NBAF
NATIONAL BIO AND
AGRO-DEFENSE FACILITY
Diagnostics • Vaccines • Training

Updated Site-Specific Biosafety and Biosecurity Mitigation Risk Assessment

February 2012
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Homeland
Security
Science and Technology Directorate

Defending America Against Foreign Animal Diseases

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Appendix A1: Stakeholder Engagement Plan

NBAF
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Stakeholder Engagement Plan

June 11, 2010

Homeland Security
Science and Technology Directorate

USDA

Defending America Against Foreign Animal Diseases

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1. Introduction and Background

The following document outlines a stakeholder engagement plan for the U.S. Department of Homeland Security's National Bio and Agro-Defense Facility (NBAF). NBAF will be a state-of-the-art integrated facility designed to protect the United States' agricultural economy, food supply, and public health from natural outbreaks or intentional introductions of foreign animal, emerging, and zoonotic (transmitted from animals to humans) diseases. DHS recognizes the need for comprehensive engagement plan to keep stakeholders informed as NBAF moves forward through design, construction, commissioning, and operation stages. DHS and the U.S. Department of Agriculture's Agricultural Research Service (ARS) and Animal and Plant Health Inspection Service (APHIS) (as the tenant research entities) are committed to transparency, open communication with stakeholders, and responding to stakeholder inquiries/concerns in a timely manner.

As with any high-containment laboratory, the study of high-consequence pathogens is not without risk. DHS is committed to mitigating these risks through comprehensive threat and risk analyses that will inform NBAF design, construction, and operation. Because public perception of these risks will be influenced by communications and outreach strategies, DHS will outline plans for risk communication as a part of the overall risk management strategy for NBAF. The purpose of the risk communication will be to educate and inform the public regarding risks and to inform the public in the highly unlikely event of an incident.

To facilitate open communication and transparency, DHS has prepared this stakeholder engagement plan as a dynamic document that will evolve with NBAF to guide efforts to provide consistent, timely and useful information. This plan draws upon stakeholder engagement best practices gathered from the Plum Island Animal Disease Center (PIADC) and other biocontainment laboratories, and builds on previous stakeholder engagement activities undertaken during the NBAF Site Selection EIS process. The plan also outlines a preliminary risk communication strategy that will be implemented when NBAF becomes fully operational in FY20. This stakeholder engagement plan will be reviewed at least annually and will be updated as needed.

2. Objectives

To ensure open communication and transparency with stakeholders, the primary objectives of this plan are to:

- Identify the appropriate stakeholders and specific activities, avenues, and venues to keep them engaged and informed.
- Establish public confidence in the NBAF project by facilitating continual dialogue among stakeholders, and DHS, and USDA (ARS and APHIS).

- Proactively establish channels of communication (e.g. a Stakeholder Engagement Committee, regular meetings, a website) for this dialogue in order to disseminate information and gather feedback throughout the design, construction, and operation of NBAF.

- Specifically engage the local Manhattan, KS community to earn public trust.

- Outline preliminary risk communication strategies for NBAF.

3. Lead Agency and Activity Coordination

As the owner of NBAF, DHS is responsible for the planning, construction, and operation. As such, DHS will work with federal partners and other involved organizations to coordinate stakeholder engagement activities. Specifically, the DHS Office of National Laboratories (ONL) within the Science and Technology (S&T) Directorate will take the lead on stakeholder activity coordination. The Director of ONL will work with senior DHS officials to answer questions regarding NBAF. ONL will be responsible for the primary information materials for NBAF, and will update and disseminate new information as it becomes available.

4. NBAF Stakeholders – Definition

For the purposes of the NBAF project, the term “stakeholder” is defined as any person or organization potentially affected by the planning, construction, and operation of NBAF, interested in the issues of biological and agricultural safety relative to current and emerging foreign animal diseases (FADs), or interested in business or research opportunities at NBAF. Currently, identified stakeholders include:

- The local community of Manhattan, KS, Kansas State University (K-State) and the Heartland BioAgro Consortium (HBAC)

- Private sector, non-profit, non-governmental organizations, and academia

- DHS, USDA and other Federal agencies

- State and local government

- Congress

- General public

5. Specific Stakeholder Engagement Activities and Action Plans

The following is a breakdown of the specific engagement activities and action plans that DHS intends to undertake with various NBAF stakeholders. The following activities incorporate many of the best practices of other high containment laboratories. The overall purpose of these activities is to increase public confidence by establishing a continual and open dialogue between DHS and stakeholders to inform, engage, and answer questions.

5.1 - The Local Community of Manhattan, KS, K-State, and HBAC

The members of the local community of Manhattan, KS are important to the success of NBAF. A strong community engagement program is the best method to inform the public, gain feedback, and develop/maintain the facility's reputation for public accountability, safety and trustworthiness. Through events such as open houses, facility tours, and town halls, the public can learn about laboratory operations and the control measures used to protect the staff, the community, and the surrounding environment. These initiatives help establish the relationships that build public confidence and accountability between the laboratory and members of the local community.

Kansas State University (K-State) already has a BSL-3 facility, the Pat Roberts' Biosecurity Research Institute (BRI). Local and regional stakeholders were engaged before and during the construction of the BRI. They are being kept updated on the status of the BRI while research is being launched by K-State faculty and scientists. DHS and USDA will work with these stakeholders to stand up the research at NBAF. To engage the local Manhattan community and other stakeholders, DHS will establish a Stakeholder Engagement Committee (SEC) and a comprehensive community outreach program to engage the public and facilitate a dialogue. To execute these approaches DHS and USDA will:

- Establish an active community outreach program, prior to beginning construction, which includes the establishment of an NBAF Stakeholder Engagement Committee (SEC). The goal of the SEC is to promote better understanding of laboratory activities (including preparedness in case of an emergency) among the general public, serve as an information exchange between the community and the laboratory, and facilitate community outreach events.

- Establish a mechanism, either through the SEC or otherwise, where members of the local Manhattan community can interact with the laboratory director and staff to ask questions and understand the facility's ongoing work in science and operations, including preparedness in case of emergency.

- Continue to participate, give briefings, gather feedback, and answer questions on the status of the program in NBAF-related meetings where members of the Manhattan community are present.

- Pro-actively seek to engage the community at each milestone of the construction project (i.e., completion of the site-specific risk assessment, award of site-preparation, etc.) through neighborhood or town hall-style meetings.

- Prepare fact sheets and briefing materials to clearly present and explain the mission, design, research, risks, and mitigation strategies associated with NBAF.

- Participate in open houses and other public outreach activities on the campus of K-State.

- Prior to and continuing through operations, host educational programs, facility tours, community forums, community days, open houses, and town hall meetings to engage and inform the general public and to facilitate communication and dialogue.

- Regularly update the DHS NBAF website, www.dhs.gov/nbaf, to disseminate timely and accurate information.

5.2 - Private Sector, Non-profit, Non-governmental Organizations, and Academia

The private sector, non-profit and non-governmental organizations, and academia are important partners in NBAF and its success. These groups represent the producer groups, agricultural associations, environmental groups, researchers, and academicians. To engage these stakeholders, DHS and USDA will, (in addition to the activities listed above):

- Establish mechanisms for information exchange between DHS and these organizations, such as research forums, national conferences, and general meetings.

- Hold monthly meetings with the HBAC to establish a cooperative relationship, inform them regarding NBAF's progress.

- Strengthen and focus community outreach efforts by keeping an integrated calendar of events where these groups will be present.

5.3 - DHS, USDA and Other Federal Agencies

ONL is the DHS office responsible for NBAF construction and operations/maintenance, and will continue to engage and communicate with DHS senior staff and other Federal agencies to keep them informed on the progress of NBAF. In addition to DHS, USDA ARS and APHIS as the lead partner agencies conducting research at NBAF are vital components in the success of the overall public outreach effort. DHS will continue to work with USDA to inform them of the progress of NBAF and to partner together in public outreach. To engage other Federal agencies, DHS and USDA will, (in addition to the activities listed above):

- Continue to proactively provide timely information and regular updates to Federal agencies through briefings, materials, website updates, and meetings.

- Commit to meeting regularly with officials from PIADC and other relevant biolabs for on-going public outreach support and collaboration.

5.4 - State and Local Government

Similar to the methods employed to engage federal government partners, DHS will seek to engage state and local government through the timely and accurate dissemination of information through a variety of methods outlined below. To engage these stakeholders, DHS and USDA will utilize all activities listed above.

5.5 - Congress

In keeping with standard practice and operations, the DHS and USDA will regularly inform Congress on the planning, construction, and operations of NBAF, as needed. The purpose of engagement with Congress is to provide timely information, discuss issues, answer questions, ensure transparency and open communication, and mitigate the risks associated with NBAF. Specifically, DHS ONL will work through the Office of the Under Secretary for S&T, the Office of Strategy, Policy and Budget, the Office of Legislative Affairs, and the Office of Public Affairs to conduct briefings, answer questions, and receive feedback from members of congress and their staff. USDA ARS and APHIS will work through their legislative affairs channels to inform members of congress, their staffs, and any appropriate committees.

5.6 - General Public

DHS intends to keep the general public informed and engaged regarding the mission, research, risks and mitigation strategies associated with NBAF. DHS considers the general public to be an important stakeholder in NBAF as the mission of NBAF is to protect the nation's animal agriculture and public health. Thus, public outreach will inform the general public as to the benefits of having this facility and inform them of possible risks to animal or public health from FADs, emerging, and zoonotic diseases. To engage these stakeholders, DHS and USDA will utilize all activities listed above.

6. Risk Communication

DHS is committed to implementing a comprehensive risk communication plan as part of the risk communication strategy at NBAF. The NBAF risk communication strategies will address qualitative and quantitative risks, clearly explain to the public in lay terms the risks of the facility, and demonstrate how DHS and USDA intend to mitigate those risks. The development of the EIS and the Site-Specific Risk Assessment are the first steps in the risk communication process. Building upon the risk communication plans of PIADC and other relevant biocontainment facilities, NBAF will employ many of the same mechanisms that have proved successful in mitigating risks and informing the public of incidents at these biolabs.

For example, NBAF will have an incident reporting system to facilitate communication between the laboratory and the community, including stakeholders. The reporting system establishes a tiered communication system for evaluating the severity of an incident, the appropriate "Incident Reporting System Response" and the required reporting to the community. The more serious the incident and the potential risk, the broader and the more high-level the incident reporting. This tool ensures that the community is kept fully informed on day-to-day activities, and understands the severity of various incidents that may occur at the laboratory and the associated potential effects on their community. It also provides a consistent method of communication to the community from the laboratory.

7. List of Acronyms and Abbreviations

ARS	Agricultural Research Service (USDA)
APHIS	Animal and Plant Health Inspection Service (USDA)
BRI	Pat Roberts' Biosecurity Research Institute
DHS	U.S. Department of Homeland Security
FAD	Foreign Animal Diseases
HBAC	Heartland BioAgro Consortium
K-State	Kansas State University
NBAF	National Bio and Agro-Defense Facility (DHS)
ONL	Office of National Laboratories (DHS)
PIADC	Plum Island Animal Disease Center (DHS)
SEC	Stakeholder Engagement Committee
S&T	Science and Technology (DHS)
USDA	U.S. Department of Agriculture

Appendix B1: NAS Comment Matrix

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
Finding 1	The SSRA lacks evidence to support the conclusion that the risk of release that results in infection is very low relative to the risk of infection introduced from an external source.	The 2010 SSRA did not attempt to quantify the risk of FMD infection from an external source. A risk-ranking and cumulative risk assessment are included in the Updated SSRA.	Section 8.2
	SSRA's data indicate that a release of FMDv resulting in infection outside the laboratory has a nearly 70% chance of occurring with an economic impact of at least $9-50 billion.	The Updated SSRA presents cumulative probability and risk values across events and over the 50-year operating lifetime of the NBAF, along with quantitative estimates of uncertainty. The updated risk estimates reflect NBAF design updates (65% design) as well as operational and accident response strategies that have been updated since the 2010 SSRA. The calculations resulted in 50-year cumulative probability estimates ranging from 1.54 × 10-9 to 2.09 × 10-2 when all events are included, and from 1.54 × 10-9 to 1.17 × 10-3 when catastrophic events are excluded. In other words, when all events are considered, the probability of at least one release resulting in an infection over the 50-year NBAF operating lifetime is estimated to range between approximately 1.5 × 10-7 % and 2.1%. When catastrophic events are excluded, the probability of at least one release resulting in an infection over the 50-year NBAF operating lifetime is estimated to range between 1.5 × 10-7% and 0.1%.	Section 8
	The SSRA does not discuss or quantify uncertainties in the risk estimates including risk the passage of time.	The Updated SSRA discusses the known uncertainties of its studies and models. In the development of frequencies, failure rates, and source terms, uncertainties in the data presented throughout Section 4 are described, if available. There are still data that are only described as point estimates. For data where the uncertainty is documented, it is characterized by the available confidence levels or standard deviation. In some cases, the distribution of a parameter is best described by presenting and modeling a low, medium and high level. Ranges and uncertainties associated with the epidemiological, and economic models are also used as input for the risk calculations.	Sections 4, 6 and 7 all use uncertainties and ranges which are used in Risk Calculations (Section 8)

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
Finding 2	The SSRA overlooks some critical issues, both site-specific and non-site-specific, that could significantly elevate the risk of accidental release and spread of pathogens.	The Updated SSRA includes additional livestock data and infrastructure data from the surrounding area that have been collected and used in the assessment.	Section 5 and Section 6
	Well publicized releases at Pirbright and the National Centre for Foreign Animal Disease in Winnipeg, Canada call into question the SSRA's estimated frequency of failure of the liquid decontamination system every 2.1 million years.	The two incidents described were extensively reviewed during the performance the Updated SSRA. An assessment of design configurations and controls that will prevent similar incidents is presented in the Updated SSRA.	Section 3.1
Finding 3	The SSRA has several methodological flaws related to dispersion modeling, tornado assessment, and epidemiological modeling. Thus the committee believes that questions remain about the validity of the overall risk estimates.	Additional fidelity has been added to the meteorological modeling and local observations data have been included in the assessment. Sensitivity analyses were performed for the modeled conditions and discussion on the sensitivity is included in the report. Specifically with regard to NAADSM inputs, the epidemiological modeling performed in the Updated SSRA uses inputs and settings developed in conjunction with nationally recognized NAADSM experts and users. All of the input data, assumptions, and settings applied to the epidemiological modeling are incorporated in the Updated SSRA documentation.	See Sections 5 and 6
	NRC could not determine the input parameters used for the NAADSM and could not independently validate the results.	The Updated SSRA provides all NAADSM related parameters with source information (e.g. CEAH, Colorado State University, etc.).	Sections 6.1 and A6 (Appendix)
	SSRA did not predict wind speed over time.	The Updated SSRA reports the enhancements made to the NBAF design relative to high wind events.	Section 5.1
	SSRA made several subjective judgments relative to the Fujita Scale intensity	The Updated SSRA uses the Nuclear Regulatory Commission (NRC) approved Pacific Northwest National Laboratory method for estimating wind speeds from tornadoes and high wind events for use in building damage estimation. This model is used to determine strike probabilities based on dimensions of the facility and provides associated wind speed data.	Section 4.6
	It is not clear that the SSRA conducted tests to check for calculation errors regarding the SCIPUFF model.	The Updated SSRA provides the details related to the calculation checks and sensitivity testing of the SCIPUFF model. The performer collaborated with Dr. Ian Sikes.	Section 5.1
	Daily cleaning of animal pens will probably result in releases that exceed the amounts estimated.	The Updated SSRA addresses the animal washdown in terms of urine and fecal excretions.	Sections 4.2, 4.4, 9.5, and 9.7

National Academy of Sciences Findings	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
Exposure distances are based on an arbitrary cut off of 0.1 virus particle and do not reflect uncertainties in meteorological variables, surface parameters and emission strength.	Updated SSRA demonstrates how the 0.1 parameter satisfies the range parameters for distance and variables. The Updated SSRA is based on dose-response information and adjusted to the size of the herd exposed. Several methods are used to estimate this relationship for low doses and sensitivity analysis is performed around these parameters. The Updated SSRA computes the number of index infections based on the material dosage ingested by the animals and no longer uses the arbitrary 0.1 cutoff dosage.	Section 6
The largest doses are likely to occur when the boundary layer height is small, the wind speed is low, and the period over which the virus is viable is long, the dry-deposition velocity is low, and the relative humidity and temperature favor FMDv viability. That corresponds to stable, low–wind speed conditions in which meteorological models are notoriously unreliable (Luhar et al., 2009).	The Updated SSRA considers the boundary layer height in plume modeling. Sensitivity studies were performed in the Updated SSRA to assess the impact of these conditions.	Section 5.1
Furthermore, several inputs cannot be specified objectively, such as the surface parameters (for example, roughness length). That suggests a need to conduct sensitivity studies to examine the effects of uncertainty in meteorological variables and values of model parameters on predicted doses.	The Updated SSRA considers the boundary layer height in plume modeling. Additional sensitivity testing has been applied to the meteorological modeling in the Updated SSRA.	Section 5.1
However, the SSRA does not provide information on the release and meteorological conditions that constitute a "reasonable worst case," so thus the committee could not judge the validity of that approach for treating model uncertainty.	Additional sensitivity testing has been applied to the meteorological modeling in the Updated SSRA.	Section 5.1.10
Under these circumstances, it might have been appropriate to assimilate the Manhattan Regional Airport meteorological data into the database constructed by Rife et al. (2010), which has a relatively coarse resolution of 40 km.	The Updated SSRA provides an assessment of the similarities between the climatological data and the local point observations from the Manhattan Regional Airport observational data.	Section 5.1
However, there are no references to support the SSRA's claim that the dataset was "specifically developed and subsequently validated to support boundary layer aerosol transport and dispersion modeling applications" (SSRA Appendix J: Aerosol Fate and Transport (Plume) Modeling).	The Updated SSRA provides references that directly related to aerosol boundary layer support and dispersion.	Section 5.1.2

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
Finding 4	The committee agrees with the SSRA's conclusion that for FMDv, long-distance plume transport will likely be less important than the near-site exposure of cattle.	Near-site exposure is modeled in the Updated SSRA and illustrates the impact of transportation hubs and local premises with susceptible species.	Sections 3 and 10.3.3
Finding 5	Substantial gaps in knowledge make predicting the course of an FMD outbreak very difficult, even under ideal circumstances and even when methods exhibit high levels of internal validity, which led to weaknesses in the 2010 SSRA.	Additional knowledge and data were collected such that relevant advancements in FMDv research and knowledge have been reflected in the Updated SSRA. The Updated SSRA Team recognizes that there are scientific gaps in knowledge about FMDv (and other pathogens of interest such as Nipah and Hendra).	Sections 4, 5, 6 and 7
	Laboratory release risks were not based on real world estimates.	The SSRA release scenarios and initial conditions were developed from data and subject matter expertise. Error rates and accident frequencies were developed from DoE data and from NBAF research plans. The Updated SSRA reports how information gained from the study of FMDv outbreaks in the UK has enhanced the release scenario modeling data. Where possible, the source terms are derived from empirical data. Likewise, failure rates and mitigations efficiencies are derived from published data.	Section 4
	The SSRA did not adequately consider case histories in arriving at risk estimates of laboratory leaks, and information from the documented cases of FMD releases were not fully taken into account.	The Updated SSRA uses relevant case study information regarding known escapes of FMDv from laboratories to highlight the improvements in laboratory design and standard operating procedures. Where possible, the source terms are derived from empirical data. Likewise, failure rates and mitigations efficiencies are derived from published data.	Section 4
Finding 6	Although the economic modeling was conducted with appropriate methods, the epidemiological data used as inputs to the SSRA were flawed.	Additional infrastructure reviews were performed and subject matter experts were engaged and interviewed to address the NAS SSRA Committee's concerns. More realistic and representative initial culling rates were developed for the Updated SSRA and were incorporated in the modeling.	Sections 6 and 7
	PIADC and NBAF surrounding populations are different. The suburban - rural human / animal populace causes for different epidemiological spread. The SSRA failed to account for the increased population density in humans and susceptible animals.	Enhanced data collection efforts to improve the epidemiological modeling have been undertaken for the Updated SSRA.	Section 6

National Academy of Sciences Findings	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
Locating the NBAF within the Kansas Animal Health corridor provides greater proximity for cleared, trained personnel to work and train in the NBAF, however the addition of more people "would in all likelihood increase the risk of accidental spread of infections agents via fomites."	The Updated SSRA provides evidence-based discussion, largely predicated from worker practices at similar facilities, on how, with proper training and procedures, personnel can enter/exit containment areas and work safely.	Section 5 and 10.2.2
The SSRA states that the estimated frequency of failure of the liquid effluent system is once every 2.1 million years, however such failure was the cause of FMDv release from Pirbright and an incident in Winnipeg.	The Updated SSRA highlights the advances and differences in design and operating procedures that minimize pathogen release. The Pirbright release was a result of antiquated infrastructure and represents a different effluent decontamination system/layout. The Winnipeg incident occurred during Cx and was the result of errors and failures that are only partially relevant to NBAF.	Sections 3 and 4
The SSRA does not discuss or quantify uncertainties in the risk estimates.	The Updated SSRA presents the uncertainties in the risk calculations. I n the development of frequencies, failure rates, and source terms, uncertainties in the data presented throughout this section are described, if available. There are still data that are only described as point estimates. For data where the uncertainty is documented, it is characterized by the available confidence levels or standard deviation. In some cases, the distribution of a parameter is best described by presenting and modeling a low, medium and high level.	Section 4
The SSRA does not address the variation of risk over time in either a quantitative or qualitative manner.	The Updated SSRA provides an analysis of the risk over time.	Section 8.3.2
The SSRA failed to provide an appropriate aggregated assessment of cumulative risk over the expected lifespan of the NBAF.	The Updated SSRA defines and estimates cumulative risks.	Section 8.3
The SSRA does not objectively define its conclusion that risk is "low."	The Updated SSRA provides an objective definition of the percentage and risk of release.	Section 8.3
The SSRA fell short of considering the cumulative effect of all independent scenarios and estimating the overall (cumulative) risk of release that would result in infection with pathogens that will be handled in the NBAF.	The Updated SSRA defines and estimates cumulative risks relative to a pathogen release.	Section 8.3
The SSRA shows an accidental FMDv fomite release leading to an infection recurring every 77 years costing a mean of $32 billion. The committee notes that the numbers are probably conservative estimates because the SSRA overlooked other factors that would elevate risk.	The figure cited from the SSRA is stated as being conservative--but in the opposite sense. The Updated SSRA provides clarification of the methods and procedures used to determine the risk of release.	Section 8

