012.

Burridge, Brian, Sir. "The Roller-Coaster Ride of Strategic Leadership." *CLS Extended Essay Series* (University of Exeter Business School), 2006.

Center for Food Safety and Public Health. "Secure Pork Supply." *Classification of Phases and Types of foot-and-mouth disease Outbreak and Response–DRAFT.* March 2013. Accessed August 23, 2013, http://www.cfsph.iastate.edu/pdf/phases-and-types-of-an-fmd-outbreak.

———. *Animal Disease Emergency–Presentation for Local Government Officials.* Ames, IA, 2008.

———. "Factsheets–Foot and Mouth Disease." *Center for food Security and Public Health, Iowa State University.* September 2007. Accessed February 17, 2013, http://www.cfsph.iastate.edu/Factsheets/pdfs/foot_and_mouth_disease.pdf.

_____. "Fast Facts—foot-and-mouth disease (FMD)." *Center for food Security and Public Health, Iowa State University.* April 2008. Accessed July 21, 2013, http://www.cfsph.iastate.edu/FastFacts/pdf/pdfs/foot_mouth_disease_F.pdf.

———. *Foreign Animal Disease Preparedness and Response (FADPReP).* 2013. Accessed June 22, 2013, http://www.cfsph.iastate.edu/Emergency-Response/fad-prep.php.

———. *Secure Food Supply Plans.* 2013. Accessed July 26, 2013, http://www.cfsph.iastate.edu/Secure-Food-Supply/index.php.

——— "Secure Pork Supply—Communications Working Group." *Working Group.* April 2013. Accessed July 31, 2013, http://www.cfsph.iastate.edu/pdf/sps-working-groups.

———. *Secure Pork Supply Project.* 2011. Accessed September 2, 2013, http://www.cfsph.iastate.edu/Secure-Food-Supply/pork-supply.php.

Code of Iowa. *Iowa Administrative Code, Chapter 65.* 2013. Accessed June 22, 2013, https://www.legis.iowa.gov/DOCS/ACO/IAC/LINC/1–25–2012.Rule.21.65.5.pdf.

Covello, Vincent T., David B. McCallum, and Maria T. Pavlova. *Effective Risk Communication: The Role and Responsibility of Government and Nongovernment Organizations.* New York: Plenum, 1989.

DEFRA. *Animal Health and Welfare Board for England website.* London, May 13, 2013.

———. "Farming Statistics Final Land Use, Livestock Populations and Agriculture Workforce at 1 June 2012 - England." *DEFRA National Statistics.* London, June 1, 2012.

———. "Foot and Mouth Disease Control Strategy for Great Britain." *DEFRA.* November 2011. Accessed May 23, 2013, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69456/fmd-control-strategy111128.pdf.

Department for Environment, Food, and Rural Affairs. *Animal Identification,Movement and Tracing Regulations.* May 21, 2013. Accessed June 21, 2013, https://www.gov.uk/animal-identification-movement-and-tracing-regulations.

———. *Responsibilities.* London. Accessed June 21, 2013, https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/about

Department of Homeland Security. "Homeland Security Presidential Directive/HSPD-9." *United States Department of Agriculture, APHIS, Animal Health, Emergency Management.* January 30, 2004. Accessed July 26, 2013, http://www.aphis.usda.gov/animal_health/emergency_management/downloads/hspd-9.pdf.

French, Simon, and Carmen Niculae. "Believe in the Model: Mishandle the Emergency." *Proceedings ISCRAM2004.* Brussels, 2004, 9–14.

GAO. GAO-02–808, *Foot and Mouth Disease, To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding Issues.* GAO Report, Washington, D.C.: Government Accountability Office, 2002.

———. GAO-06–15, *Results Oriented Government Practices That Can Help Enhanse and Sustain Collaboration Among Federal Agencies.* GAO Report, Washington, D.C.: Government Accountability Office, 2005.

———. GAO-12–813T, *Disaster Recovery, Select Themes for Effective Long-Term Recovery, Statement of Stanley J. Czerwinski.* GAO Report, Strategic Issues, Washington D.C.: Government Accountability Office, 2012.