National Academy of Sciences Findings	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
The enhanced tornado data analysis failed to include the area-intensity relationship and failed to assess the probability that a point would experience tornado wind intensity.	The Updated SSRA clarifies the methods and procedures used to determine the tornado wind intensity. The Updated SSRA uses the Nuclear Regulatory Commission (NRC) approved Pacific Northwest National Laboratory (PNNL) method for estimating wind speeds from tornadoes and high wind events for use in building damage estimation. The PNNL model has been adopted for use in the Updated SSRA. This model is used to determine strike probabilities based on dimensions of the facility and provides associated wind speed data.	Section 4
The SSRA makes a poor assumption that the release would be minimal even if the facility were damaged and containment were lost.	The Updated SSRA defines the assumptions regarding the pathogen release.	Sections 4 and 5
It is not clear that SSRA SCIPUFF tests have been conducted to check for calculation errors.	The Updated SSRA provides the calculations and supporting data for the modeling applied.	Section 5.1
The SSRA does not provide information on the release and meteorological conditions that constitute a "reasonable worst case." Thus the NRC cannot judge the validity of treating model uncertainty.	The Updated SSRA provides the model uncertainties and supporting data.	Section 5
The SSRA is unclear as to how the specific mitigation parameter values were determined, in part due to the inherent complexity of the NAADSM as well as the SSRA's focus on a more general analysis.	The Updated SSRA provides the NAADSM parameters used and the supporting data that drove their use. The parameterization of mitigation measures (such as culling, vaccination and surveillance) for the Updated SSRA were based on resources available at the local and federal level as determined by interviews with local and federal stakeholders.	Section 6
The SSRA lost realistic constraints on mitigation measures (supply, cost, efficiency) because of particular modeling decisions.	Enhanced data collection efforts related to mitigation efforts are included in the Updated SSRA. The Updated SSRA attempts to quantify the cost of achieving enhanced mitigation levels. The SSRA's analysis was limited to parametric analysis.	Section 6.3
The SSRA does not consider the logistical demands that culling would place on personnel and equipment.	The Updated SSRA documents the basis for the culling rate(s) used. Culling rate calculations include the time needed to deploy and set up for depopulation, time to depopulate, and time to tear down the equipment.	Section 6
The SSRA selects only seven states and should focus more on how FMD is being transmitted within and among states and/or Canada and Mexico.	The Updated SSRA explains the reasons for limiting the focus of the study area. The Updated SSRA includes TX in the study region.	Section 6

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
	The SSRA's attempts to enhance the key weakness in the NADDSM inability to consider FMD transmission over longer distances did not reasonably and adequately account for interstate transmission.	In collaboration with CEAH, the Updated SSRA team improved the evaluation of interstate transmission. The Updated SSRA used Certificate of Veterinary Inspection data to account for more interstate movement.	Section 6
	The SSRA does not provide contingency plans for auxiliary diagnostic support by other laboratories in the case of an outbreak that renders the NBAF inoperable.	The Updated SSRA considers the need for future operating procedures for auxiliary diagnostic support in the case of an outbreak that renders the NBAF inoperable. Future needs planning related to diagnostic support would be included in emergency response plans. Cost/benefit analysis in the Updated SSRA begins to inform these plans.	Sections 3, 9 and 10
	The SSRA's economic modeling of the magnitude of livestock culls and the duration of outbreaks are underestimated	The Updated SSRA documents the basis for the culling rate. The epidemiological outputs used as inputs for the economic assessment reflect the impacts of the new culling rate assumptions.	Sections 6 and 7
Finding 7	The Committee agrees with the SSRA's conclusion that early detection and rapid response can limit the impact of an FMDv release from the NBAF, but is concerned that the SSRA does not describe how the NBAF could rapidly detect such a release.	The risk assessment team is in full agreement with the NAS SSRA Committee's observation on the importance of early detection and rapid response. DHS has initiated efforts to develop or leverage technologies that will be beneficial for surveillance and response strategies. The Updated SSRA provides additional information on these concepts.	Sections 3, 9 and 10
	The SSRA observes that an outbreak's risk can be "nearly completely mitigated" by active surveillance, but does not discuss what implementation measure this would require.	The Updated SSRA recommends what implementation measures are needed to provide adequate active surveillance.	Section 6
	The SSRA excluded certain groups and species that could fall outside of the scope of a passive monitoring system ("backyard operations, feral swine, sheep herds).	The rationale for exclusion of groups or species is discussed in the Updated SSRA. The Updated SSRA includes backyard operations and sheep and goat herds. Wild animals cannot be modeled with currently available tools.	Section 6
	The time to develop clinical signs and the time to detect and report clinical signs once they appear are considered, but location type specific observation rates are not adequately documented.	Enhanced data collection efforts were applied to the Updated SSRA. Data supporting detection and reporting are provided. These data are based on interviews with producers and local veterinarians regarding current animal health practices and accounting for differences in the interaction of the livestock with personnel in the facility.	Section 6

	National Academy of Sciences Findings	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
	The SSRA assumption that "self announcing" leaks from the NBAF would result in rapid detection of cases is unrealistic due to the detection process.	Additional evidence-based research is used to support or modify the assumptions regarding rapidity of detection. The SSRA did not assume that an outbreak would be detected, but that animal trade near the NBAF would cease if an obvious and catastrophic breach of containment occurred. The Updated SSRA makes these assumptions more clear.	Section 6
	The SSRA's assumption that a fomite "walking out" of the NBAF would remain in the Manhattan area ignores the reality of human travel and disease movement.	Additional evidence-based research and expert advice was used to support or modify the assumptions regarding infection distribution. Data on the behaviors of research personnel in KS was used to determine likely probabilities of travel to various parts of the country.	Section 5
Finding 8	The SSRA lacks a comprehensive mitigation strategy developed with stakeholder input for addressing major issues related to a pathogen release. The mitigation strategies that are provided do not realistically demonstrate current or foreseen capacity for how federal, state, and local authorities would effectively respond to and control a pathogen release.	The 2010 SSRA and the Updated SSRA were not intended to provide the comprehensive mitigation strategies. DHS (and others) are developing such strategies and have made significant progress since the performance of the 2010 SSRA. Information and data were collected from USDA experts on federal response strategies and these data were used in the Updated SSRA.	Section 6.3
	Mercy Regional Health Center does not have the appropriate level of clinical isolation facilities, diagnostic laboratory capability, or world class infectious disease clinicians experienced in diagnosing and treating for exposure to BSL-4 pathogens.	The Updated SSRA addresses specific means to increase the level of readiness for the regional healthcare providers in Manhattan, Kansas.	Sections 3, 9 and 10
	The SSRA states that the Manhattan, Kansas area does not have adequate resources or capabilities to undertake all the prevention, mitigation, preparedness, response and recovery activities necessary to develop and implement the emergency and contingency plans needed for the NBAF	The Updated SSRA addresses specific deficits in risk planning and communication and provides an analysis of regional health and medical outlets that can respond to potential emergency situations.	Section 3
	There is no active national surveillance system for FMD.	Currently there is not funding allocated to an active national surveillance plan for FMD. In the current passive observational surveillance system, the U.S. veterinary practitioners and producers notify State or Federal animal health officials of animals with disease signs that could be a suspect FAD.	Section 3, 6 and 10
	It would be essential to provide funding and validated tests to the National Animal Health Laboratory Network to conduct routine active surveillance for agents studied at NBAF.	The Updated SSRA considers the analytical requirements for a surveillance system.	Sections 3, 9 and 10

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
	As the Manhattan, Kansas region serves as a hub of animal movement, a potential FMDv release would increase the likelihood of a widespread outbreak. Consequently, USDA may wish to implement an emergency vaccination policy.	Emergency vaccination policy was discussed with USDA during the preparation of the Updated SSRA. The Updated SSRA considers vaccination as part of the mitigation measures modeled.	Sections 6 and 7
Finding 9	The committee agrees with the SSRA's conclusion that human error will be the most likely cause of an accidental pathogen release, and fomite carriage is the most likely way that a pathogen would escape the facility's outer biocontainment and biosecurity envelope.	Human error is a significant contribution to the potential for an accidental pathogen release. The Updated SSRA demonstrates that mitigation of fomites is an important consideration in the facility design and operational plans.	Sections 3 and 10
	SSRA timelines do not provide the level of and extent of training needed to reduce the possibility of an inadvertent release .	The Updated SSRA informs an iterative risk management process that demonstrates how operating procedures, design and training mitigate the chances of a human error release.	Section 3
	The SSRA should be thorough and address the risk of transmission to cattle in the Manhattan, Kansas area due to the contamination of respiratory tracts of workers.	The Updated SSRA provides a more thorough assessment of the human carrier risk. Several Events are considered that include the contamination of the respiratory tracts of humans and the effectiveness of personal respiratory protection on the amount of virus retained. Contact and behavior data are used in to model the interaction of respiratory-contaminated personnel in the Manhattan, Kansas area.	Sections 4 and 5
	The SSRA does not mention site-specific risks associated with staffing.	The Updated SSRA provides a more thorough assessment of likely staff composition and training.	Section 3
Finding 10	The committee agrees with the SSRA's conclusion that investment in biosafety and biosecurity engineering and the training of personnel and responders can reduce the risks, but is concerned about current design plans that potentially compromise safety measures.	The 65% Design is fully compliant with the recommendations and guidelines in the most recent version (Fifth Edition) of Biosafety in Microbiological and Biomedical Laboratories (BMBL) [USDHHS/CDCP, 2007]. Comprehensive design reviews have been conducted by an experienced team, including partners from international laboratories.	Section 3
	NBAF should comply with national guidelines developed to reduce the risk of escape of severe foreign animal pathogens.	The Updated SSRA highlights the updates to design that reduce the escape of severe foreign animal pathogens.	Section 10
	The SSRA doesn't recognize that BSL-3Ag areas will generate much greater concentrations of pathogens than typical laboratory scale work due to the rate infected animals shed pathogens.	The Updated SSRA more clearly reports its concerns with the greater concentrations of pathogens in the BSL-3Ag areas. An assessment of contribution sources and summary of empirical data from animal room aerosol measurements is made as the basis for the modeled source terms.	Section 4.3

National Academy of Sciences Findings		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
	The committee is seriously concerned that the current NBAF design omits a parallel redundant bank of HEPA filters for BSL-3Ag and BLS-4 rooms.	A more detailed discussion of the HEPA filtration design recommendations is provided in the Updated SSRA. Redundant series HEPA filtration has been incorporated. The redundancy scheme is described and modeled and reference to its compliance with BMBL is made.	Sections 2 and 4
Finding 11	The SSRA's qualitative risk assessment of work with BSL-4 pathogens in large animals was inadequate.	An updated assessment of risks associated with working in a BSL-4 environment with livestock was performed for the Updated SSRA. The conclusions and recommendations derived from this study are presented in the body of this report.	Section 9
	The committee does not concur with the SSRA's finding that its quantitative risk assessment regarding FMDv and Rift Valley fever virus (RVFV) sufficiently represents the range of risk regarding the other pathogens that will be studied at the NBAF, that is, the pathogens that are included in the qualitative risk assessment. The committee does not agree that the BSL-3 quantitative risk assessment adequately frames the risks associated with operating a BSL-4 large animal facility, because it is insufficient to use BSL-3 pathogens to predict risks associated with BSL-4 pathogens that are zoonotic and for which no treatment is available.	In collaboration with the NAS committee invited experts, the Performer defined the goals and objectives for the Large Animal BSL-4 Assessment contained in the Updated SSRA .	Section 9
	The RVF model is described in detail, however implementation remains opaque.	Quantitative modeling of RVF is not required in the Updated SSRA due to a lack of validated models.	NA

National Academy of Sciences Findings	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
The RVF model was created for this report and has not undergone peer review and independent validation.	The Updated SSRA includes a Large Animal BSL-4 (ABSL-4) Assessment which relied on a panel of international containment subject matter experts (SMEs), members of the NBAF Design Partnership (NDP), and risk assessment professionals to develop and analyze a set of events that represent the state-of-the-practice risks associated with handling (infected) large animals within BSL-4 containment. This effort represents a significant change from the SSRA, which performed a purely qualitative assessment of the eight primary research pathogens to be studied at the NBAF. In the Updated SSRA, a comprehensive event-driven evaluation of ABSL-4 (NiV and HeV) risk was completed. This effort was informed and supported by the enhanced fidelity of BSL-4 design data from the 65% Design; additional detail on proposed NBAF BSL-4 containment practices; BSL-4 systems performance, including failure nodes and probabilities across all four release pathway associated systems; published data regarding the amount of NiV and HeV typically observed during ABSL-4 activities; prevalence and proximity of susceptible species/reservoir hosts surrounding the NBAF; and a historical review of NiV and HeV case studies to inform impact metrics integral to the estimation of the associated ABSL-4 risk.	Section 9

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
1	Proper training, education, and monitoring of skills would reduce the risk of human error causing a release from the NBAF. Yet increasing the number of scientists, students, and postdoctoral scholars who have access to high-containment facilities would in all likelihood increase the risk of accidental spread of infectious agents via fomites, the primary identified risk in the SSRA. Pg 22	This comment is a valid observation. An increase in the number of individuals that are potentially involved in FMDv research may increase the likelihood of an accidental release. The mitigation measures that will be used at NBAF include advanced engineered systems and application of best practices gathered from years of FMDv containment experience around the world. The Updated SSRA models the anticipated number of researchers and mitigation techniques. It should also be considered that more research and researchers may provide solutions to eliminate or provide more effective control measures that will greatly reduce the impact of an FMDv containment loss. It is not productive to consider the increase in the number of researchers to represent only an enhanced risk--it may also result in an overall cumulative risk reduction.	Sections 4.4 and 4.5 describe the modeled number of researchers per room type Section 4.2 describes the mitigation procedures for reducing the likelihood of a release Section 8 describes and presents the modeled risk calculations
2	The NBAF will venture into a new and unprecedented area of BSL laboratory operations with respect to its mainland location, scale of operations, and scope of agents. It would therefore be prudent not only to abide by the strongly recommended guidelines set forth in the most recent Biosafety in Microbiological and Biomedical Laboratories (BMBL), but to also glean best practices and guidance from existing BSL-4 laboratories. Pg 66	DHS has fully embraced the BMBL and the current NBAF design is compliant with guidelines and requirements established by the BMBL and cognizant regulatory agencies. DHS has established cooperative relationships with numerous domestic and international laboratories to facilitate the exchange of best practices. DHS has also embraced the one-health concept--integrating best practices from animal research and human research.	Section 3
3	The estimated spill rate is low for several reasons: (1) In some instances, a person responsible for the spill either would not report it or would be unaware of it. (2) The spill rate does not include the likelihood of spills from sample shipments or damage occurring during shipment. (3) The omission of anticipated virus spillage that would occur routinely as part of regular cleaning of large animal rooms. Pg 27	Non-reporting of spills and a lack of spill awareness are incorporated into the accident frequency estimates in the Updated SSRA. The Updated SSRA also includes an originating accident location that models events, such as shipment accidents, outside of containment. The regular animal room washdown contributions to the quantities of potentially released pathogen are modeled in the Updated SSRA as discussed below.	Section 4.4 (source term development) and 4.5 (event frequency development)
4	The wash-down process would aerosolize virus deposited in the room from animal secretions and excretions, and would result in removal of massive amounts of virus through the air filtration system. Even with the use of disinfectants,1 the committee feels that those sources offer more frequent (daily) opportunities and possibly higher viral loading than the laboratory-scale spills that were evaluated in the SSRA. Pg 28	Twice-daily animal washdowns are modeled in the effluent contributions to the modeled virus loading to the aerosol pathway and the liquid effluent pathway.	Sections 4.4 and Section 4.5
5	If only one room were used for FMD experiments, it would be the equivalent of experiencing 365 necessary and anticipated spills per year. Such a spill rate would raise the risk estimates by a factor of more than 140 from what is given in the SSRA (365/2.6 = 140). Pg 28	See above response. The suggested increase in risk estimates is modeled in the Updated SSRA. The factor of 140 is not usable input because it incorporates an assumption that FMDv research in the animal holding rooms is continuous.	Sections 4.4 and Section 4.5

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
6	An important factor that was neglected in the SSRA is the distinction between real and simulated conditions for viral disinfection and natural viral decay. The hosing of waste materials (such as secretions and excretions) would create a protective bioburden matrix for virus particles, and their aerosolization would lead to a severe underestimation of the amount and duration of potentially infectious material generated. Pg 28	The potential of virus concentration enhancement by animal room washdown techniques is specifically addressed in the Updated SSRA. Data sources cited in the received comments are in reference to the concentration enhancement of virus in the surface of bubbles liberated by gas streams injected into a deep liquid matrix and do not seem to be applicable to the animal room washdowns.	Section 4.4
7	The SSRA also did not address the effects of large amounts of aerosolized material (such as dust, dander, and other particles [such as fur, feed, vomit, cud, mucus, and hoof detritus]) on high-efficiency particle air (HEPA) filters in animal rooms and how it would affect filter performance over time. Pg 28	Empirical data indicate that the rough pre-filter mitigates detrimental affects on filter performance. Thirteen years of data from the Australian Animal Health Laboratory indicated that intake air HEPA filters are replaced more frequently than exhaust room filters and animal holding room filters with pre filters do not have a statistically significant difference in failure than other room exhaust filters.	Sections 4.2 and 4.5
8	The SSRA did not adequately consider case histories in arriving at risk estimates of laboratory leaks, and information from the documented cases of FMD releases were not fully taken into account.	Documented cases do not provide empirical data on all of the Events. There are a very limited number of relevant case histories with well-documented accident sequences. Case histories are reviewed in Section 3.	Section 3
9	When DHS was asked about this at the public session of the committee’s meeting, a somewhat confusing answer was provided: that the escape from Plum Island (Margasak, 2008) was irrelevant because livestock were being housed on the island, and this will not be the case for the NBAF, which will be in Manhattan, Kansas. Pg 28	Site-specific data on premises with susceptible species are included in the Updated SSRA.	Sections 5.1 - 5.3 and 6.1
10	The committee believes that an assessment based on a plethora of information on case histories of escape of agents from laboratories would likely have provided a more realistic assessment of the case scenarios, likely frequencies, and confidence intervals of laboratory escapes projected for the NBAF. Pg 29	The modeled Updated SSRA events and initial conditions are developed from published data and elicitation of date from experienced professionals and subject matter experts. While there is much information available on FMDv accident causes, the limited number of incidents make it impractical to use only this information for a quantitative risk assessment. Moreover, the information available on such releases is antiquated and speculative. For example, the precise mode of initial index infection from the Pirbright incident is still not known., While it is known (with some certainty) that the virus was released from a wastewater connection, the fate and transport of the virus via a contaminated construction vehicle and the premises of the index location is speculative. Furthermore, the mechanism between the road (near the index premises) and the infected animal is not understood. It is not realistic or practical to attempt to perform a quantitative assessment on such incomplete data that is not necessarily applicable to the modern NBAF design and new operating protocols.	Sections 4 and 9

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
11	The SSRA does not discuss or quantify uncertainties in the risk estimates. Pg 29	Uncertainties are incorporated, where available, in the Updated SSRA.	Section 4.4 provides source term uncertainty development information. Sections 5, 6, and 7 address uncertainties in fate & transport, epidemiological modeling, and economic consequence assessments. Section 8 incorporates discussion and calculations on the propagation of uncertainties throughout the Updated SSRA.
12	While sensitivity analyses of several case model components were undertaken, the SSRA does not provide a quantitative assessment of the uncertainty surrounding the case event risk estimates (for example, in the form of confidence intervals) nor is there a qualitative discussion of the sources and magnitude of the uncertainties associated with these scenario risk estimates. Pg 29	Uncertainties are incorporated, where available, in the Updated SSRA.	Section 4.4 provides source term uncertainty development information. Sections 5.0, 6.0, and 7.0 address uncertainties in fate & transport, epidemiological modeling, and economic consequence assessments. Section 8.0 incorporates discussion and calculations on the propagation of uncertainties throughout the Updated SSRA.
13	The Tornado analysis failed to include the area-intensity relationship and failed to assess the probability that a point would experience tornado wind intensity. Pg 33	The Updated SSRA applies the PNNL tornado model that accounts for the footprint of the modeled area. (The SSRA included a detailed analysis on the probability and frequency of a point experiencing a tornado strike and a discussion on the rationale behind not incorporating the straight-line high winds of tornado magnitudes.)	Section 4.5
14	The tornado scenario in the SSRA assesses the risk of a direct hit of the facility by a tornado of F3 or greater intensity, and it makes a poor assumption that the release would be minimal even if the facility were damaged and containment were lost. Pg 33	Such assumption is not made in the Updated SSRA. The amount of material released is dependent on the wind speed of the tornado, with complete release of the available material at a wind speed of 280 mph, and no material released at the designed wind speed which the NBAF can withstand at 228 mph.	Section 4.6
15	The use of a tornado hazard model would provide a more accurate assessment that correlates tornadic wind speed with the annual probability of occurrence (or the mean return period) for Manhattan, Kansas. Pg 33	The PNNL tornado model is incorporated in the Updated SSRA.	Sections 4.6 and 5.1
16	The results of the planned tornado hazard model to be pursued by DHS were not available for the committee's review, thus it is not possible to comment on its efficacy. Pg 33	The SSRA appendices included the custom tornado frequency model details.	A5 (Appendix)

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
17	For a highly contagious disease, such as FMD, the risk of infection corresponds to the collective dose to all the animals exposed to the puff of virus particles. Thus, the dose calculation requires summing the doses to all the animals exposed to the puff of virus particles. If enough animals are exposed, infection may be likely even if the doses are very small. Pg 34	These are now included in the Updated SSRA	Section 6.1
18	Need to conduct sensitivity studies to examine the effects of uncertainty in meteorological variables and values of model parameters on predicted doses. Pg 35	Sensitivity analyses were conducted for the aerosol fate and transport.	Section 5.1.10
19	SSRA does not provide information on the release and meteorological conditions that constitute a “reasonable worst case”. Pg 36	Meteorological conditions are discussed and described in the Updated SSRA.	Sections 5.1.1 - 5.1.8
20	It might have been appropriate to assimilate the Manhattan Regional Airport meteorological data into the database constructed by Rife et al. (2010), which has a relatively coarse resolution of 40 km. The appendix to the SSRA states that the Rife et al. database was constructed to “recreate the observed characteristics of the Great Plains Nocturnal Low Level Jet”; however, there are no references to support the SSRA’s claim that the dataset was “specifically developed and subsequently validated to support boundary layer aerosol transport and dispersion modeling applications” (SSRA Appendix J: Aerosol Fate and Transport (Plume) Modeling). Pg 36	Meteorological conditions are discussed and described in the Updated SSRA.	Section 5.1
21	The committee remains unsure about the following sanitation-driven air-quality engineering issues: • How relatively large indoor bioaerosol loads—in terms of mass, particle size distribution, and agent longevity—would differ markedly from those in biosafety level 3-4 (BSL-3/BSL-4) facilities that do not house cohorts of large animals. • How such bioaerosol loads are likely to affect the design and operations of the associated indoor air quality systems. Pg 52	Data from 13 years of animal holding experience with HEPA filtration systems and pre-filters at the Australian Animal Health Laboratory indicates that animal holding room exhaust air systems are less likely to fail than intake air HEPA filtration systems.	Sections 4.2 and 4.5
22	The projected sanitary redundancies are in accordance with those of facilities that have similar charters, but need to be appropriately scaled for the projected NBAF loadings. Pg 52	The NPD Basis of Design incorporates scaling for NBAF loadings. This data is summarized in Section 2.0 and available to the Committee to review in the BOD and its supporting documentation.	Section 2
23	The recent announcement of a wastewater treatment plant on the NBAF campus will need to be clearly justified and explained with respect to its service intents and mission over the design life of the NBAF. Pg 52	The need for the on-site pretreatment system is described, in detail, in the NBAF BOD and is summarized in Sections 2.0 and 4.2 of the Updated SSRA.	Sections 2, 4.2, and 9.5

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
24	As the NBAF progresses through the design phase, it is important that a commitment be made to not "value engineer"1 out critical secondary containment systems in BSL-3Ag and BSL- 4 spaces that will house large animals. Pg 52	DHS has fully embraced the BMBL and the current design is compliant with guidelines and requirements established by the BMBL and cognizant regulatory agencies. It is believed this reference is related to the lack of complete redundancy (like all other containment facilities) that was originally incorporated in the NBAF design (15%). The current design meets or exceeds all recommendations and requirements for animal containment spaces.	Sections 2, 4.2, and 9.5
25	At a minimum, NBAF should comply with national guidelines that were developed to reduce the risk of escape of severe foreign animal pathogens, such as foot-and-mouth disease virus (FMDv), that can result in catastrophic economic loss, and of potentially lethal zoonotic pathogens, such as Nipah and Hendra viruses, that have medium to high lethality and for which no vaccines or treatments are available. Pg 52	See above response.	See above response
26	For BSL-3Ag spaces, the guidelines strongly recommend two HEPA filters installed in series and a parallel redundant bank of HEPA filters so that one or both of the HEPA filters in the primary bank can be replaced while the room is still operational ("hot") (CDC, 2009). Pg 53	See above response. The 65% design incorporates this design feature.	See above response
27	The SSRA falls short of recognizing that BSL-3Ag areas will generate much greater concentrations of pathogens than typical laboratory-scale work because of the large animal component in BSL-3Ag areas: infected animals shed significant amounts of pathogens. Pg 53	Empirical data and contributions from animal respiration, excrement, and other sources (skin, hair, mucous, vomit, blood, etc.) are incorporated in the Updated SSRA source term calculations.	Section 4.4
28	The SSRA does not discuss or describe the effects of additional residues—such as animal hair and food residues—that may also become aerosolized by the animals themselves or by cleaning processes, each of which may shorten the life span of the HEPA filters because of loading beyond normal operational limits. Pg 53	See above and response to comment 21.	See above and response to comment 21
29	The committee is seriously concerned that the current NBAF design strategy omits a parallel redundant bank of HEPA filters for BSL-3Ag and BSL-4 animal rooms (see Figures 3-21 through 3-28 of the SSRA). Pg 53	See multiple responses related to this same comment.	See above responses
30	The SSRA indicates that the most probable cause of accidental release will be human error. Human error can be reduced by rigorous hands-on training in laboratories that will have comparable biocontainment and biosecurity practices. However, SSRA timelines do not provide for that level and extent of training and could increase the probability of an inadvertent release or human exposure. Pg 54	Best practices will inform the NBAF SOPs.	Section 3

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
31	As noted in the committee's preliminary letter report: "it would be useful to consider the risks associated with the lack of respiratory protection for workers that come into contact with FMDv. It is a common recommendation that workers exposed to FMDv-infected animals not contact other susceptible animals for 5 days—as a result of studies demonstrating recovery of virus from nasal passages (Sellers et al., 1970, 1971)—to reduce the risk of respiratory transmission. While the committee is not aware of literature showing this as an important route of transmission, the SSRA should be thorough and also address the risk of transmission to cattle in the Manhattan, Kansas area due to the contamination of respiratory tracts of workers." The SSRA did not address those issues. Pg 55	DHS has determined that respiratory protection will be required when laboratory workers will be exposed to respiratory aerosols from infected animals. A discussion of the efficacy of respiratory protection (N95) is provided in Section 4.2 and the failure of (failure to use) respiratory protection is modeled in the Updated SSRA.	Sections 4.2 and 5.4
32	Whereas the SSRA estimates roughly 300 staff members in the NBAF, it does not mention site-specific risks associated with staffing. Pg 55	Original data collection on the contact behaviors of potential NBAF workers is presented in Section 5.4.	Section 5.4
33	Because the SSRA did not account for important uncertainties and risk factors as discussed below, the SSRA could well have underestimated the risk of pathogen release and transmission and its consequences. In many scenarios considered, the numbers probably represent conservative estimates of risk. Pg 59	See above responses.	See above responses
34	The SSRA failed to account for other site-specific factors, including: The movement of personnel between KSU facilities, the Biosecurity Research Institute, and the NBAF, which increases risks related to fomites and respiratory transfers. Pg 59	See response to Comment 32.	See response to Comment 32.
35	The SSRA neglected to consider is the maintenance and cleaning of BSL-3Ag and BSL-4 large animal pens. Pg 59	See above responses.	See above responses
36	Large animal pens are normally washed daily, and this would likely result in substantial aerosol formation of BSL-3Ag and BSL-4 pathogens in addition to fomites. Pg 59	See above responses.	See above responses
37	The daily cleaning of animal pens as a potential pathway of pathogen release would result in aerosol emissions much greater than were assumed in the aerosol scenario in the SSRA and would place greater strain on the HEPA filters and air handling system than noted in the SSRA. Pg 59	See above responses.	See above responses
38	The cleaning scenario is likely to lead to significantly increased risks of infection through fomites and airborne pathways. Pg 59	See above responses.	See above responses

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
39	The execution of the SCIPUFF model to estimate risk of infection associated with exposure to airborne virus was not based on approaches described in the literature (see Cannon and Garner, 1999; Schley et al., 2009), but instead was based on an arbitrary threshold dose of 0.1 plaque forming unit for infection, which leads to uncertainties in the estimation of risk. Pg 60	A range of thresholds are presented in the Updated SSRA.	Section 6.1
40	The omission of the animal pen cleaning leads to a major underestimation of the magnitude of aerosol release. Pg 60	See above responses.	See above responses
41	The SSRA used a tornado risk assessment that is sensitive to user bias. The use of a tornado hazard model would have eliminated the need for user judgment, and would more appropriately provide information about the design basis wind speed and building envelope design. Pg 60	The Updated SSRA incorporates the use of the PNNL tornado model.	Section 4.6 and Section 5.1

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
1	One overlooked characteristic that would contribute to risk is the NBAF's proximity to KSU's College of Veterinary Medicine. If an agent were released from the NBAF, those animals could readily become infected and serve as a conduit for amplification and transport. Pg 22	All locations near the NBAF with susceptible species were included in the model for the Updated SSRA.	A6.2.4 (Appendix)
2	The SSRA states that the Manhattan, Kansas, area does not have adequate resources or capabilities to undertake all the prevention, mitigation, preparedness, response, and recovery activities necessary to develop and implement the emergency and contingency plans needed for the NBAF. Pg 23	Resources to implement mitigation measures were explicitly considered in the Updated SSRA	Section 6.3
3	Although many high-containment laboratories are located in highly-populated areas, the SSRA failed to adequately account for such populations and the large animal aspects of the NBAF's work in its risk analysis. Pg 21	All locations nearby the NBAF with susceptible species were included in the FMD model. The proximity of susceptible species near the NBAF as well as the unique risks associated with handling large animals within containment was also considered in the Updated SSRA ABSL-4 assessment.	Sections 6.1.3, 6.1.4 and Section 9 (throughout)
4	There is no active national surveillance system for FMD detection. Pg 24	We agree, insinuation removed	n/a
5	To fulfill the SSRA's recommendation of enhancing local diagnostic capability to support regional surveillance and traceback capability, it will be essential to provide funding and validated tests to enable the National Animal Health Laboratory Network (NAHLN) at a minimum to conduct routine active surveillance for the agents under investigation in the NBAF. Pg 24	The Updated SSRA can make recommendations as to which additional pathogens should undergo routine surveillance; however, the risk assessment can not assure funding to do so. Surveillance and diagnostic plans would be part of overall emergency response planning by DHS and USDA.	Section 9.10
6	For an active FMD surveillance system to become fully operational, the NAHLN will need to expand its repertoire of testing and will need diagnostic surge capacity for those agents in the event of an outbreak. Pg 24	We do not mention active FMD surveillance in the Updated SSRA.	n/a
7	If USDA implements vaccination policy as a result of an outbreak adequate supplies and distribution policy will need to be in effect and agreed to nationally. Pg. 24	Vaccination is only modeled notionally because of shortcomings of NAADSM and issues like limited supply of vaccine are not considered in this iteration of the risk assessment.	A6.2.18 (Appendix0, A6.2.21 (Appendix), Sections 7 and 10.2
8	The SSRA is unclear as to how the specific mitigation parameter values were determined. Pg 37	These are now included in the Updated SSRA	Section 6.1.4
9	The quantitative epidemiological study in the SSRA does not connect the general mitigation rates to the logistics of specific mitigation practices in a site-specific manner. Pg 37	These are now included in the Updated SSRA	Section 6.1.4
10	The report observes that an outbreak's risk can be "nearly completely mitigated" by active surveillance (page 225), but it does not discuss what implementation measures this would require. Pg 37	Active surveillance is not discussed in the Updated SSRA. Interviews suggest it is impractical.	n/a

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
11	When an index case initiates an epidemic, modest transmission between locations is usually sufficient for final epidemic sizes to be independent of index-case location, particularly with respect to FMD. That suggests that the cumulative distribution in Figure 4-20 of the SSRA may be an artifact of specific model assumptions placed on contact patterns and mitigation. pg 38	The outbreak starting location determines the extent to which the outbreak spreads to other premises before detection or, indeed, if the outbreak starts at all.	Section 6.2
12	The committee is concerned about the exclusion of specific species or management-type groups, such as “backyard” operations, sheep herds, and feral swine (the committee recommended inclusion of the latter in its preliminary letter report, see Appendix B). pg 38	These are now included in the Updated SSRA.	Section 6.1.4
13	Feral swine would be important to consider in that they would probably become infected and be outside the passive surveillance system. Pg 38	Wildlife species are not explicitly modeled in the Updated SSRA but are discussed.	Section 6.1.6
14	Failure of the model to include the other 41 of the 48 states as well as incursions in and out of Canada and Mexico would clearly be manifested as unrealistically low estimates of the overall impact of FMD in the United States. Pg 39	The full US cannot currently be modeled. A future iteration could include the development of a higher-level, full North American model.	Section 6.1.2
15	While adding sales barns to the NAADSM is an improvement because it takes some interstate animal movement into account, sales barns are not the sole source of long-distance animal movement rates (USDA-ERS, 2003), and therefore the SSRA underestimates the long-distance transport of animals and equipment and in doing so also underestimates the rate and extent of FMD spread. Pg 39	The method to estimate long-distance movement has been substantially revised in the Updated SSRA.	Section 6.1.5
16	Both the time to develop clinical signs (lesions) and the time to detect (and report) clinical signs once they appear were considered in the model (pages 179 and 219 of the SSRA), but location-type-specific observation rates were not adequately documented. Pg 40	All parameters are documented in the main text.	Section 6.1.4
17	The SSRA does not provide contingency plans for auxiliary diagnostic support by other laboratories (such as state laboratories and the Winnipeg and Pirbright laboratories); such diagnostic contingency plans are critical for NBAF operations and should have been included in the SSRA. Pg 41	Diagnostic capacity was discussed with USDA representatives. Key concepts and considerations from these conversations are incorporated into the Updated SSRA. Surveillance and diagnostic plans would be part of overall emergency response planning by DHS and USDA.	Sections 3, 6, 9 and 10
18	The NAADSM uses a sensitivity value of 1.0 (1.0 being perfect accuracy) in identifying FMD-affected premises and assumes that the clinical diagnostic processes involved in contact tracing would be reliable and accurate. However, the 2001 UK epidemic demonstrated that sensitivity is not perfect and that it may be around 0.947 (McLaws et al., 2007). On the basis of that estimate, clinical monitoring and declaration could miss about 5.3% of infected herds. Pg 41	The Updated SSRA now considers disease control to be highly imperfect (direct movement is only reduced to 20% of pre-event values) which reflects this and other real world shortcomings.	Section 6.1.4

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
19	Because a percentage of infected herds would be missed in a real outbreak, the model has underestimated the number of cases and the duration of the epidemic. Pg 42	See above.	Section 6.1.4
20	The assumption that the first case of FMD resulting from fomite escape from the NBAF would appear only in the Manhattan area (pages 168-169) ignores the reality of human travel and disease movement. Pg 42	Agreed. Transference is modeled to possibly start an infection in any part of KS.	Section 6.1.3
21	The SSRA failed to account for other site-specific factors, including: The location of the KSU College of Veterinary Medicine clinics adjacent to the NBAF, where large numbers of sick and susceptible animals are treated and where there are large numbers of transient animal patients. Pg 59	The Updated SSRA included all these locations. However, the health status of the animals was not modeled due to lack of data. It is possible that animals already sick may be more or less susceptible to FMD.	A6.2.4 (Appendix)
22	The SSRA failed to account for other site-specific factors, including: The location of the Kansas State University (KSU) football stadium in close proximity to the NBAF, which presents a large human population that potentially could be periodically exposed to a released zoonotic pathogen and that potentially could transport a released pathogen outside of the area. Pg 59	Zoonotic diseases, Nipah, Hendra and emerging pathogens were considered within the Updated SSRA ABSL-4 Assessment, and that analysis accounts for factors such as proximity of susceptible species - animals and humans-around the NBAF. The previous SSRA did clearly document and consider proximity of dense human populations around the NBAF - including the K-State campus in it's analysis of RVFv. Given the relative infrequent occupancy of the K-State stadium compared to the daily occupancy of the K-State campus at large - the impact of a periodic increase at a single location (stadium) was considered within uncertainty of the modeling.	Section 9.9

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
23	Many uncertainties of the epidemiological modeling of FMD transmission were inadequately considered so the sensitivity analyses were insufficient and many scenarios were probably overoptimistic. Some parameter values and assumptions used in the North American Animal Disease Spread Model (NAADSM) were inconsistent with what is known about epidemiological and veterinary aspects of and experience with FMD. Pg 60 1. The scope of spread was limited to seven states by the exclusive use of sales barns as the sources of animal movement. The scope was also limited only to cattle and swine and did not include infection of feral swine, deer, and small ruminants. 2. The extent of spread did not address the critical elements of animal movement within and among states. The transportation modeling methods considered animal movement only in an indirect and superficial manner and excluded movement within and among states (as well as incursions in and out of Canada and Mexico) by individual producers and neighbors, therefore underestimating the spread. 3. The response did not provide realistic assumptions regarding mitigation values of input parameters, and the values inflated prospects of surveillance, diagnosis, available manpower, depopulation rate, and movement bans (direct and indirect). Mitigation strategies did not mention how and where FMDv diagnostics, research activities, and matching of vaccine to outbreak strain might be conducted if the NBAF had to shut down or curtail some activities because of a pathogen escape or physical damage to the facility.	Interstate movement is modeled completely differently in the Updated SSRA than the SSRA. Resources for culling are explicitly described and are the basis of the baseline and enhanced measures.	(1) Section 6.1.2, (2) Section 6.1.5, and (3) Section 6.1.4
24	Restricting epidemiological modeling to its effect on seven states that have large livestock populations would mean that inferences about the other 41 contiguous states (with Alaska and Hawaii excluded) cannot be drawn, so external validity would be lacking. Pg 61	See response to comment 14 above.	Section 6.1.2
25	On the basis of the information provided, the committee could not determine the input parameters used for the NAADSM and could not independently validate the results. As a result of the assumptions and methodological flaws, the committee concludes that the epidemiological results of the SSRA deflate the duration and magnitude estimates of a possible FMD epidemic. Pg 61	The Updated SSRA includes an explanation of all parameters used in the main body of the report and in Appendix 6.	Sections 6.1.4 and A6.4 (Appendix)

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
26	Without data relative to the potential role of wildlife in the spread of FMD, there is not way to fill in the gaps and improve precision beyond the scope of opinion. Pg 61	Wildlife cannot be included a quantitative FMD model currently. They are considered qualitatively. Incorporation of wildlife into a model of FMD could be a future risk assessment activity. Supporting information is included in the appendix.	Sections 6.1.4 and 6.1.6
27	Although there is a lack of data regarding the role of wildlife in the role of FMD spread as it regards to the use of the NAADMS, viral outbreaks in other countries (Taiwan, UK, etc) can provide valuable lessons in understanding realistic expectations for mitigation measures and disaster preparation plans. Pg 62	Wildlife is discussed qualitatively. Using data from outbreaks in other countries with MUCH smaller and more contained wildlife populations is problematic.	Sections 6.1.4 and 6.1.6
28	The epidemiological modeling assumptions that were used in the economic assessment, such as depopulation rates and outbreak duration, were overoptimistic in their estimates. The committee does not think that infected herds could be detected and culled at the rate of 120-720 herds per day. Pg 62	Culling rate now includes mobilization and demobilization times and is based off a herd size of larger than median. Also, estimates for the number of culling teams that a state could field was obtained (instead of head-per-day estimates).	Section 6.1.4
29	To implement appropriate FMD surveillance and response, it would be necessary for a number of things to occur that were not described in the SSRA, including: 1. Development and testing of adequate real-time diagnostic capabilities for FMDv. 2. Development of real-time global full-length genomic surveillance for FMDv. 3. Development of a real-time active surveillance system1 for FMDv in the United States. 4. Development and testing (through modeling) methods and scenarios for surveillance, control, eradication, vaccination, and mitigation of FMD in the United States. Pg 62	Agree. A full FMD prevention plan and response plan needs many of these components. However, a risk assessment is not an appropriate place to address these issues.	None
30	Make sure to point out that networks are not captured with NAADSM as a NAADSM weakness	Agree	Section 6.1.5
31	When discussing results, discuss if our model shows controllable vs. out of control outbreaks one panel member mostly cares about that	All results are shown for duration (chance that the outbreak lasts more than 100 days or more than a year) and chance that they spread to other states. Also, giving more than the median percentile outcome from NAADSM also gives an idea of that. To do more than this, one would have to define what "out of control" means.	Section 6.2
32	As the Manhattan, Kansas region serves as a hub of animal movement, a potential FMDv release would increase the likelihood of a widespread outbreak. Consequently, USDA may wish to implement an emergency vaccination policy.	Animal movement to other states is explicitly modeled and uses data for the counties around the NBAF and KS as a whole. Vaccination policy is an on-going discussion with USDA with or without NBAF.	Section 6.1.4
33	Did you consider changing the time to vaccine protection to partially account for the fact that larger premises require more time to vaccinate.	Yes. Discussion is included.	Section 6.1.4