Graham, Stephen. *Disrupted Cities, When Infrastructure Fails.* New York: Routledge, 2010.

Homeland Security News Wire. *A World Free of foot-and-mouth disease within sight.* July 9, 2012. Accessed May 26, 2013, http://homelandsecuritynewswire.com/dr20120708-a-world-free-of-footandmouth-disease-within-sight.

Innes, Judith E., David E. Booher. *Planning with Complexity.* New York: Routledge, 2010.

Iowa Department of Agriculture and Land Stewardship. *Animal Industry Bureau - Chronic Wasting Disease.* Accessed August 23, 2013, http://www.iowaagriculture.gov/animalIndustry/chronicWastingDisease.asp.

———. *Iowa Administrative Code Chapter 64.* 7 10, 2013. Accessed July 20, 2013, https://www.legis.iowa.gov/DOCS/ACO/IAC/LINC/7–10–2013.Rule.21.64.1.pdf.

Iowa State Legislature. *2013 IOWA CODE.* 2013. Accessed August 22, 2013, http://search.legis.state.ia.us/nxt/gateway.dll/ic?f=templates&fn=default.htm.

———. *Chapter 163 INFECTIOUS AND CONTAGIOUS DISEASES AMONG ANIMALS.* 2013. Accessed August 1, 2013, http://coolice.legis.iowa.gov/Cool-ICE/default.asp?category=billinfo&service=IowaCode&ga=83&input=163.

Kettle, Donald F. *Systems Under Stress, Homeland Security and American Politics.* Washington, D.C.: CQ Press, 2007.

Kurtz, Charles F., and D.J. Snowden. “The New Dynamics of Strategy: Sense Making in a Complex and Complicated World.” *IBM Systems Journal*, 2003: 462–483.

Lewis, Patrice. “Animal disease traceability.” *Backwood Homes Magazine.* September/October 2012. Accessed August 23, 2013, http://www.backwoodshome.com/articles2/lewis137.html.

Lubroth, Juan. “Prospects for the Global Eradication of Foot-and -Mouth Disease.” *One Hundred and Fifteenth Meeting of the United States Animal Health Association.* Buffalo: Richardson Communications Group, 2011. 234–237.

MacDonald, James, and William McBride. *The Transformation of U.S. Livestock Agriculture: Scale, Effi ciency, and Risks / EIB-43.* Economic Information Bulletin No. (EIB-43) 46 pp, January 2009, Washington: Economic Research Service/USDA, 2009.

Maday, John. *Learning From FMD Outbreaks.* April 19, 2013.

Marcus, Leonard J., Barry C. Dorn, and Joseph M. Henderson. “Meta-Leadership and National Emergency Preparedness. Strategies to Build Government Connectivity.” Center for Public Leadership, Working Papers, 2005, 42–64.

Meadows, Donella. *Thinking in Systems: A Primer.* White River Junction, Vermont: Chelsea Green Publishing, 2008.

Morag, Nadav. *Comparative Homeland Security, Global Lessons.* Hoboken, New Jersey: John Wiley& Sons, 2011.

Multi-State Partnership for Security in Agriculture. *Multi-State Partnership for Security in Agriculture.* 2013. Accessed July 27, 2013, http://www.multistatepartnership.org/index.cfm/projects/.

———. *Risk and Crisis Communications Pocket Guide.* 2013. Accessed July 27, 2013, http://cerc4ag.com/sites/default/files/uploads/file_attachments/Agricultural%20Emergency%20Response%20Risk%20and%20Crisis%20Communication%20Pocket%20Guide.pdf.

National Animal Health Laboratory Network. “Porcine Epidemic Diarrhea virus (PEDv) Testing Data from NAHLN Laboratories.” *American Association of Swine Veterinarians.* July 17, 2013. Accessed July 21, 2013, http://www.aasv.org/aasv%20website/Resources/Diseases/PED/PEDv_weekly_report_071713.pdf.

National Association of State Departments of Agriculture. *List of State and Territory Members.* 2013. Accessed August 22, 2013, http://www.nasda.org/9383/6479.aspx.

National Institute for Animal Agriculture. *Foot and Mouth Disease--Fostering a New Preparedness Paradigm: Facilitating a Conversation Among Public and Private Sector Stakeholders.* White Paper- Information synthesized from April 17–18, 2013, foot-and-mouth disease Symposium in Louisville, KY, Louisville: National Institute for Animal Agriculture, 2013.

National Pork Board. *Animal Welfare During a Disease Outbreak Presentation.* Louisville, 2013.

———. One Health Initiative. Mission Statement. Accessed August 30, 2013, http://www.onehealthinitiative.com/mission.php.

———. *PEDV - Latest Update.* July 31, 2013. Accessed August 23, 2013, http://www.pork.org/News/4061/LatestPEDVUpdate.aspx#.UhiMZHk8U6o.

Parker, Lucinda J. *Agroterrorism Risk Communication: Challenges and Implications for Communicators.* Master's Thesis, Naval Postgraduate School, Monterey, CA., 2005.

Patton, Douglas:Violanti, John M. "Terrorism Stress Risk Assessment and Management." In *Psychology of Terrorism*, by Bruce Bongar, Lisa M. Brown, Larry E. Beutler, James N. Breckenridge and Philip G. Zimbardo, 225–246. Oxford: Oxford University Press, 2007.

Pfeifer, Joseph W. "Understanding How Organizational Bias influenced First Responders at the World Trade Center." In *Psychology of Terrorism*, by Bruce Bogner, Lisa M Brown, Larry E. Beutler, James N. Breckenridge and Phillip G. Zimbardo, 207–215. Oxford: Oxford University Press, 2007.

Rosen, Jefferey. "Man-Made Disaster." *New Republic.* December 24, 2008. Accessed May 16, 2013, http://www.newrepublic.com/article/man-made-disaster.

Schwartz, Peter. *LEARNINGS from the Long View.* Peter Schwartz, 2011.

Secure Milk Supply. *Secure Milk Supply.* 2013. Accessed May 23, 2013, http://www.securemilksupply.org/Assets/SMS-Executive-Summary-14Jan2012.pdf.

———. "SMS Plan Executive Summary 2012." *Secure Milk Supply.* 2012. Accessed September 12, 2012, http://www.securemilksupply.org/Assets/SMS-Executive-Summary-14Jan2012.pdf.

Secure Pork Supply Program. *Center for Food Security and Public Health.* 2013. Accessed July 31, 2013, http://www.cfsph.iastate.edu/Secure-Food-Supply/pork-supply.php.

Snowden, David J., and Mary E. Boone. "A Leaders's Framework for Decision Making." *Harvard Business Review*, November 2007: 1–8.

Taleb, Nicholas Nassim. "The Black Swan: The Impact of the Highly Improbable," *The New York Times*, April 22, 2007. Accessed July 22, 2013, http://www.nytimes.com/2007/04/22/books/chapters/0422–1st-tale.html.

United States Code 2012 Title 7. *7 USC § 8305 - Interstate movement.*

United States Department of Agriculture. “Animal and Plant Health Inspection Service.” *Feral Swine: Damage and Disease Threats.* June 2013. Accessed July 31, 2013, http://www.aphis.usda.gov/publications/wildlife_damage/content/printable_version/feral_swine.pdf.

———. *Animal and Plant Health Inspection Service, Veterinary Services.* July 2013. Accessed July 20, 2013, http://www.aphis.usda.gov/publications/animal_health/2013/fs_fmd_general.pdf.

———. *Animal Disease Traceability.* June 22, 2013. Accessed June 22, 2013. http://www.aphis.usda.gov/traceability/.

———. “APHIS Foreign Animal Disease Framework.” *Animal and Plant Health Inspection Services.* May 2012. Accessed July 21, 2013, http://www.aphis.usda.gov/animal_health/emergency_management/downloads/documents_manuals/fadprep_manual_2.pdf.