NAS Letter Report Criticisms by Updated SSRA Section		Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
34	The SSRA lost realistic constraints on mitigation measures (supply, cost, efficiency) because of particular modeling decisions.	The SSRA was a parametric analysis to determine break-points in the benefit. The Updated SSRA continues the parametric analysis but underpins it with the resources necessary to achieve particular mitigation strategies.	Section 6.1.4
35	The SSRA does not consider the logistical demands that culling would place on personnel and equipment.	The Updated SSRA does this explicitly both for the baseline estimate and the enhancements.	Section 6.1.4
1 econ	The SSRA is unclear as to how the specific mitigation parameter values were determined, in part because of the inherent complexity of the NAADSM (Schoenbaum and Disney, 2003; Harvey et al., 2007) but also in part because of the SSRA's focus on a more general analysis. Pg 45	These are now included in the Updated SSRA	Section 6.1

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
1	The SSRA is unclear as to how the specific mitigation parameter values were determined, in part because of the inherent complexity of the NAADSM (Schoenbaum and Disney, 2003; Harvey et al., 2007) but also in part because of the SSRA's focus on a more general analysis. Pg 45	The mitigation parameter values for the Updated SSRA have been supplemented by an extensive and unprecedented data collection effort to bring clarity and regionally relevant specificity to the NAADSM modeling applied to the Updated SSRA.	Section 6.1 and A6 (Appendix)
2	The SSRA description of how the regional analysis is conducted is shock introduced into the regional input-output is not reported. The total dollar regional impact of each scenario is reported, but results for individual economic activities that would help to confirm the quality of the analysis are not reported. Pg. 46	Agree. A more detailed output would assist in the review of the data generated. Please refer to the updated data presentation throughout Section 7 which includes additional economic detail (p5, p50, p95 for all outputs modeled) as compared to data presentation in the SSRA.	Please see tables, figures and exhibits throughout Section 7
3	The SSRA recognizes the problems inherent in WTP estimates and describes steps undertaken to mitigate them. Comparisons with similar values from research on diseases other than RVF are used to validate the results. Because the values are unknown, it is difficult to determine the success of the efforts beyond noting that the proper methods were applied. Pg 46	RVF modeling was not included in the Updated SSRA analyses. These discussions have been removed from Section 7.	Not applicable to the Updated SSRA

	NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
1	Mercy Regional Health Center does not have the appropriate level of clinical isolation facilities, diagnostic laboratory capability, or world-class infectious disease clinicians experienced in diagnosing and treating for exposure to BSL-4 pathogens. Pg 23	Section 3 (Best Practices) of the Updated SSRA discusses the capabilities of the Mercy Regional Health Center. One recommendation from the Updated SSRA ABSL-4 Assessment includes the elements of medical response that should be established near the NBAF (and likely at Mercy Regional Health Center or the equivalent on-site medical facility) prior to ABSL-4 activities at the NBAF.	Sections 3 and 9.10
2	Passive surveillance methods in which veterinarians report suspected "vesicular diseases would not be applicable to zoonotic pathogens that would be in the NBAF Pg 24	Agreed, alternative methods would be needed to identify/survey for Nipah and Hendra infections, and some may not even be effective given that animals can experience viremia with subtle to no observable symptoms. Training of healthcare personnel and veterinarians for disease detection is discussed in the Updated SSRA.	Section 9.10
3	The Rift Valley Fever study was not validated and the section was greatly maligned. The updated SSRA will need to provide guidance how zoonotic threats are studied in the new assessment.	The Updated SSRA includes an assessment of the specific ABSL-4 pathogens to be researched at the NBAF, Nipah and Hendra virus, including documentation of the specific methods and assumptions used in the assessment. The Rift Valley Fever model was not used in this assessment with the minor exception that one input parameter (value of a human life) that was informed by a survey performed during the SSRA was referenced in the Updated SSRA ABSL-4 Assessment.	Section 9
4	Finding 11: The SSRA's qualitative risk assessment of work with BSL-4 pathogens in large animals was inadequate.	The Updated SSRA includes an in-depth assessment of the risks involved in handling Nipah and Hendra within ABSL-4 containment. While the previous SSRA qualitatively discussed the risks involved with all of the 8 pathogens to be studied at the NBAF, this Updated SSRA focused specifically on the risks inherent with handling Nipah or Hendra infected large animals in ABSL-4 containment . Where-ever available, published data and containment facility SMEs were used to quantify the event assessment.	Section 9; specifically discussed in 9.1.
5	The qualitative risk assessment was inadequate because it failed to fully consider the characteristics of the pathogens and the risks of working with BSL-4 pathogens in large animal facilities. Pg 66	The Updated SSRA includes an in-depth assessment of the risks involved in handling Nipah and Hendra within ABSL-4 containment. While the previous SSRA qualitatively discussed the risks involved with all of the 8 pathogens to be studied at the NBAF, this Updated SSRA focused specifically on the risks inherent with handling Nipah or Hendra infected large animals in ABSL-4 containment . Where-ever available, published data and containment facility SMEs were used to present the pathogen characteristics and quantify the risks for Nipah and Hendra.	Section 9 throughout; with pathogen data in 9.5, outbreak considerations in 9.9, and risks in 9.10.
6	The committee does not concur with the SSRA's finding that its quantitative risk assessment regarding FMDv and Rift Valley fever virus (RVFV) sufficiently represents the range of risk regarding the other pathogens that will be studied at the NBAF. Pg 66	A specific evaluation of the risks involved in handling Nipah and Hendra virus within ABSL-4 containment was performed to address this finding.	Section 9

NAS Letter Report Criticisms by Updated SSRA Section	Updated SSRA Response /Actions	Relevant Updated SSRA Section Reference
7 There is a need to develop strong working relationships with the CDC, USAMRIID, USDA, and National Institutes of Health to understand how the NBAF can work safely with dangerous zoonotic pathogens in large animals. Pg 66	In preparation of the Updated SSRA ABSL-4 Assessment, DHS has began the close and interactive partnership of international containment facility experts who have informed and will continue to inform the operations at the NBAF regarding handling large animal in ABSL-4 containment. The experts and their associated affiliations are presented in the Updated SSRA.	Section 9.2

Appendix A3: Draft Plan for Preparing the NBAF Emergency Response Plan (ERP)

1. Scope of the Effort

The Department of Homeland Security Science & Technology Directorate (through the Office of National Laboratories) has the primary responsibility to develop the National Bio and Agro-Defense Facility (NBAF) emergency response plan (ERP) covering preparedness, response and recovery. The NBAF ERP will follow components in the National Incident Management System (NIMS; http://www.fema.gov/emergency/nims/). The NBAF ERP will provide guidance and direction to assure an integrated and coordinated response to emergency situations (e.g., an accidental or intentional release of foot-and-mouth disease virus or other hazardous pathogen from the facility, hazardous chemical spill, weather-related event, etc.). It will support/define the response efforts both horizontally across the Federal Government and vertically among Federal, State, and local entities.

In addition the ERP will address NBAF's response to emergencies and other incidents occurring at nearby facilities (e.g., Kansas State University, Biosecurity Research Institute) or within the local community that could impact the operations and/or security at NBAF.

The ERP will build upon the documents prepared, or to be prepared, in support of the NBAF site selection and the pre-construction/construction of the actual facility. The ERP will be developed and implemented prior to beginning operations of the NBAF.

2. Organizations who will be Engaged in the ERP Development

The NBAF ERP will be the responsibility of the ONL Operations and Oversight Group working with appropriate NBAF staff (e.g., Laboratory Director, Operations Director, and Responsible Official [RO] for biological select agent and toxins [BSTA]). ONL will reach out for support/expertise in developing the ERP to other organizations such as:

- S&T ChemBio Division and S&T Laboratories (PIADC and NBACC)
- Other DHS Components (e.g., Office of Security, Office of Health Affairs, and Federal Emergency Management Agency)
- U.S. Army Garrison, USAMRIID, and other National Interagency Biodefense Campus (NIBC) partners at Ft. Detrick
- U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service-Veterinary Services (APHIS–VS) and Agricultural Research Service (ARS) at HQ and field operations/laboratories
- State of Kansas (e.g., KS Emergency Management Director, State of KS Division of Emergency Management, KS State Veterinarian, KS Public Health Director, KS Homeland Security, KS Homeland Security Advisor, KS USDA, and KS Secretary of Agriculture)
- Biosecurity Research Institute (BRI) personnel
- Kansas State University (e.g., Director, Environmental Health and Safety; Public Safety; Emergency Management Coordinator, and KSU Police Chief)

- City of Manhattan, KS
- Riley County, Pottawatomie County
- Ft. Riley (Police Department, EMS, etc.)
- FBI (Manhattan, KS office), KS Bureau of Investigation (Intelligence Fusion Center), KS Threat Integration Center

- KS Highway Patrol
- Mercy Regional Health Center, University of Kansas Hospital Medical Center

3. NBAF ERP

3.1 ERP Table of Contents (Appendix A shows more detail for topics to be included in the ERP)

- Overview (scope and purpose)
- Preparation and Mitigation (e.g., annual update of plans, staff education, new employee orientation and refresher classes, systems and resources to minimize a potential release of infectious agents or hazardous materials, emergency exercises and drills, evacuation instructions for evacuation, fitness for duty, how employees will be vaccinated or prophylaxed before or during an event, emergency supplies [clothing, footwear, respiratory protection], employee identification badges, mutual aid agreements, emergency communication system, regional hospital disaster planning, emergency weather preparations, risk vulnerability assessment with mitigation strategies, establishment of a site Emergency Operations Center, etc.)
- Response (e.g., response to internal or external emergency; Incident Management System to manage emergency conditions in cooperation with external public service agencies; evacuation plans; reporting an emergency incident; communication via media including discontinuation of emergency operations and return to normal operations; implement mitigation strategies [including establishing effective area quarantine, animal movement controls, surveillance and response zones if necessary], etc.)
- Recovery (e.g., damage assessment of building spaces, equipment and personnel impacts and repairs; documenting emergency outcomes; debriefing the incident; NBAF business continuity; etc.)
- Acronyms and Glossary of Technical Terms
- Appendices

3.2 Events to be Covered in the ERP

The emergency response plan for NBAF will incorporate the breath of activities that may be encountered at such a facility including animal health, human (public) health, security, and environmental issues. The emergency response plans will include, but not be limited to, clearly indentifying and articulating the procedures for the following:

- Emergency notification
- Medical emergency
- Evacuation of buildings and/or site (including those with disability)
- Fire
- Tornado, earthquake, or flood
- Criminal or violent behavior including demonstration/civil disturbance, bomb threat, etc.
- Hazardous materials release (e.g., biological select agents and toxins, pathogens other than BSAT, flammable/ combustible gases in labs and storage areas, radioactive material, oil spill or leak) including shipments to the NBAF
- Utility failure
- Building system failure (e.g., response actions to discharge scenarios such as ventilation

problem resulting in loss of negative pressure in containment spaces, effluent waste discharge problem, natural gas leak, breaches of primary biocontainment)

The ERP will address an emergency at facilities in proximity to the NBAF (e.g., K-State TRIGA Mark II research reactor used to train nuclear reactor operators) that might affect NBAF operations.

3.3 NBAF Operational Plans

The ERP will be integrated with the appropriate NBAF operational plans including, but not limited to:

- Incident Response Plan (IRP) for biological select agents and toxins (BSAT) per 42 CFR 73.14, 7 CFR 331.14 and 9 CFR 121.14 (including plans for theft, loss or release of BSAT in compliance with Federal statutes; accidental releases or occupational exposures will be immediately reported to APHIS Agricultural Select Agent Program via Form 3; BSAT-exposed animals will be handled in the same manner as the agent or toxin itself for the purpose of reporting a BSAT theft, loss or release to appropriate Federal, state and local agencies). The IRP will address pathogens other BSAT.
- Biological Safety Plan
- Biosecurity Incident Response Plan for Non-Biological Incident
- Occupant Emergency Plan for the laboratory/animal room sections and for administrative sections of the NBAF
- Security Plan (facility, physical, policies for personnel, data and cyber)
- Emergency Preparedness (drills, training and documentation, securing building contents, building evacuation diagram and plan)
- Spill Prevention Control and Countermeasures Plan

3.4 Supporting Agreements for the Plan

Effective implementation of the NBAF ERP will require MOU's or formal agreements with local, state, and Federal authorities (and others as necessary) for mutual aid and sharing/ utilization of resources (personnel, equipment, and facilities). In order to assure effective emergency management operations, there exists the need to coordinate activities of government agencies or other entities which provide mutual aid and have their own incident response plans. Per the NIMS model, protocols must be in place to designate the overarching authority to manage and coordinate structure and concurrent implementation processes consistent with their responsibilities. These may include:

- Kansas State University (KSU)
- KSU's Biosecurity Research Institute (BRI)
- City of Manhattan, KS
- Riley County
- Ft. Riley (Chemical unit, Bomb Unit, Irwin Army Community Hospital, possibly setting up special immunization program [SIP] with new hospital being built, etc.)
- Hospital/Facility emergency plan at local and regional hospitals (e.g., Mercy Regional Health Center, Irwin Army Community Hospital at Ft. Riley, and University of Kansas Medical School)
- State of Kansas
    - Kansas Secretary of Agriculture
    - Kansas Director of Emergency Management and Homeland Security
    - Kansas State Veterinarian - Kansas Animal Health Department

    - Kansas State Fire Marshall

3.5 Implementation of the Plan (Training, Drills, and Reviews)

Effective implementation of the NBAF ERP will also include on-going training, coordination, and drills for preparing for actual events. Potential FMDV scenario-based workshops, meetings exercises and/or drills for assessment and finalization of the Plan (may also include other BSAT) including:

- Emergency FMD vaccination strategy exercise (scenario-based discussion)
- FMD standstill exercise (scenario-based discussion)
- Functional FMD exercise (rapid response team from local and state level simulation of a hypothetical FMD outbreak) to include mitigation strategies (e.g., may include establishing an area quarantine, animal movement controls, and response zones; may involve diagnostics, surveillance, depopulation/ disposal, cleaning/disinfection; spraying for infected insect release)
- FMD communications strategy (information management) workshop
- Resourcing workshop
- Sectional coordination workshop (KS local and regional counties)
- Incident Command training and workshops
- Veterinary investigations, restricted area movement and security, infected premises operations workshop
- Directors, operations managers, etc. meetings

4. Review and approval (distinctions will be made for review and approval) of the ERP

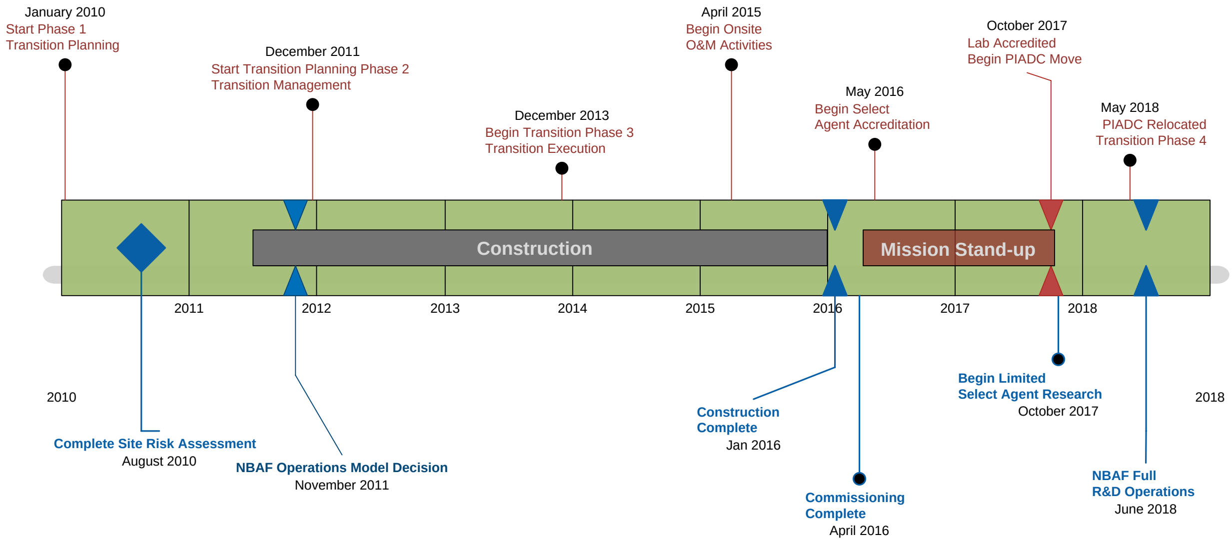
The NBAF ERP will be reviewed by:

- NBAF Laboratory Director and appropriate NBAF Management
- S&T (ONL and ChemBio)
- DHS Office of Security
- USDA (ARS and APHIS)

5. Schedule for Preparation of the NBAF ERP

The NBAF ERP will address the specific requirements of NBAF operations and memorandums of understandings (MOUs).

- Late 2015/2016: ERP will cover NBAF initial operations including the CUP, main lab building, trans-shipping building and out-buildings as the facilities are transferred from the construction contractor to DHS.
- 2016/2017: ERP will be updated by DHS ONL for the operations of the NABF site including the security plan, biosurety plan, incident response plan (IRP), and contingency/business continuity plans (a possible off-site continuity of operations or COOP location).



6. References

A. Emergency Management Plan- Kansas State University- Manhattan Campus (2009)

B. Kansas Incident Specific Plan for Foreign Animal Diseases- Prevention, Preparedness, Response and Recovery (March 2008)

C. Riley County, KS Emergency Management website information (http://www.rileycountyks.gov/index.aspx?NID=207)

D. Risi, G.F., M.E. Bloom, N.P. Hoe, T. Arminio, P. Carlson, T. Powers, H. Feldmann, and D. Wilson. 2010. Preparing a community hospital to manage work-related exposures to infectious agents in biosafety level 3 and 4 laboratories. Emerg. Infect. Dis. 16:373-378.

E. "The Medical First Response to Bioterrorism," Tara O'Toole, M.D., M.P.H., *Medicine and Global Survival*, Volume 6, No. 2.

F. Biodefense Strategy for the 21st Century, Homeland Security Presidential Directive 10 (HSPD-10)

7. Attachments

Appendix A (examples of details to be included in the ERP)

Acronyms and Glossary of Technical Terms

For example:

• BSL	Biosafety Levels (there are 4 levels of biosafety used to designate and regulate lab work with microorganisms; the range is BSL-1 in which the microbes are not know to cause disease in healthy adult humans to BSL-4 in which the microbes pose a risk of life-threatening disease and for which there is no known vaccine or therapy; BSL-3Ag refers to research involving large agricultural animals; increasing levels of personnel and environmental protection are provided for by the different biosafety levels; the higher the level of the biosafety lab, the more stringent the level of protection)
• DHS	Department of Homeland Security
• FADs	Foreign Animal Diseases (Diseases not present in the United States that are capable of rapidly spreading and causing high numbers of deaths and/or devastating economic consequences; e.g., foot and mouth disease)

• PIADC	Plum Island Animal Disease Center (US laboratory for the diagnosis, research, vaccine and other countermeasure development for foreign animal diseases, as well as training veterinarians in the recognition and diagnosis of these diseases)
• USDA APHIS	United Stated Department of Agriculture Animal and Plant Health Inspection Service
• USDA ARS	United Stated Department of Agriculture Agricultural Research Service
• Zoonotic	A term for diseases transmitted by animals to humans

Facility Description and Facts

- Characteristics of surrounding area (college campus including buffer zone around the stadium sports complex and student recreation center across from the NBAF site, neighborhood, rural)
- Building plans and floor plans (NBAF, CUP, Trans-shipping, etc.)
- Construction information (year completed, exterior material, total square footage, total number of floors with number above and below ground, etc.)
- Total number of typical building occupants along with estimate of total number of daily visitors
- List of emergency equipment (fire extinguishers, fire alarms, AEDs, protective clothing, etc.) and spill response materials (biological, chemical, petroleum, radiological) at the facility including location, physical description and capabilities
- Types of access/egress from buildings on NBAF campus including shelters and evacuation shelters adjoining NBAF biocontainment facilities
- Security (e.g., fences, lighting, alarms, guards, emergency cut-off valves and locks)
- Weather tracking strategy
- Plume modeling scenarios

Training, Simulation Exercises and Drills:

- Local “First Responders” NBAF lab access and response coordination training. Because of the understandable concern that EMS and hospital medical staff may/will have about their risk of exposure to a zoonotic (BSL-3 or -4) pathogen, training will be ‘‘end-to-end’’ and include first responders (firefighters, law enforcement officers, emergency medical service providers), clinical laboratory staff, hospital healthcare providers, and security personnel.
    - For zoonotic pathogens handled at the NBAF: provision in advance for the medical care of any employee potentially infected during the course of research, in a setting that minimizes the risk of transmission of infection to others (e.g., care and isolation units)
- Employee emergency response training (ERT) reviewed annually including evacuation plan for facility (audible and visible alarms, key building contact information, emergency assembly area location, etc.)
- Incident Command Structure
- Provide life safety (“man down”), fire extinguisher training and fire safety training (including building evacuations) to NBAF campus personnel

Emergency Notification

- Names, addresses, email and phone numbers of emergency coordinators (include primary designees; emergency coordinator at facility or on call, NBAF security, ES&H, etc.)
- 24-hour emergency medical contact information (e.g., competent medical authority for the NBAF, local and regional medical facilities (e.g., Mercy Hospital Medical Center, U. of KS Hospital, Irwin Army Community Hospital at Ft. Riley)
  - For zoonotic pathogens handled at the NBAF: provision in advance for the medical care of any employee potentially infected during the course of research, in a setting that minimizes the risk of transmission of infection to others (e.g., care and isolation units)
- Contact information of other authorities and resources such as KSU University Police and ES&H; City of Manhattan police and fire, Riley EMS; local and regional medical facilities (e.g., Mercy Hospital Medical Center, U. of KS Hospital, Irwin Army Community Hospital at Ft. Riley), KS Health Department (Riley County), Center for Disease Control and Prevention (CDC), USDA APHIS Agricultural Select Agent Program, FBI Topeka Field Office, DOT, Ft. Riley bomb unit, etc.
- Non-life threatening emergency phone numbers (e.g., chemical or biological spill during business hours and during off-hours/weekend).

Response

- Protocols for major emergency situations and activation of emergency management plan(s)
  - Situation (e.g., biological agent release) affects livestock, wildlife, human health (disease reporting, epidemiology, vaccination), environment, etc.
  - Incident Management System to manage emergency conditions (e.g., roles and responsibilities with local, county, state, and Federal agencies)
- Communications plan to coordinate and manage all official notices and alerts; collect, prepare and disseminate information to NBAF staff, KSU faculty/staff/students, news media and the public, etc.
  - Emergency news plan (e.g., coordinate and manage all official notices and alerts; collect, prepare and disseminate information to NBAF staff, KSU faculty/staff/students, news media and the public; resources available include KSU campus emergency information line/campus emergency web site/campus radio station, City of Manhattan emergency radio station, etc.)
  - What to Do When You Hear Campus Warning Sirens (shelter, listen for campus emergency information)
  - State-wide Kansas 800 system for crisis communication

Recovery Activities

- Plan for the transition of emergency operations to normal laboratory management.
- Consideration of circumstances, if any, that might require the emergency relocation of BSAT to another secure facility
- Conduct damage assessment and identify critical needs for repair (capture and determination of costs with financial impacts, burdens and compensation, if any)
- Record keeping and documentation (logs, forms, photos, final report, etc.) and their distribution
- Critique of emergency response and follow-up

- Upon resolution of an emergency event, the NBAF RO (and others as appropriate) will conduct a debriefing with all personnel involved including the facility manager, the facility director, local emergency responders, etc. Possible prevention of future events (e.g., lessons learned to identify areas of improvement) and appropriateness of the response actions will be discussed. Shortcomings and improvements to preventative and response actions will be discussed, documented and implemented.
- A follow-up report will be prepared and reviewed by the NBAF RO (facility Manager and others as appropriate). This report will be sent to the appropriate Entities (e.g., the USDA APHIS Select Agent Program, CDC Division of Select Agents and Toxins, OSHA, etc.).

Appendix A5: NBAF Updated SSRA Tornado Hazard Analysis

1.0 Introduction

Since 1994, there have been, on average, approximately 1,250 confirmed tornadoes per year in the U.S. Many of these tornados occur in the central plains, including Kansas. During this same period, within approximately 120 nautical miles of Manhattan, Kansas, there were about 42 tornados per year, and as recently as June 11th, 2008 a tornado hit the Kansas State University campus in Manhattan.

For the original NBAF SSRA [DHS, 2010], a tornado frequency analysis (Table 1) was performed to estimate the mean return periods for tornados of a given intensity (Table 2) or higher, based on the original Fujita Scale (F-Scale), for a 9° by 7° region encompassing the NBAF site (Figure 1). Tornado tracks for all of the confirmed tornados from 1950-2010 are shown: F/EF0-F/EF1 (Black), F/EF2-F/EF3 (Blue), and F/EF4-F/EF5 (Red). The proposed NBAF location is denoted by the red dot in north-eastern Kansas on this figure. The SSRA analysis used tornado records from the National Oceanic and Atmospheric Administration (NOAA) Storm Prediction Center (SPC) available online at www.spc.noaa.gov/wcm/ covering the period from 1 January 1950 to 31 December 2009. These data were adjusted using the spatial bias correction technique of Ray, Bieringer, et al. [2003].

Table 1: Tornado Mean Return Periods for the NBAF Region from the 2010 SSRA

F Scale	Tornado Count	Percentage of Total	Mean Return Period
F0 or Greater	5429	50.80 %	16 Years
F1 or Greater	2932	28.38 %	33 Years
F2 or Greater	1601	15.49 %	77 Years
F3 or Greater	453	4.38 %	300 Years
F4 or Greater	89	0.86 %	1687 Years
F5 or Greater	9	0.09 %	18370 Years

Table 2: Fujita Damage Classification Scale (F Scale)

F Scale	Highest 1/4-mile Wind Speed	3-Second Gust (mph)	Damage Description
F0	40-72 mph	45-78 mph	Minor damage
F1	73-112 mph	79-117 mph	Moderate damage
F2	113-157 mph	118-161 mph	Considerable damage
F3	158-207 mph	162-209 mph	Critical damage
F4	208-260 mph	210-261 mph	Severe damage
F5	261-318 mph	262-317 mph	Devastating damage

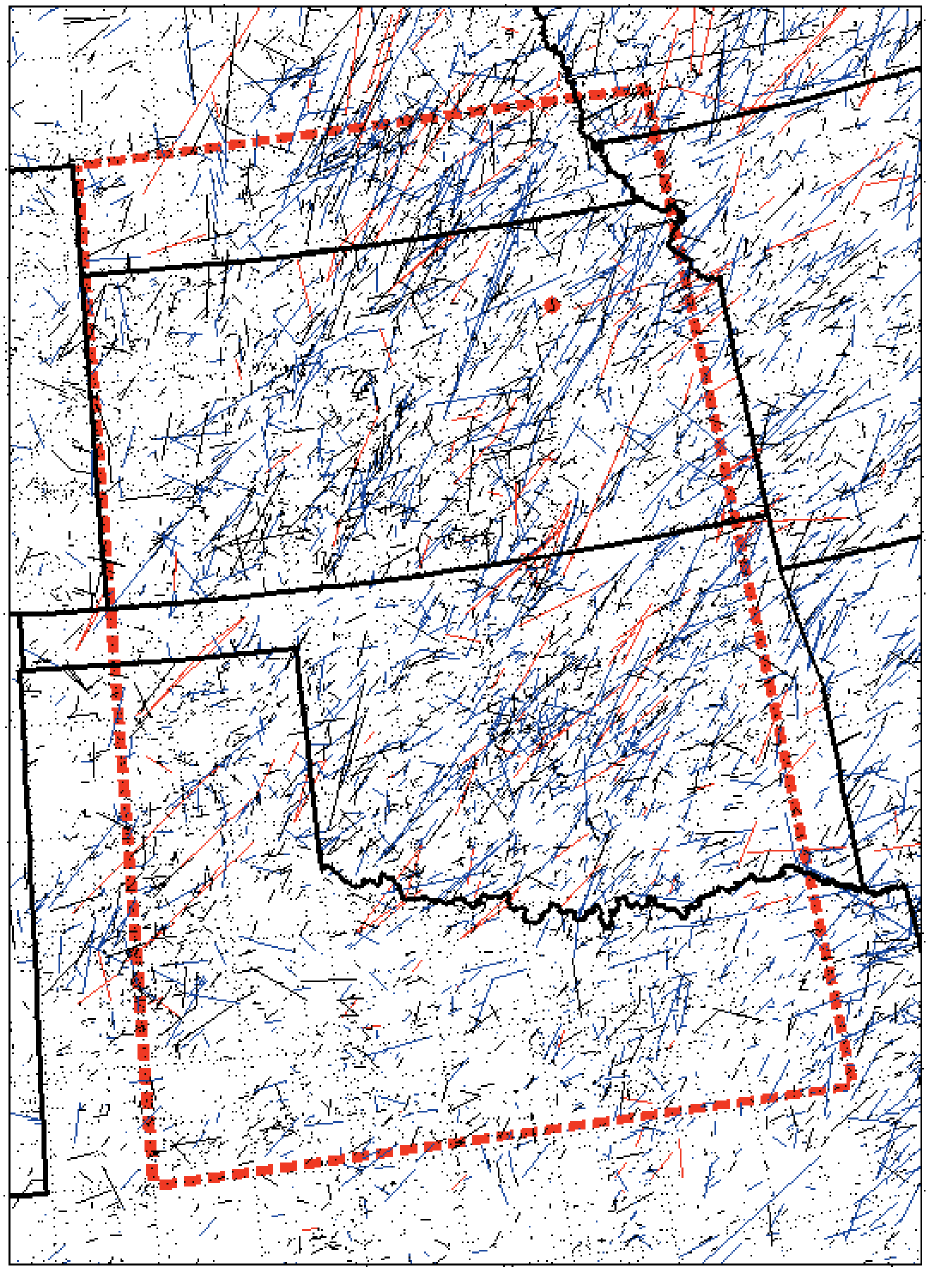


Figure 1: 9° by 7° Region From Which the Tornado Climatological Statistics Were Determined for the 2010 SSRA

For the NBAF Updated SSRA, the analysis results have been updated and refined by leveraging methods developed by the Pacific Northwest National Laboratory (PNNL) and described by Ramsdell and Rishel [2007] to a) include recent tornado events recorded since the original SSRA, b) account for the conversion from the Fujita (F-Scale) to the Enhanced Fujita Scale (EF-Scale) classification system (Table 3), c) account for the size of the NBAF facility when determining the probability of a tornado strike, d) account for the documented variation of wind speeds across the tornado damage area when determining the probability of exceeding a specified wind speed at the NBAF, and e) use these probabilities to develop probabilities of exceedance curves for a continuous range of wind speeds. Details of this methodology and associated results are summarized below.

Table 3: Enhanced Fujita Damage Classification Scale (EF Scale)

EF Scale	3-Second Gust (mph)	Damage Description
EF0	65-85 mph	Minor damage
EF1	86-110 mph	Moderate damage
EF2	111-135 mph	Considerable damage
EF3	136-165 mph	Critical damage
EF4	166-200 mph	Severe damage
EF5	>200 mph	Devastating damage

2.0 Methodology

Choice of Tornado Hazard Analysis Methodology

In April of 2011, the American Nuclear Society published a revision to ANSI/ANS 2.3-1983, “Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites”, expanding its scope to include hurricanes, replacing the original Fujita Tornado Damage Scale (F-Scale) with the Enhanced Fujita Scale (EF-scale), and expanding its applicability to all nuclear facility sites [American Nuclear Society, 2011]. Within this revised standard, “Estimating Tornado, Hurricane, and Extreme Straight Line Wind Characteristics at Nuclear Facility Sites”, two methodologies for estimating tornado strike probabilities and developing tornado wind hazard curves are recommended: one developed by the Lawrence Livermore National Laboratory (LLNL) and the other developed by the Pacific Northwest National Laboratory (PNNL). The LLNL methodology, detailed by Boissonnade, Hossain et al. [2000], uses a variety of information to develop a final set of probabilistic wind hazard curves for a specific size facility and location, including tornado heading, touchdown locations within a specified area surrounding the location of interest, area of the tornado footprint, variation of wind speeds within the tornado damage footprint, and tornado intensity based on the Fujita scale (F-scale). This methodology also accounts for the uncertainties associated with the observed parameters. The PNNL methodology incorporates many of the same sources of information to calculate probabilistic hazard curves, but also incorporates the Enhanced Fujita Scale (EF-Scale) in the analysis. Since the NAS SSRA Committee recommended suing the EF-Scale for future tornado hazard analyses, the PNNL methodology was selected for use in the Updated SSRA.

PNNL Methodology

At the heart of the PNNL methodology, as documented in NUREG/CR-4461, Rev.2, “Tornado Climatology of the Contiguous Unites States” [Ramsdell and Rishel, 2007], is the calculation of the probability of exceeding a specified wind speed threshold at a specific site. This probability is defined as the product of the probability of a tornado of any intensity striking the site and the probability of exceeding a wind speed threshold, given that a strike has occurred (Equation 1).

Equation 1

$$P(u \geq u_o) = P(s) \times P(u \geq u_o \mid s)$$

where $P(u \geq u_o)$, is the total probability of the wind speed, u, exceeding the wind speed threshold, u_o, $P(s)$ is the probability of the site being struck by a tornado, and $P(u \geq u_o \mid s)$ is the conditional probability of exceeding u_o, given a strike has occurred.

In revision 1 of NUREG/CR-4461, the total probability of exceedance (e.g. tornado event exceeding a given wind speed) was solely based on a point structure calculation, which neglected the dimensions of the structure. Accordingly, the probability of a tornado striking any point, $P_p(s)$, within a user defined region of interest, A_r, is represented as:

Equation 2

$$P_p = \frac{A_t}{NA_r}$$

where A_t represents the total area impacted by tornadoes within the region of interest and N is the total number of years of record. The total area impacted by tornadoes, A_t is simply the sum of expected areas, $E[A(F_i)]$ for each F-scale, F_i $(i=0,1,2,3,4,5)$, multiplied by the number of tornado events, associated with that F-scale, within the analysis region, $N_t[F_i]$:

Equation 3

$$A_t(F_i) = E[A(F_i)] \times N_t[F_i]$$

Equation 4

$$A_t = \sum_{i=0}^{5} A_t(F_i)$$

Calculation of the conditional probability of exceeding a wind speed threshold, given a tornado strike, for a point structure, is subsequently defined as:

Equation 5

$$P_p(u \geq u_o \mid s) = \frac{A_{u \geq u_o}}{A_t}$$

where, $A(u \geq u_o)$, is the total area receiving wind speeds greater than or equal to the wind speed threshold, u_o. By assigning the minimum wind speed associated with each damage classification category (0 thru 5) to u_o, six values are obtained for the conditional probability (Equation 5). To calculate conditional probabilities over a continuous range of wind speed thresholds, a continuous distribution functional form is assumed and then numerically fit to the six values calculated using Equation 5. Ramsdell and Rishel [2007](Ramsdell and Rishel 2007) recommend the use of a Weibull distribution to represent the continuous conditional probability of exceedance:

Equation 6

$$P_p(u \geq u_0 \mid s) = e^{[-\left(\frac{u_0-65}{a_p}\right)^{b_p}]}$$

where a_p and b_p are parameters of the Weibull distribution which need to be estimated using a numerical optimization method, which minimizes the difference between the observed probabilities and the estimated probability distribution.

Revision 2 of NUREG/CR-4461 further extended this methodology to include probabilities of exceedance associated with a finite size structure, $P_l(u \geq u_o)$. This is combined with the probability of exceedance, $P_p(u \geq u_o)$, for a point structure to determine the total probability that a given wind speed is exceeded as a result of a tornado:

Equation 7

$$P(u \geq u_o) = P_p(u \geq u_o) + P_l(u \geq u_o)$$

As with the point structure, the finite structure probability of exceedance is also the product of the probability of a strike, $P_l(s)$, and the probability of exceedance given a strike, $P_l(u \geq u_o \mid s)$:

Equation 8

$$P_l(u \geq u_o) = P_l(s) \times P_l(u \geq u_o \mid s)$$

where the probability of a tornado strike is similarly calculated:

Equation 9

$$P_l(s) = \frac{w_s L_t}{NA_r}$$

but instead utilizes a characteristic building dimension, w_s, multiplied by the total length impacted by tornadoes, L_t to characterize the total impacted area. The total length impacted by tornadoes is simply the sum of expected lengths, $E[L(F_i)]$ for each F-scale, F_i $(i=0,1,2,3,4,5)$, multiplied by the number of tornado events, associated with that F-scale, within the analysis region, $N_t[F_i]$:

Equation 10

$$L_t(F_i) = E[L(F_i)] \times N_t[F_i]$$

Equation 11

$$L_t = \sum_{i=0}^{5} L_t(F_i)$$

Calculation of the conditional probability of exceeding a wind speed threshold, given a tornado strike, for a point structure, then becomes:

Equation 12

$$P_l(u \geq u_o \mid s) = \frac{L_{u \geq u_o}}{L_t}$$

where, $L(u \geq u_o)$, is the total length receiving wind speeds greater than or equal to the wind speed threshold, u_o. As for the point structure methodology, the Weibull distribution is similarly used to represent the continuous conditional probability of exceedance:

Equation 13

$$P_l(u \geq u_0 \mid s) = e^{\left[-\left(\frac{u_0 - 65}{a_l}\right)^{b_l}\right]}$$

After combining the probabilities for a point and finite size structure, the equation for the final probability of exceedance becomes:

Equation 14

$$P(u \geq u_o) = \frac{A_t}{NA_r} e^{\left[-\left(\frac{u_0 - 65}{a_p}\right)^{b_p}\right]} + \frac{w_s L_t}{NA_r} e^{\left[-\left(\frac{u_0 - 65}{a_l}\right)^{b_l}\right]}$$

Using Equation 14, probabilities are calculated for a continuous range of wind speeds, u_o, and used to develop the final tornado wind hazard curves, as illustrated in Figure 2:.

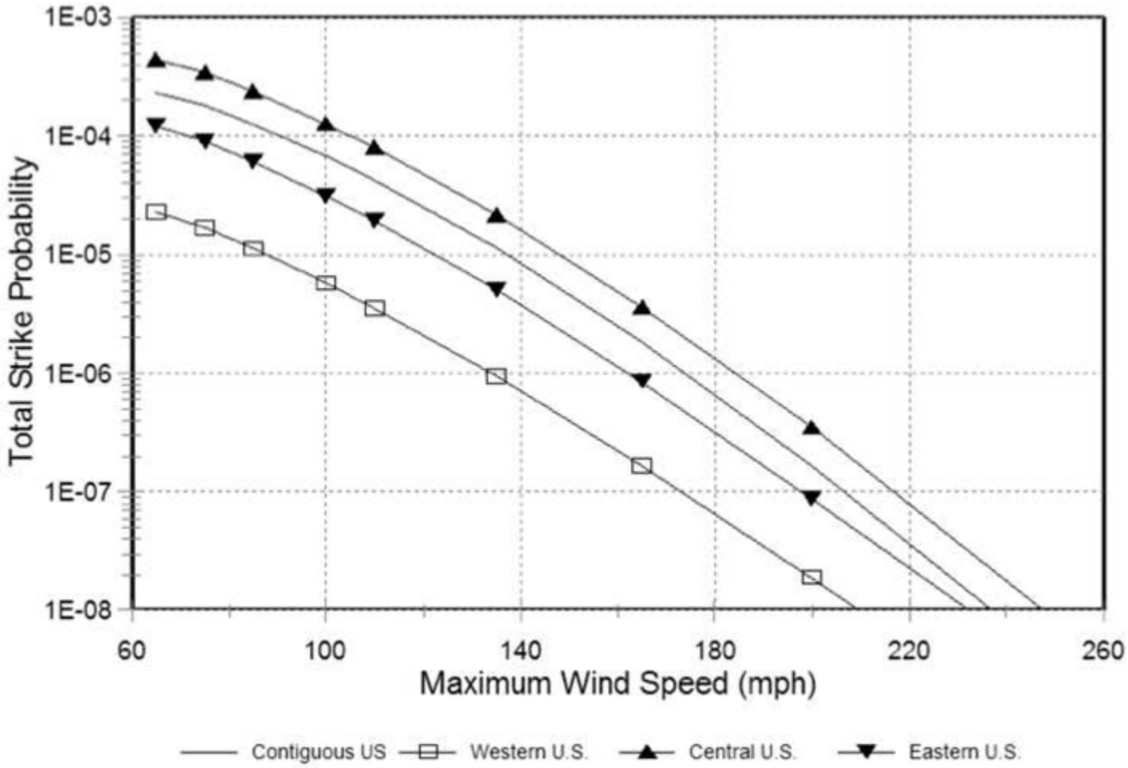


Figure 2: Tornado Hazard Curves from Ramsdell and Rishel [2007] Representing Total Probabilities of Exceedance Calculated for the Continguous, Western, Central, and Eastern United States

Implicit in Equation 3 and Equation 10 is the need to estimate the values for tornado areas and lengths, for tornadoes of record within the defined region of interest. In place of calculating a simple arithmetic average, Ramsdell and Rishel [2007] recommend using the expected value, assuming tornado dimension statistics follow a lognormal distribution. The expected value and associated 5% and 95% confidence intervals can be computed using Equations 15 – 17, below:

Equation 15

$$E[x] = e^{\left(\mu - \frac{\sigma^2}{2}\right)}$$

Equation 16

$$p_{95}[x] = e^{(\mu + 1.645\sigma)}$$

Equation 17

$$p_5[x] = e^{(\mu - 1.645\sigma)}$$

where μ and σ represent the mean and standard deviation of the natural logarithm of the tornado length, width, and areas in the climatological record.

In addition to incorporating the probabilities associated with a finite structure size, revision 2 of NUREG/CR-4461 also made modifications to the revision 1 methodology to account for variation of wind speeds within the tornado impact area for the conversion from F-scale to EF-scale wind speeds (not detailed here).

Using the revised methodology, PNNL subsequently calculated probabilities of exceeding specified wind speeds for the contiguous, western, central, and eastern United States for a characteristic building dimension of 200 ft using tornado records covering the period from 1 January 1950 to 31 August 2003. The results of their analysis included recommended design wind speeds of 230, 200, and 160 mph for the central U.S., east coast/western great plains, and western U.S., respectively, using a best estimate probability of 10^{-7} per year.

NBAF Updated SSRA Methodology

For the Updated SSRA tornado hazard analysis, the PNNL methodology was used with a few modifications. First, tornado records from 1 January 1950 to 31 December 2010 were used to estimate the tornado dimension statistics. Second, a characteristic building dimension of 380 ft was used to estimate the probabilities associated with a finite size structure. This dimension was based on the latest NBAF design (65%) which calls for a “first floor tornado wall plan” with a rectangular area of dimensions 320’ (in the east/west direction) by 380’ (in the north/south direction). The tornado record used in the Updated SSRA was the “event-based” climatological record maintained by the NOAA SPC, versus the “segment-based” record maintained by the NOAA National Climatic Data Center (NCDC) that was used by PNNL. Lastly, to provide a more representative statistical record, the tornado records used in the Updated SSRA were extracted from a smaller analysis region surrounding the NBAF location versus the significantly larger “Central US” domain used by PNNL. These adjustments are discussed in more detail in the sections, below.