United States Department of Agriculture. *Appendix 2 - Overview of U.S. Livestock, Poultry, and Aquaculture Production in 2010 and Statistics on Major Commodities.* Statistical Report, APHIS, Animal Health, Washington, D.C.: USDA, 2010, 1–14.

———. “FADPReP Foreign Animal Disease Preparedness and Response Plan.” *Animal and Plant Health Inspection Services, Veterinary Services.* May 2012. Accessed July 22, 2013, http://www.aphis.usda.gov/animal_health/emergency_management/downloads/documents_manuals/fadprep_manual_1.pdf.

———. “FADPReP/NAHEMS Guidelines: Disposal (2012).” *Animal and Plant Health Inspection Service, Veterinary Services.* 2012. Accessed August 2, 2013, http://www.aphis.usda.gov/animal_health/emergency_management/downloads/nahems_guidelines/disposal_nahems.pdf.

_____. “FADPReP/NAHEMS Guidelines: Vaccination For Contagious Diseases, Appendix A: Foot-and-Mouth Disease (April 2011) *Animal and Plant Health Inspection Service, Veterinary Services.* Accessed July 21, 2013, http://www.aphis.usda.gov/animal_health /emergency_management/downloads/nahems_guidelines/nahems_guidelines_appa%20_vacfmdv2.pdf.

———. “Federal Register / Vol. 78, No. 6 / Wednesday, January 9, 2013 / Rules and Regulations.” *United States Department of Agriculture, Animal and Plant Health Inspection Service.* January 9, 2013. Accessed July 26, 2013, http://www.aphis.usda.gov/newsroom/2012/12/pdf/traceability_final_rule.pdf.

———. *Foot-And-Mouth Disease Response Plan–The Red Book–Draft.* June 2012. Accessed August 22, 2013, http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf.

———. "Lesson 2: Command and Management Under NIMS—Part 1." 2013. Accessed August 24, 2013, http://www.usda.gov/documents/NIMLesson02.pdf.

———. *Livestock Appraisal, Indemnity & Compensation.* May 24, 2012. Accessed August 1, 2013, http://www.aphis.usda.gov/animal_health/emergingissues/compensation/comp.shtml.

United States General Accounting Office. *Foot and Mouth Disease, To Protect U.S. Livestock USDA Must Remain Vigilant and Resolve Outstanding Issues.* Report to the Honorable Senator Tom Daschle, Washington, D.C.: Government Accountability Office, 2002.

USDA APHIS. *Veterinary Services - Animal Health.* March 1, 2012. Accessed May 23, 2013, http://www.aphis.usda.gov/animal_health/area_offices/.

USDA NASS. *Statistics by State.* 2011. Accessed May 23, 2013, http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_IA.pdf.

Wageman, Ruth. "Building Great Leadership Teams for Complex Problems." *Rethinking Health Stewardship Initiative.* Accessed July 26, 2013, http://fl.eqhs.org/Portals/6/reThink%20Health/Multistakeholder%20Leadership%20Teams.pdf.

Webb, Patrick. "Dr. Patrick Webb—Animal Welfare During a Disease Outbreak." *slindeshare.net.* April 15–17, 2013. Accessed June 23, 2013, http://www.slideshare.net/trufflemedia/dr-patrick-webb-animal-welfare-during-a-disease-outbreak.

Wisconsin Department of Agriculture. Trade and Consumer Protection. *Livestock Premises Registration.* 2013. Accessed July 27, 2013, http://datcp.wi.gov/animals/premises_registration/.

World Organisation for Animal Health. About us: OIE–World Organisation for Animal Health. 2013. Accessed July 9, 2013, http://www.oie.int/about-us/.

_____. OIE Listed Diseases. 2013. Accessed July 9, 2013, http://www.oie.int/for-the-media/animal-diseases/animal-disease-information-summaries/.

_____. *World Organisation for Animal Health–Foot and Mouth Disease Portal*. 2013. Accessed July 20, 2013 http://www.oie.int/fileadmin/Home/eng/Meida_Center/docs/pdf/Disease_cards/FMD-EN.pdf.

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