NOAA SPC Tornado Dataset

The Updated SSRA tornado hazard analysis used the latest “event-base” archive of tornado events for the continental Unites States from the NOAA SPC [available online at: http://www.spc.noaa.gov/wcm/], which covered the period from 1 January 1950 to 31 December 2010. The archive includes a variety of information related to documented tornado touchdown events, including intensity (F-Scale: 1950-2007, EF-Scale: 2007-Present), starting/ending locations, length/width of damage paths, date/time of event, injuries, fatalities, and other related data. An important distinction regarding this archive and the one used by PNNL is that the NOAA SPC archive currently lists the tornadoes in terms of a single event in contrast to the “segment-based” archive currently maintained by the NOAA National Climatic Data Center (NCDC) which lists a single tornado as a series of segments that correspond to the specifics of the tornado as they pertain to a given county of a state. In the “segment-based” record, a single tornado can be archived more than once and the length of a tornado that crosses county and state lines will be reported as the length within the county and state and not the total length of the tornado path. As will be discussed, the use of the “segment-based” record has implications on the accuracy of the 5th and 95th percentile total strike probability calculations.

Choice of Statistical Analysis Region and Associated Statistics

The relatively small sample size and well documented data quality issues associated with the U.S. tornado climate record poses a significant challenge in using it to draw robust conclusions for facility design and risk assessment analyses [Doswell, 2007]. One of the challenges of calculating tornado statistics as a function of F-Scale is that the more intense tornados (F4-F5) are extremely rare events. For example, during the entire period of record (60 years), over the entire continental U.S., there were only 730 F4 and F5 tornado events (Table 4). The relative rarity of these strong tornado events is also illustrated in Figure 1. Here the tracks of all of the confirmed tornados between 1950 and 2010 are depicted over the US central plains region. Because of the rarity of intense tornados, it is difficult to produce a statistically relevant sample size for the immediate vicinity of Manhattan, Kansas. This point is illustrated in Table 5 which contains a summary of the confirmed tornadoes that occurred within approximately 10 nautical miles (nmi) of Manhattan and in Figure 3 which depicts the paths of these tornados. Over the 60-year record, there have been only 15 confirmed tornadoes of any intensity documented in this area.

Table 4: U.S. Total Confirmed Tornados (1950 2010)

F Scale	Tornado Count	Percentage of Total
Unknown	1,864	3.36 %
F0	23,966	43.23%
F1	17,826	32.16 %
F2	8,623	15.55 %
F3	2,430	4.38 %
F4	652	1.18 %
F5	78	0.14 %

Table 5: Confirmed Tornados Within 10 nmi of NBAF (1950 2010)

F Scale	Tornado Count	Percentage of Total
F0	8	53.33 %
F1	5	33.33 %
F2	1	6.67 %
F3	0	0.00 %
F4	1	6.67 %
F5	0	0.00 %

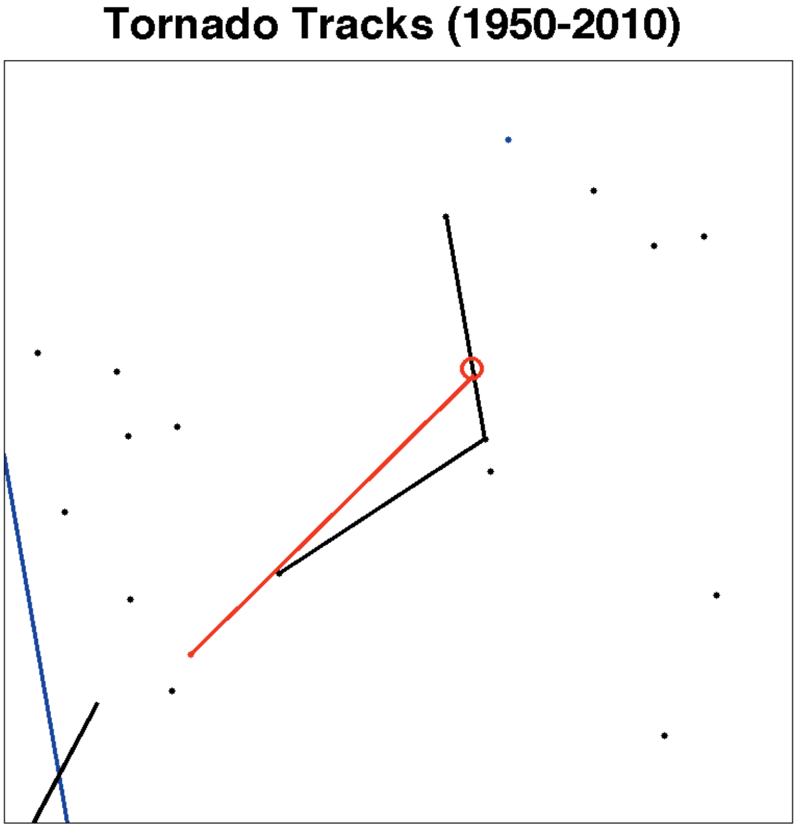


Figure 3: Touchdown Location and/or Tracks for all of the Confirmed Tornados from 1950-2010 Within 10 nmi of the NBAF. The red circle denotes the NBAF location.

Since the climatological record is not long enough to capture a statistically relevant number of tornadoes at all of the intensity levels in the immediate vicinity of the NBAF, it is necessary to identify an area (as large as possible) where the overall tornado occurrence statistics are relatively uniform and representative of tornado statistics for Manhattan, Kansas. To accomplish this, tornado occurrence statistics were examined in 1° longitude bands from west to east and 1° latitude bands from north to south to identify regions of uniform tornado occurrence and/or trends in the NOAA SPC database (Figure 4: and Figure 5). The results illustrate that a region of higher tornado occurrence is present over southern Nebraska, most of Kansas and Oklahoma, and northern Texas between longitudes of 102° to 95° W and latitudes of 32° to 41° N. This area constitutes a portion of what is often referred to as "Tornado Alley." The local maximums in tornado frequency at 98° west and at 32°, 35°, and 39° north roughly correspond with localized regions of higher population associated with the cities of Dallas/Fort Worth, Oklahoma City, Kansas City, and smaller towns along the transportation corridors of U.S. interstate highways 20, 40, and 70. Outside of the 32° to 41° N latitude and 102° to 95° W longitude band, the number of tornados markedly decreases. Based on these findings, the area illustrated by the dashed red box in Figure 1 was selected to provide tornado climatology statistics used in this assessment. Using an area of this size significantly increases the total number of tornadoes in each of the F-Scale categories and provides tornado occurrence data that are both statistically relevant and representative of the conditions that can be expected at the NBAF facility. Table 6: lists the tornado occurrences by F-Scale for the area outlined by the red dashed-line box in Figure 1.

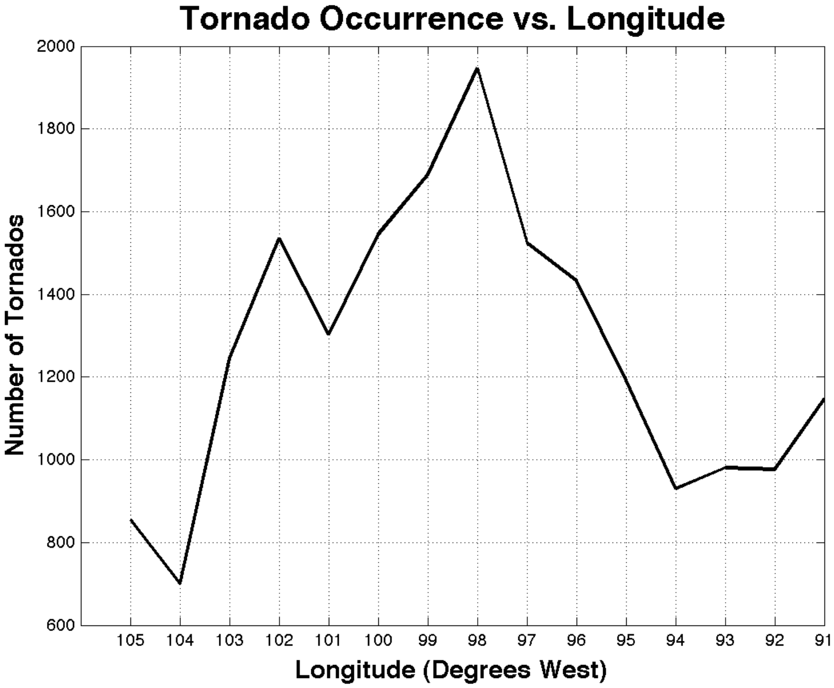


Figure 4: The Number of Tornados as a Function of Longitude Inside a 1° Longitude by 14° Latitude Region (29° to 43° N)

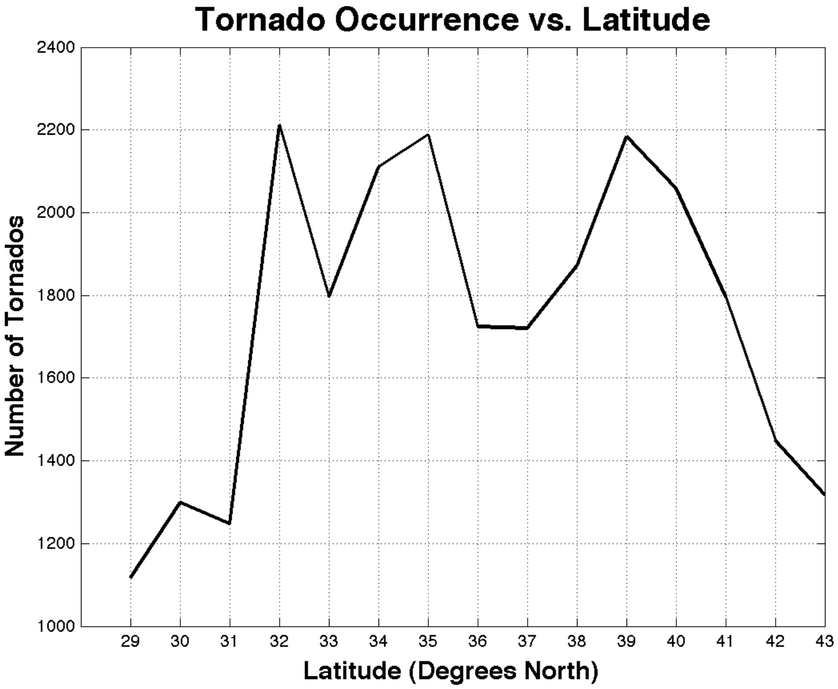


Figure 5: The Number of Tornados as a Function of Latitude Inside a 1° Latitude by 14° Longitude Region (105° to 91° W)

Table 6: Tornado Occurrences (1950 2010) Within the Defined Analysis Region

F Scale	Tornado Count	Percentage of Total
Unknown	474	4.20 %
F0	5423	48.10 %
F1	3048	27.03 %
F2	1672	14.83 %
F3	502	4.45%
F4	139	1.23 %
F5	18	0.16 %

3.0 Results

The PNNL-based methodology adopted for this report uses the climatological record of tornado lengths, widths, and total path area to compute the tornado strike probability. First, the strike probability is computed for the entire NOAA SPC tornado database and is used as a comparison to the PNNL results [Ramsdell and Rishel, 2007]. Second, the tornado strike probability is computed for the 9^o by 7^o NBAF analysis region for the reasons discussed above. Third, the analysis of tornado strike probability is computed for the 9^o by 7^o NBAF analysis region where a correction for the unreported tornado events based on the findings of Ray, Bieringer et al. [2003] is applied.

The statistics for tornado path length, width, and area for the entire NOAA SPC database are listed in Table 7. This table provides the mean and median tornado path characteristics computed using standard methods, along with the expected value, 5th percentile, and 95th percentile values when the tornado path characteristics are represented by a lognormal distribution. The statistics based on the lognormal distribution assumption are the values then used to compute the strike probabilities for the NBAF (assuming a 380 ft horizontal length of the structure) over a continuous range of wind speeds (Figure 6:).

Table 7. Tornado Path Statistics (Entire Tornado Climate Record)

Statistic	F/EF - 0	F/EF - 1	F/EF - 2	F/EF - 3	F/EF - 4	F/EF - 5
Total Number of Events	23911	17810	8592	2407	628	72
Events with Reported Length	23796	17805	8592	2407	628	72
Median (mi)	0.200	1.000	3.000	9.300	18.360	28.605
Mean (mi)	1.116	3.211	6.989	14.797	26.826	36.572
5th Percentile (mi)	0.036	0.071	0.121	0.544	2.078	2.942
Expected Value (mi)	0.810	3.664	10.598	22.476	32.581	49.664
95th Percentile (mi)	2.993	14.166	40.695	86.490	115.192	177.456
Events with Reported Width	25523	17736	8575	2397	628	72
Median (ft)	75	150	300	600	1200	1500
Mean (ft)	122.096	266.590	492.774	1047.330	1677.640	2108.500
5th Percentile (ft)	19.355	22.693	24.964	51.856	118.939	478.435
Expected Value (ft)	112.936	257.311	535.144	1318.712	2138.581	2258.683
95th Percentile (ft)	319.005	860.484	1968.778	4931.974	7706.222	5935.502
Events with Area	23441	17732	8575	2397	628	72
Median (mi)	0.003	0.028	0.142	1.034	3.345	8.691
Mean (mi)	0.045	0.247	0.911	3.654	9.648	15.642
5th Percentile (mi)	0.000	0.001	0.001	0.012	0.132	0.562
Expected Value (mi)	0.030	.0440	3.209	12.668	15.820	26.140
95th Percentile (mi)	0.112	1.308	7.410	35.884	59.810	101.026

The results depicted in Figure 6: represent the strike probabilities based on the entire NOAA SPC tornado record and are comparable to those computed by PNNL shown in Figure 2:. Both analyses indicate that strike probabilities are on the order of 10^{-7} or lower for wind speeds in excess of 200 mph. The primary difference in the magnitude of the strike probabilities between Figure 2: and Figure 6: is due to the size of the structure used in the analyses. The PNNL study used a 200 ft structure while the NBAF analysis assumed a structure with a length of 380 ft. The other significant difference between this analysis and the one done by PNNL are the spread of the 5th and 95th percentile strike probabilities (red and blue dashed lines, respectively) from the expected value (black line). The NBAF analysis shows a significantly broader spread of the 5th and 95th percentile values than those identified in the PNNL analysis (not shown). The estimates of 5th and 95th percentile strike probability shown in Figure 6: and Figure 7 for the NBAF are more accurate than those reported in the PNNL study. The improved accuracy of this analysis is a direct result of the use of the NOAA NCDC “segment-based” tornado database in the PNNL study versus the NOAA SPC “event-based” record used here. When the “segment-based” tornado database is used, the tornado lengths are artificially shortened as a result of the way they are reported.

This issue does not impact the accuracy of expected value results reported by PNNL which are comparable to those reported for the NBAF. It does, however, result in the lognormal distribution of tornado path length being narrower than it should be in the PNNL analysis. This then impacts the 5th and 95th percentile values, which are incorrectly closer to the expected value. The values used for NBAF in this assessment are correct.

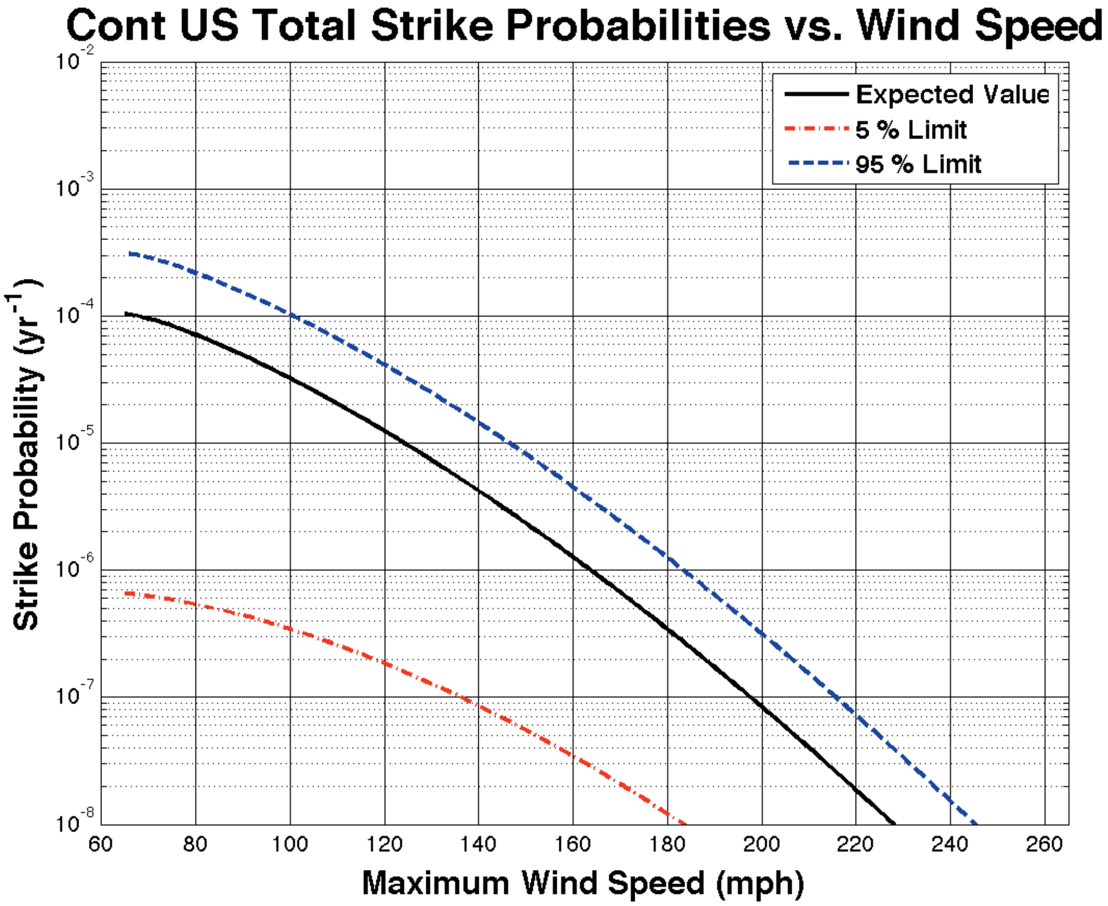


Figure 6: Tornado Strike Probability vs. Maximum Wind Speed Based on the Full Tornado Climatological Record Over the Contiguous United states.

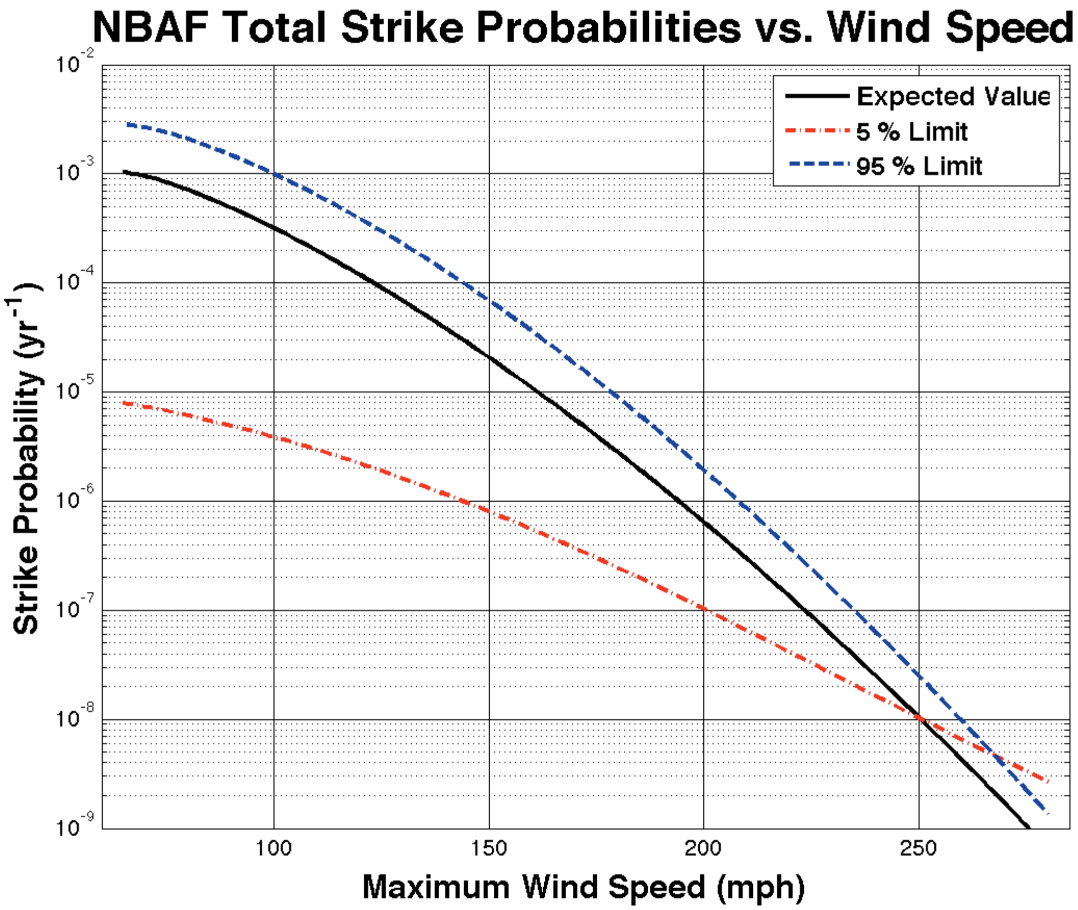


Figure 7: Tornado Strike Probability vs. Maximum Wind Speed Based on the Tornado Climatological Record in the NBAF Analysis Region Located in the US Central Plains. (Note that the Maximum Wind Speed is 280 mph for this Plot.)

Table 8 lists the comparable set of statistics for tornado path length, width, and area that are used in the computation of the strike probability for the 9° by 7° NBAF analysis area. Many of the tornado intensity characteristics are comparable between the analysis that used the entire data-base and the analysis that used the NBAF analysis area. Notable differences are the statistics from the NBAF analysis that indicate longer tornado path lengths and corresponding larger areas. This result is expected, and due to the fact that the US central plains, area in which the NBAF analysis area is located, is known to have the more frequent, larger, and more intense tornadoes than the average tornado path characteristic when computed over the entire US. The larger, more intense tornadoes, which occur more frequently in the US central plains, result in a higher total strike probability than when the entire tornado climate record is used. The 95th percentile is also higher; however, the 5th percentile estimate over the NBAF region has an artificially shallow slope. This result is due to an insufficient sample size of large tornadoes in the NBAF analysis region. Consequently, the 5th percentile results should be used with caution.

Table 8: Tornado Path Statistics (NBAF Analysis Area)

Statistic	F/EF - 0	F/EF - 1	F/EF - 2	F/EF - 3	F/EF - 4	F/EF - 5
Total Number of Events	5423	3048	1672	502	139	18
Events with Reported Length	5408	3048	1672	502	139	18
Median (mi)	0.200	1.000	2.700	9.000	20.400	32.905
Mean (mi)	1.081	3.465	6.755	14.712	26.174	35.367
5th Percentile (mi)	0.038	0.061	0.094	0.655	2.397	7.189
Expected Value (mi)	0.852	4.294	10.783	20.419	32.309	37.858
95th Percentile (mi)	3.148	16.584	40.876	77.531	111.518	103.393
Events with Reported Width	5343	3035	1671	500	139	18
Median (ft)	90.000	150.000	270.000	600.000	1500.00	2520.00
Mean (ft)	134.697	289.684	548.873	1174.020	2111.633	2977.167
5th Percentile (ft)	20.445	18.009	18.695	47.299	212.532	994.584
Expected Value (ft)	125.854	274.716	606.928	1582.090	2639.295	2954.293
95th Percentile (ft)	361.485	967.290	2310.121	6032.016	8979.414	6378.301
Events with Area	5333	3035	1671	500	139	18
Median (mi)	0.004	0.028	0.127	1.220	6.000	14.628
Mean (mi)	0.048	0.294	1.017	3.721	11.790	18.967
5th Percentile (mi)	0.00023	0.00036	0.00067	0.01357	0.223	2.632
Expected Value (mi)	0.037	0.687	4.850	13.108	21.467	20.843
95th Percentile (mi)	0.138	1.726	8.773	37.817	82.115	64.270

The tornado strike probability methodology used in the previous 2010 SSRA used the spatial bias correction technique of Ray, Bieringer et al. [2003] which corrected for un-reported tornadoes. In this study it was found that in the Manhattan, Kansas region, the tornado climatological record under-reports the total number of tornadoes by approximately 60%. Since the larger more intense tornadoes often leave identifiable damage even in remote locations, the most likely type of tornadoes to be under-reported are the weaker, F0 events. Further evidence of this can be seen in a plot of the number of tornado events over the year as a function of F/EF scale intensity (Figure 8). The number of F0 events has increased markedly since the beginning of “official” record keeping in 1950 in the NBAF analysis area, while there has not been a marked increase in the number of F1-F5 events. A similar finding was reported by Ramsdell and Rishel [2007] for the entire tornado climatological record. Consequently, it is reasonable to assume that if a correction is to be made to the tornado climate record to account for the under-reporting of tornadoes documented by Ray, Bieringer et al. [2003], it should be applied only to the F0 events. Based on this assumption, the number of F/EF0 tornado events in the NOAA SPC database was increased by 60% to account for the unreported events and then the tornado strike probability was recomputed. The increase in the number of F/EF 0 tornado events results in an increase in the tornado path area expected values relative to the unadjusted analysis for the NBAF region (Tables 9 and 10). This in turn results in a corresponding change in the relative percentages of tornado path area of the weaker storms between the adjusted and unadjusted analyses. This change associated with the adjustment due to under-reporting of weak tornadoes results in only a small change in the cumulative probability of exceeding a wind threshold. Since this in-turn results in only a small change to the 6 data points that are the basis for the Weibull function fit, there is little change to the corresponding Weibull function coefficients used to determine the continuous strike probability estimate. Consequently it is acceptable to use the tornado strike probabilities illustrated in Figure 7 to determine the design-basis wind speed for the facility and the tornado return frequencies for the final risk calculations.

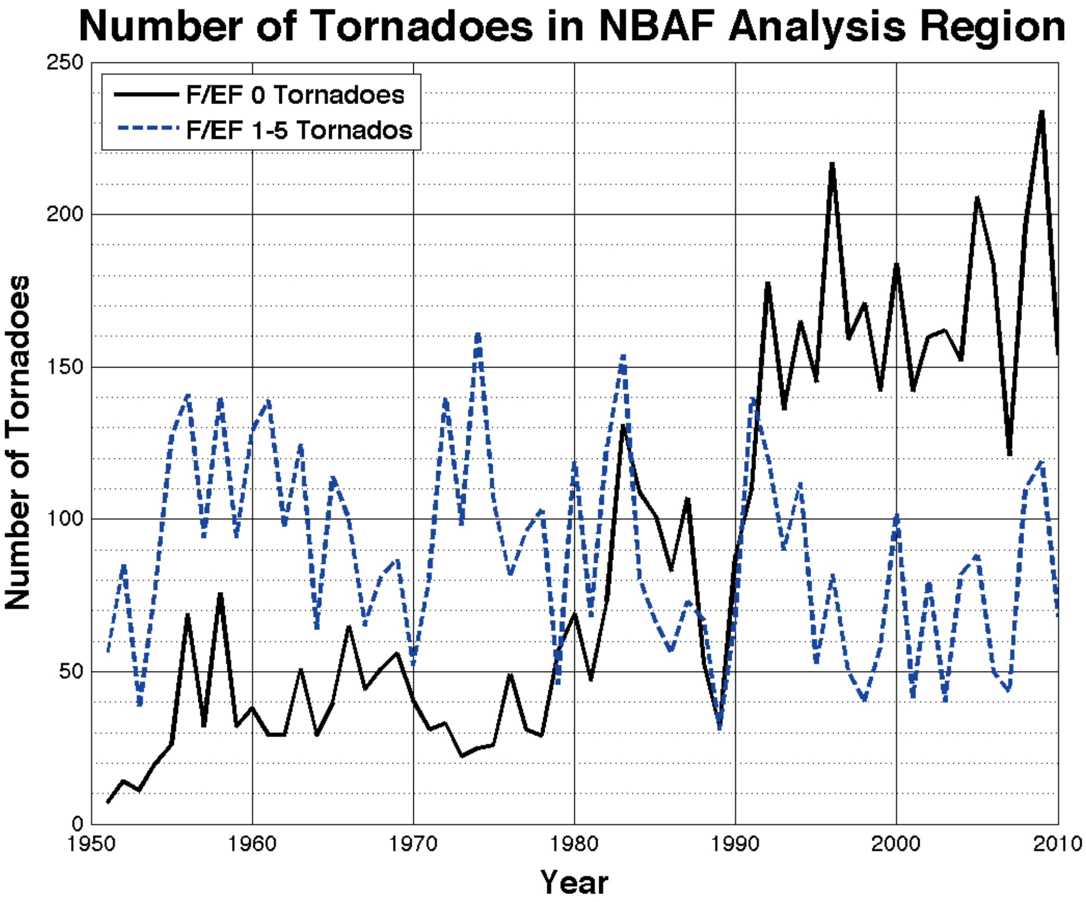


Figure 8: Number of Tornado Events per Year in the 9° by 7° NBAF Analysis Area. The Solid Black Line Represents the F/EF0 Events and the Blue Dashed Line Depicts the F/EF 1 – 5 events.

Table 9: Tornado Path Area Statistics (No Adjustment Made for Unreported Events)

Reported F/EF Scale	Expected Area (mi^2) by F/EF Scale	Expected Area (mi^2) by Wind Speed Range	Cumulative Area (mi^2) by Wind Speed Range	Probability of Exceeding Wind Speed Threshold	Wind Speed Threshold (mph)
0	202.66	12117.71	20345.36	1.00×10^{0}	65
1	2094.32	5227.81	8227.64	4.04×10^{-1}	86
2	8109.16	2251.36	2999.83	1.47×10^{-1}	111
3	6580.10	634.23	748.47	3.68×10^{-2}	136
4	2983.93	107.87	114.24	5.62×10^{-3}	166
5	375.17	6.38	6.38	3.13×10^{-4}	200

Table 10: Tornado Path Area Statistics (Adjustment Made for Unreported Tornadoes)

Reported F/EF Scale	Expected Area (mi^2) by F/EF Scale	Expected Area (mi^2) by Wind Speed Range	Cumulative Area (mi^2) by Wind Speed Range	Probability of Exceeding Wind Speed Threshold	Wind Speed Threshold (mph)
0	324.26	12239.32	20466.96	1.00×10^{0}	65
1	2094.32	5227.81	8227.64	4.02×10^{-1}	86
2	8109.16	2251.36	2999.83	1.47×10^{-1}	111
3	6580.10	634.23	748.47	3.66×10^{-2}	136
4	2983.93	107.87	114.24	5.58×10^{-3}	166
5	375.17	6.38	6.38	3.12×10^{-4}	200

4.0 References

Ramsdell, J. V. and J. P. Rishel (2007). Tornado Climatology of the Contiguous United States, U.S. Nuclear Regulatory Commission.

Appendix A6: Epidemiological Model

A6 Epidemiological Model Appendix

A6.1 Determining Outbreak Start Locations

A6.1.1 Certificates of Veterinary Inspection (CVIs)

An important aspect of disease modeling is accounting for the movement of infected animals. Movement of animals within each state is modeled using direct contact parameters in the Updated SSRA. Livestock is also shipped between states. To account for this, data from animal certificates of veterinary inspection (CVIs) were used to develop multiple parameters for epidemiological modeling. CVIs are the most comprehensive data source available for interstate livestock movement. CVIs are required for animals sold directly by the producer and for animals sold through markets; however, animals moved from Kansas to a sales barn in another state are not issued a CVI, so this approach somewhat underestimates the movement of animals between states. Subject matter experts (SMEs) believe that a small fraction of animals are sold through markets in states other than the state where they were produced. Additionally, there will be some illegal movement of animals that will not be captured using this approach. According to SMEs, the larger livestock species modeled for the SSRA and Updated SSRA (as opposed to poultry) are not typically part of illegal activities or an underground market system or culture (e.g., cockfighting), nor are they traded at unregulated swap meets, a common event in the small scale poultry industry. This greatly limits the opportunity for "off-the-grid movement."

Two sets of CVI data were collected. The first dataset contains limited information from all CVIs issued in 2010 to states in the modeled region. The second dataset includes detailed information collected from all CVIs issued in the nine counties nearest the NBAF during the first half of 2011. Resources and data availability limited the CVI data collection effort. Additionally, a 2003 interstate livestock movement report from the USDA Economic Research Service (ERS) was used when sufficient data were not available from CVIs .

A6.1.1.1 2010 CVIs for Modeled Region

One CVI dataset included the species, animal number, and reason for export for every CVI issued in Kansas in 2010 to a shipment of animals destined for the six other states modeled for the Updated SSRA.

Table 1: Total Livestock Exported to Six States in the Modeled Region, Organized by Reason for Export

		Total Livestock Shipped					
Production Type	**Reason for Export**	**Oklahoma**	**Missouri**	**Nebraska**	**Iowa**	**Texas**	**Colorado**
Cattle	Breeding	3056	2635	7630	1522	7871	4770
	Feeding	13483	2301	342687	44375	53129	117846
	Sale	1580	539	1403	184	773	1427
	Show	183	195	690	136	119	605
	Other	86	96	1521	2	440	854
	TOTAL	18388	5766	353931	46219	62332	125502
Swine	Breeding	1348	562	6614	12595	64	201
	Feeding	160	844	92035	168260	0	0
	Sale	169	0	0	7	50	0
	Show	106	68	16	33	30	162
	Other	13	12	12	0	59	0
	TOTAL	1796	1486	98677	180895	203	363
Sheep	Breeding	19	19	0	75	6	3
	Feeding	0	0	0	0	9	0
	Sale	35	92	17	8	107	0
	Show	56	128	123	12	38	54
	Other	7	0	1	0	26	0
	TOTAL	117	239	141	95	186	57
Goats	Breeding	77	475	26	0	28	0
	Feeding	0	0	8	0	0	0
	Sale	3	0	50	0	6	0
	Show	97	232	165	0	29	23
	Other	17	0	4	0	0	0
	TOTAL	194	707	253	0	63	23

Table 2: Total Number of Livestock Shipments Exported to Six States in the Modeled Region, Organized by Reason for Export

		Total Number of Shipments					
Production Type	**Reason for Export**	**Oklahoma**	**Missouri**	**Nebraska**	**Iowa**	**Texas**	**Colorado**
Cattle	Breeding	323	422	310	126	489	207
	Feeding	84	30	3974	371	299	802
	Sale	49	149	70	24	63	47
	Show	44	65	41	31	36	145
	Other	17	22	346	2	43	27
	TOTAL	518	688	4741	554	930	1228
Swine	Breeding	14	15	37	115	3	7
	Feeding	1	2	116	173	0	0
	Sale	16	0	0	2	9	0
	Show	27	25	6	18	12	19
	Other	2	1	1	0	3	0
	TOTAL	60	43	160	308	27	26
Sheep	Breeding	4	4	0	1	2	1
	Feeding	0	0	0	0	1	0
	Sale	3	10	2	5	2	0
	Show	7	22	7	4	1	10
	Other	1	0	1	0	3	0
	TOTAL	14	46	9	10	9	11
Goats	Breeding	5	6	1	0	2	0
	Feeding	0	0	0	0	0	0
	Sale	1	0	6	0	2	0
	Show	14	38	13	0	6	6
	Other	3	0	2	0	0	0
	TOTAL	23	44	22	0	10	6

Table 3: Median Number of Livestock per Shipment for the Six States Modeled

		Median Number of Livestock per Shipment					
Production Type	Reason for Export	Oklahoma	Missouri	Nebraska	Iowa	Texas	Colorado
Cattle	Breeding	1.0	1.0	3.0	1.0	6.0	3.0
	Feeding	90.5	51.0	62.0	78.0	114.0	105.0
	Sale	2.0	1.0	1.0	1.0	3.0	4.0
	Show	3.0	2.0	3.0	3.0	3.0	1.0
	Other	1.5	1.0	33.5	46.0	22.0	66.0
Swine	Breeding	80.0	21.0	50.0	110.0	17.0	25.0
	Feeding	160.0	422.0	550.0	800.0	0.0	0.0
	Sale	3.5	0.0	0.0	3.5	1.0	0.0
	Show	1.0	3.0	2.0	1.0	1.0	3.0
	Other	6.5	12.0	12.0	0.0	12.0	0.0
Sheep	Breeding	1.5	4.5	0.0	75.0	3.0	3.0
	Feeding	0.0	0.0	0.0	0.0	9.0	0.0
	Sale	11.0	8.0	8.5	1.0	53.5	0.0
	Show	4.0	3.0	11.0	2.5	38.0	2.0
	Other	7.0	0.0	1.0	0.0	25.0	0.0
Goats	Breeding	15.0	4.0	26.0	0.0	14.0	0.0
	Feeding	0.0	0.0	0.0	0.0	0.0	0.0
	Sale	3.0	0.0	5.5	0.0	3.0	0.0
	Show	5.5	4.0	15.0	0.0	5.0	2.0
	Other	6.0	0.0	4.0	0.0	5.0	0.0

A6.1.1.2 Detailed Data from CVIs Issued Near the NBAF in the First Half of 2011

The second set of data was pulled from CVIs issued between 1 January 2011 and 15 July 2011 in Marshall, Washington, Clay, Riley, Pottawatomie, Geary, Waubaunsee, Dickinson, and Morris Counties. These are the nine counties surrounding the proposed NBAF site. Data collected included: date, city of origin, destination city, reason for export, number of animals by species and sex, and some sales barn data (Table 4 and Table 5).

Table 4: Overview of CVIs Issued between 1/1/2011 and 7/15/2011 in the Nine Counties Nearest the NBAF

State	Number of Animals Shipped	Number of Shipments
AL	3	1
AR	9	4
AZ	67	5
CA	27	11

Table 4: Overview of CVIs Issued between 1/1/2011 and 7/15/2011 in the Nine Counties Nearest the NBAF

State	Number of Animals Shipped	Number of Shipments
CO	3,740	64
FL	3	3
GA	3	2
IA	52,647	158
ID	10	2
IL	625	13
IN	75	22
KS	1	1
KY	260	11
LA	43	6
MA	0	0
MD	54	1
MI	189	5
MN	698	20
MO	589	52
MS	5	1
MT	43	10
ND	25	6
NE	87,969	614
NM	25	12
NV	7	2
NV	640	11
OH	1,088	30
OK	35	3
OR	76	10
PA	1,573	5
SD	5	1
TN	5,503	80
TX	4	2
UT	17	6
VA	5	2
WV	9	6
WY	2	1
TX/CO	1	1
NE/MO	3	1

Table 5: Data from CVIs Issued between 1/1/2011 and 7/15/2011 in the Nine Counties Nearest the NBAF

Production Type	Reason for Export	Total Shipments	Total Animals	Median Number of Animals per Shipment
Cattle	Breeding	216	1,216	2
	Feeding	554	45,618	62.5
	Sale	15	263	3
	Show/Other	6	212	2
	TOTAL	791	47,309	69.5
Swine	Breeding	151	10,483	36
	Feeding	117	96,246	800
	Sale	0	0	0
	Show/Other	0	0	0
	TOTAL	268	106,729	806.5
Sheep	Breeding	2	13	6.5
	Feeding	3	498	111
	Sale	0	0	0
	Show/Other	3	13	2
	TOTAL	8	524	119.5
Goats	Breeding	0	0	0
	Feeding	0	0	0
	Sale	0	0	0
	Show/Other	5	54	13
	TOTAL	5	54	13

A6.1.2 Infectious Dose 50 (ID_{50}) and Probit Analysis: Aerosol and Intranasal Exposure

One important parameter when modeling an outbreak of infectious disease is the relationship between the dose a susceptible animal is exposed to and their probability of infection. This relationship is called a dose-response relationship, where ‘dose’ is the amount of virus a susceptible animal is exposed to and ‘response’ is the probability of that animal responding to that particular dose. In the model used here, a positive response was a successful infection, and the marker of a successful infection was viremia. For example, if the response at a given dose was 50%, then 50% of animals exposed to that dose would have been infected, as indicated by the presence of viremia. This 50% infection rate is also known as an infectious dose 50 (ID_{50}). The calculation of this dose-response relationship from published experimental data was accomplished using probit analysis, which is a standard method used to characterize the effects of dose within a population. The following section reports the results of probit analysis, including the ID_{50}, for the aerosol and intranasal inoculation of cattle, swine, and sheep with Foot-and-Mouth Disease virus (FMDv).

A6.1.2.1 Method

Choosing a Method for Characterizing the Dose-Response Relationship

Multiple methods could have been used to characterize the relationship between dose and response after exposure of cattle, swine, and small ruminants to FMDv. These methods include probit analysis, an exponential model, and a beta poisson model. Probit analysis involves transforming the response within a population so that the relationship between dose and response is characterized by a linear function as opposed to a sigmoid curve [Finney, 1952]. This analysis is data-driven and does not require the estimation of any parameters. The exponential model calculates the probability of at least one organism causing an infection, assuming that the organisms within the inoculum follow a poisson distribution. This model assumes all organisms have the same probability of causing an infection, defined by the parameter r [French et al., 2002; Teunis and Havelaar, 2000]. The beta poisson model has an additional dimension of analysis by using two parameters, α and β, which describe the variability in the probability of an organism causing an infection [French et al., 2002; Teunis and Havelaar, 2000].

Probit analysis was initially used to characterize the dose response, as it relies solely on experimental data rather than parameter estimations, and the resulting dose-response curves fit the data well, as demonstrated in Figure 1. The exponential and beta poisson model were also considered; however, the potential of these models to characterize the dose-response relationship of FMDv in cattle and sheep was previously studied by French et al. and was found to be unsatisfactory, particularly at low doses [French et al., 2002]. The exponential model that included viremia as a measure of response to FMDv exposure did not fit the data well and underestimated the probability of infection at low doses. Additionally, French et al. were unable to establish reasonable parameter estimates for the beta poisson model and concluded that this model was not suitable for characterizing the FMDv dose-response relationship [French et al., 2002]. The results of French et al., combined with the relative success of probit analysis to fit the data well, indicated that probit analysis was the best method by which to characterize the dose-response relationship for the Updated SSRA.

Characterizing the Dose-Response Relationship

The available literature was searched for any experimental data on the infectiousness of FMDv in cattle, swine, and sheep inoculated via aerosol (natural and artificial) or intranasally. Although goats are also included in this model, the majority of data available on the exposure of small ruminants to FMDv came from experiments in sheep rather than goats and so the probit slope and ID_{50} calculated for sheep were applied to all small ruminants. Data for each species and route of inoculation combination were analyzed separately because the susceptibility of animals to infection may vary considerably depending on the route of exposure. For this same reason, experimental data obtained from inoculation via any method other than the one being analyzed were excluded from analysis. For example, data from intradermolingual (tongue) inoculation, although numerous in the literature, were not used at all. Similarly, data from an aerosol exposure were not used for probit analysis of an intranasal exposure. Additionally, data could also only be included for analysis if the studies they were from reported both the amount of virus in each inoculum and the response within the population after exposure to a specified dose, because these two parameters (dose and response) are necessary for probit analysis. The dose had to be expressed in either plaque forming units (PFU) or a unit that could be converted to PFU. For example, doses expressed as a tissue culture infectious dose 50 ($TCID_{50}$) could be converted to PFU by multiplying by 0.7, because 1 $TCID_{50}$ is equivalent to 0.7 PFU [Burrows, 1966].

Other data were excluded from probit analysis, including data from animals examined before the first animal in the group developed markers of infection. This is because it was possible that those animals would have developed markers of infection, but were examined too early. Data from animals that developed markers of infection at the same time or after control animals were similarly excluded, as it is possible they developed a secondary infection rather than in response to the primary exposure. Additionally, data from aerosol exposures lasting more than 24 hours were excluded from analysis because it is unlikely that reasonable estimates of dose can be determined over such an extended period of time.

Before analyzing the data, the endpoint that would be the measure of infection was determined. The three most commonly reported endpoints after exposure to FMDv were seroconversion (the development of antibodies), viremia (the presence of virus in blood) and clinical symptoms (e.g. lesions). While clinical symptoms are a good indicator of successful infection, it has been demonstrated that some animals infected with FMDv may not develop lesions [Sutmoller et al., 1968]. Additionally, sheep are less likely than cattle to have lesions after infection with FMDv [Donaldson et al., 1970]. Basing the infectious dose on the presence of clinical symptoms would thus fail to capture these asymptomatic animals. However, because the model predicts the spread of FMDv throughout the population, all animals that can transmit the virus need to be accounted for, not just those displaying clinical symptoms, and so the presence of clinical symptoms was not used as the measure of infection. The measure of infection also needed to provide evidence that FMDv was actively replicating within the host (indicating the host is infectious) because this dose-response data feeds into the model of disease spread, and the disease spreads via infectious animals or contact with infectious animals. Thus seroconversion was eliminated as the marker of infection because animals may seroconvert without displaying evidence of virus replication and multiplication, such as viremia or isolation from oesophageal-pharyngeal fluid [Donaldson et al., 1987]. Additionally, antibodies may fail to be detected in animals which have viremia, indicating that animals which are potentially infectious may be not be accounted for if seroconversion is used as the measure of infection [Aggarwal et al., 2002; Donaldson et al., 1987]. Therefore, the remaining endpoint, viremia, was determined to be the best marker of successful infection, as it demonstrated active replication within the host and likely captured those animals that were infectious, yet didn't present with clinical symptoms.

For each species and route of exposure combination, the responses of the individual animals were paired with their respective doses and then sorted and grouped by dose. The groupings by dose were necessary because individual animals were either infected (100%) or not (0%), but probit analysis can only use responses between 0% and 100%, which requires multiple exposed animals. For example, if two out of four animals are infected by a dose of 100 PFU, as a population the response is 50%, whereas as individuals the response rate is 0% for two and 100% for the other two. In probit analysis, population responses which equal 0% or 100% are excluded because the theoretical sigmoid response curve never reaches 0% or 100%, but extends infinitely [Finney, 1952]. Dose groups were defined by one log intervals (e.g. 0-0.99 $\log_{10}$ PFU, 1-1.99 $\log_{10}$ PFU, etc.), and for each group the mean dose was determined. The number of viremic animals out of all exposed within each dose group was used to determine the percent response to that mean dose. Using the method described by Finney, the linear transformation of the dose response (probit) was plotted as a function of dose, so that the relationship between dose and dose response was linear as opposed to a sigmoid curve [Finney, 1952]. A linear best-fit line was then calculated, which gave the probit slope. The equation followed the formula

$$y = mx + b$$

where ‘y’ is the probit, ‘m’ is the probit slope, ‘x’ is the dose expressed as $\log_{10}$ PFU, and ‘b’ is the y-intercept. The ID_{50} was determined by solving the best-fit equation for the dose at which the probit was 5, because a probit of 5 is equivalent to a 50% response [Finney, 1952].

Method Exception: Intranasal Exposure in Swine

Only one study was identified with appropriate data on the intranasal infection of swine with FMDv; however, there were some difficulties with using this data that had to be addressed [Li et al., 2010]. The central issue was that each of the swine received the same dose of virus; however, probit analysis requires at least two different exposure doses because a linear best-fit line cannot be calculated from a single dose. The second issue was that the amount of virus in each inoculum was reported in ID_{50}, without detailing how the virus was titrated (e.g. in tissue culture, suckling mice, etc.) and so it was not clear how many PFU were in each ID_{50}. Finally, Li et al. reported the presence of fever or lesions, but not viremia, which was problematic because viremia was the marker of infection for probit analysis. Therefore, the probit analysis and ID_{50} determination for the intranasal infection of swine were performed using a method different than that used for the other exposures.

First, it was assumed that one ID_{50} was equivalent to one $TCID_{50}$ so that the dose in PFU could be calculated. This assumption was made because many of the studies performed with FMDv use $TCID_{50}$ as the dosage unit. Once the exposure dose was calculated, a new marker of infection had to be substituted for viremia. Because clinical symptoms alone are not a good marker for infection, the marker of infection for this study was the presence of clinical symptoms, fever or both. This method captured those animals that did not develop clinical symptoms, but still became ill, as characterized by fever.

Once the dose and marker of infection were identified, the issue remained that there was only one dose, and so a probit equation could not be calculated. Therefore, it was assumed that the swine intranasal probit slope was equal to the swine aerosol probit slope, which was determined using the method described previously. This was supported by the fact that in cattle, for which the data and sources were most numerous, the aerosol probit slope (0.33) was similar to the intranasal probit slope (0.55). The probit for the swine intranasal dose response was determined using Finney’s tables [Finney, 1952]. All that was then missing from the probit equation was the y-intercept, and because the probit (y), dose (x), and slope (m) were known, the y-intercept could be calculated. Once the y-intercept was calculated, the probit equation was complete. The ID_{50} was then calculated by solving for the probit equation when y = 5, identical to the ID_{50} calculation method for the other exposures.

A6.1.2.2 Results

Aerosol Exposure

Table 6 below lists for each species the calculated probit slope and ID_{50}. The probit graphs and complete equations specific to each species are reported in the following subsections.

Table 6: Probit Slope and ID_{50} for Cattle, Swine, and Sheep Exposed to FMDv via Aerosol

Animal	Probit Slope	ID_{50} (PFU)
Cattle	0.33	15
Swine	0.89	30,000
Sheep	0.72	3

Cattle

Data from 57 animals and 5 studies were compiled for probit analysis [Aggarwal et al., 2002; Burrows et al., 1981; Donaldson et al., 1987; Donaldson and Kitching, 1989; Sutmoller and McVicar, 1976]. The dose-response curve is shown in Figure 1, while the transformed probit and best-fit equation are displayed below in Figure 2. The probit slope is equal to 0.33 and the calculated ID_{50} is 15 PFU. This ID_{50} is supported by a report assessing the risk of an airborne outbreak of FMDv in Australia, which reported a calculated ID_{50} of 20 PFU, very similar to the results shown here [Garner and Cannon, 1995].

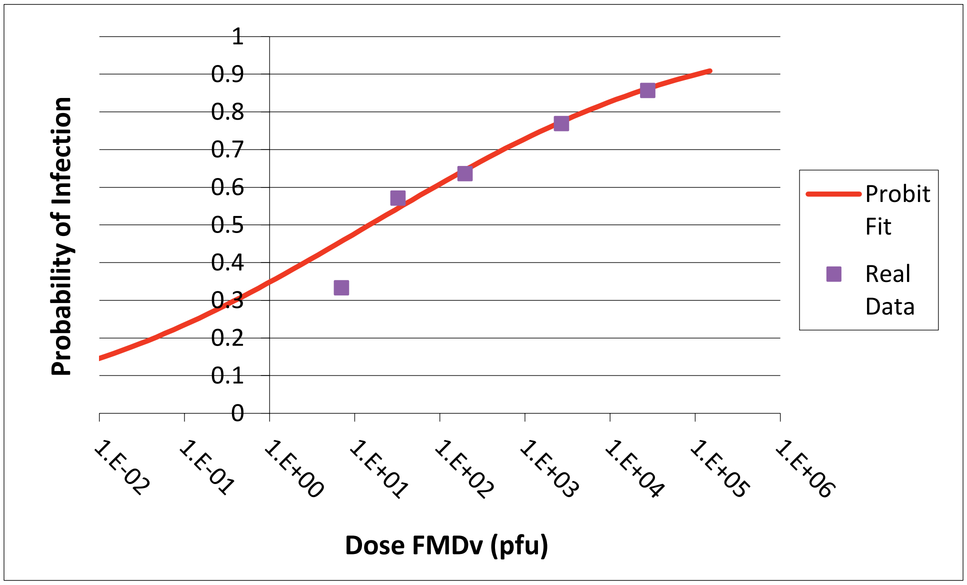


Figure 1: Dose-Response Curve Depicting Aerosol Infection of Cattle

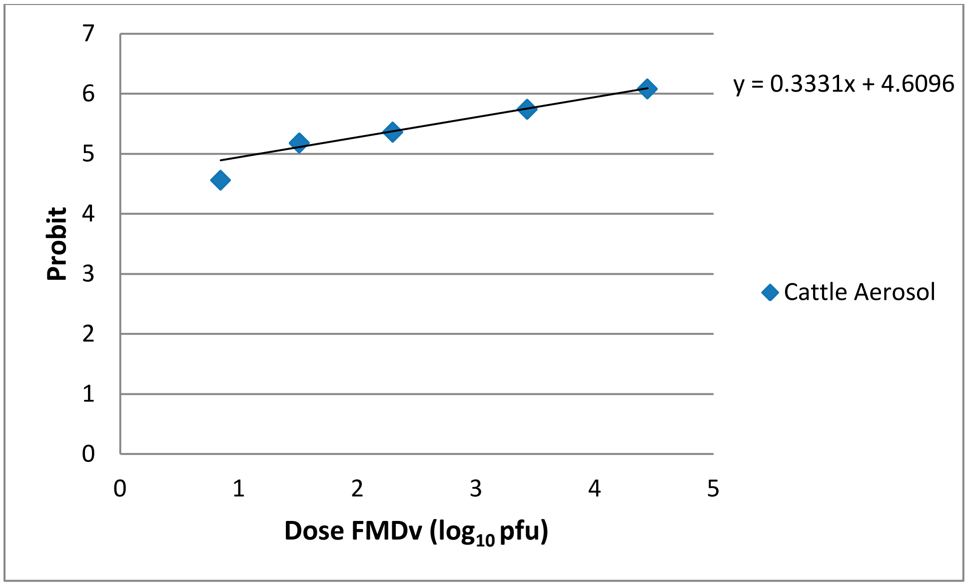


Figure 2: Probit Graph for Aerosol Infection of Cattle

Swine

Data from 51 animals and 3 studies were compiled for probit analysis [Aggarwal et al., 2002; Alexandersen et al., 2002; Alexandersen and Donaldson, 2002]. Despite the large number of animals exposed, only two animals were actually infected. This resulted in only two data points for probit analysis, both of which were less than a 15% response. Because responses towards the termini of the response range are statistically less reliable than responses in the middle (i.e., a response of 5% is less reliable than a response of 50%), there is more uncertainty surrounding the calculated probit slope and ID_{50} for an aerosol exposure in swine than that of cattle or sheep. However, all available data were used if possible, and Alexandersen and Donaldson established that swine are at least 60 times more resistant to FMDv infection via aerosol than cattle or sheep, and they admit that even that amount is likely an underestimate of swine's true resistance to aerosol infection [Alexandersen and Donaldson, 2002] . The transformed probit and best-fit equation are displayed below in Figure 3. The probit slope is equal to 0.89 and the calculated ID_{50} is 30,000 PFU.

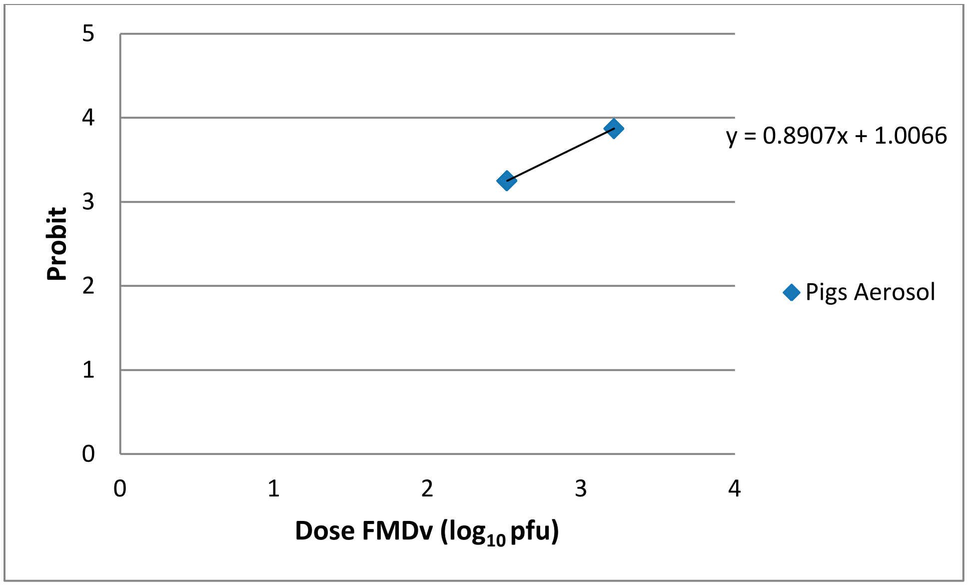


Figure 3: Probit Graph for Aerosol Infection of Swine

Sheep

Data from 32 animals and 3 studies were compiled for probit analysis [Aggarwal et al., 2002; Gibson and Donaldson, 1986; Gibson et al., 1984]. The transformed probit and best-fit equation are displayed below in Figure 4. The probit slope is equal to 0.72 and the calculated ID_{50} is 3 PFU. This ID_{50} is similar to that calculated in an Australian report, which estimated an ID_{50} of 11 PFU [Garner and Cannon, 1995].

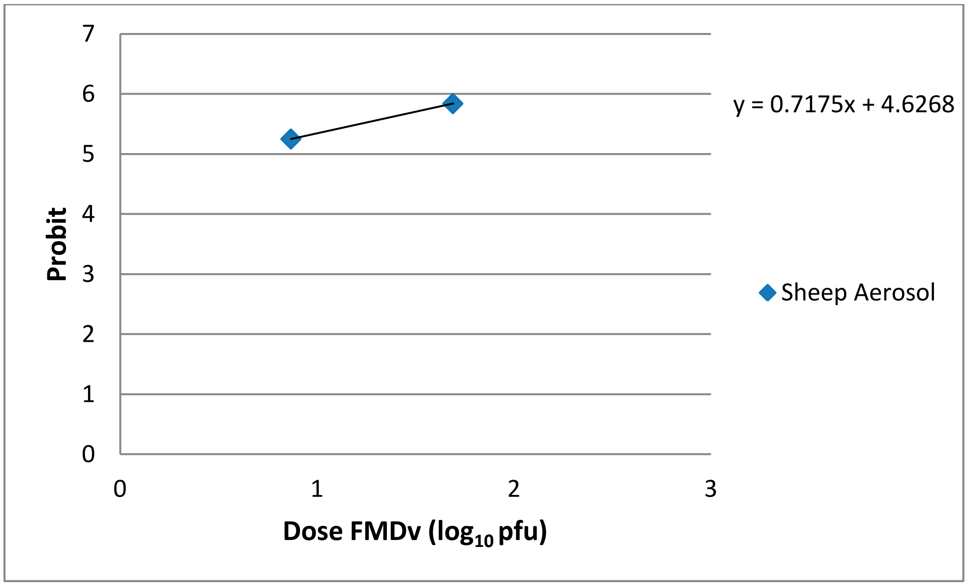


Figure 4: Probit Graph for Aerosol Infection of Sheep

Minimum Infectious Dose

The literature was reviewed for the minimum infectious doses that caused infection in cattle, swine, and sheep. Although minimum infectious dose data were collected from experiments, reviews, and models, ultimately only original experimental data were used to determine minimum infectious dose. While this may potentially overestimate the minimum infectious doses, as there may be lower doses that could cause infection if a large number of animals were exposed, it was more scientifically sound to report the minimum infectious doses based upon experimental data than conjecture. In addition, all minimum infectious doses reported in Table 7 are already low so it may be unlikely that the true minimum infectious doses are significantly lower than experimental evidence suggests. To determine these minimum infectious doses, all experimental data were compiled for each species, and the lowest dose resulting in infection, as measured by the presence of viremia, was determined to be the minimum infectious dose. Minimum infectious doses reported in $TCID_{50}$ were converted to PFU.

Table 7: Reported Minimum Infectious Doses for Cattle, Swine, and Sheep Exposed to FMDv

Animal	Minimum Infectious Dose (PFU)	Reference
Cattle	9	[Donaldson et al., 1987]
Swine	150	[Alexandersen et al., 2002])
Sheep	7	[Gibson and Donaldson, 1986]

Each of the minimum infectious doses was lower than the calculated ID_{50} for each species, with the exception of sheep. The sheep ID_{50} was calculated using probit analysis and equaled 3 PFU, while the lowest reported infectious dose in sheep is 7 PFU. This is an artifact of the probit analysis, as there were only two sheep exposed to doses less than 7 PFU, and neither became infected; however, six of eight (75%) of sheep exposed to doses between 7 and 10 PFU became infected [Gibson and Donaldson, 1986]. Therefore, while the lowest reported infectious dose is 7 PFU, the expected ID_{50} is actually less than 7 PFU, which accounts for the ID_{50} being greater than the minimum infectious dose.

Intranasal Exposure

Table 8 below lists for each species the calculated probit slope and ID_{50}. The probit graphs and complete equations specific to each species are reported in the following subsections.

Table 8: The Probit Slope and ID_{50} for Cattle, Swine, and Sheep Exposed Intranasally to FMDv

Animal	Probit Slope	ID_{50} (PFU)
Cattle	0.55	680
Swine	0.89	4,100
Sheep	1.8	9,200

Cattle

Data from 65 animals and 7 studies were compiled for probit analysis [Bouma et al., 2004; McVicar and Sutmoller, 1976; Orsel et al., 2007; Orsel et al., 2005; Sutmoller and McVicar, 1972; Sutmoller and

McVicar, 1976; Sutmoller et al., 1968]. The transformed probit and best-fit equation are displayed below in Figure 5. The probit slope is equal to 0.55 and the calculated ID_{50} is 680 PFU.

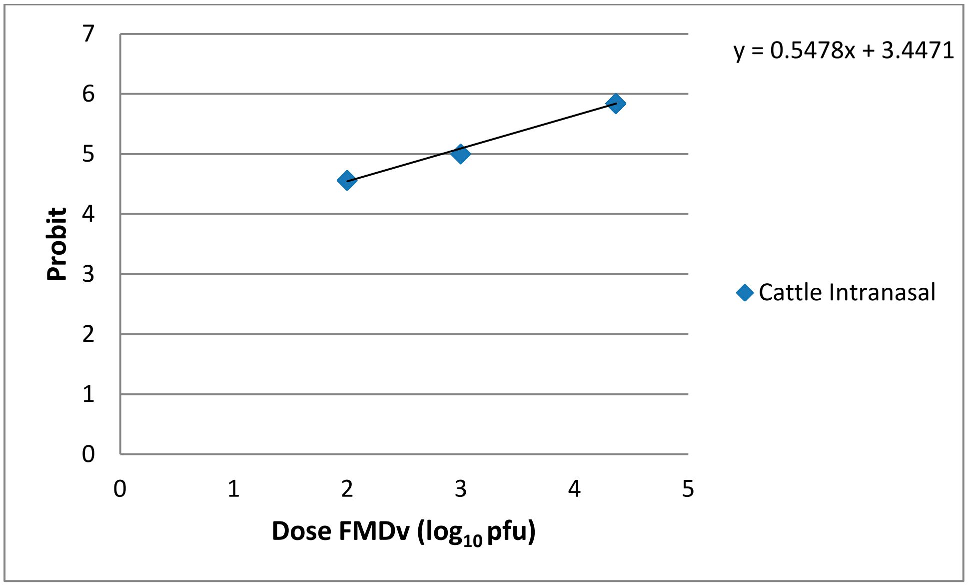


Figure 5: Probit Graph for Intranasal Infection of Cattle

Swine

Data from 12 animals and 1 study were used to calculate the ID_{50} [Li et al., 2010]. As explained in the methods section, Li et al. only investigated the response at one dose of FMDv, so a probit equation could not be calculated. It was therefore assumed that the swine intranasal probit slope is equal to the swine aerosol probit slope of 0.89. The calculated ID_{50} is 4,100 PFU.

Sheep

Data from 32 animals and 3 studies were compiled for probit analysis [Hughes et al., 2002a; Hughes et al., 2002b; McVicar and Sutmoller, 1972]. The transformed probit and best-fit equation are displayed below in Figure 6. The probit slope is equal to 1.8 and the calculated ID_{50} is 9,200 PFU.

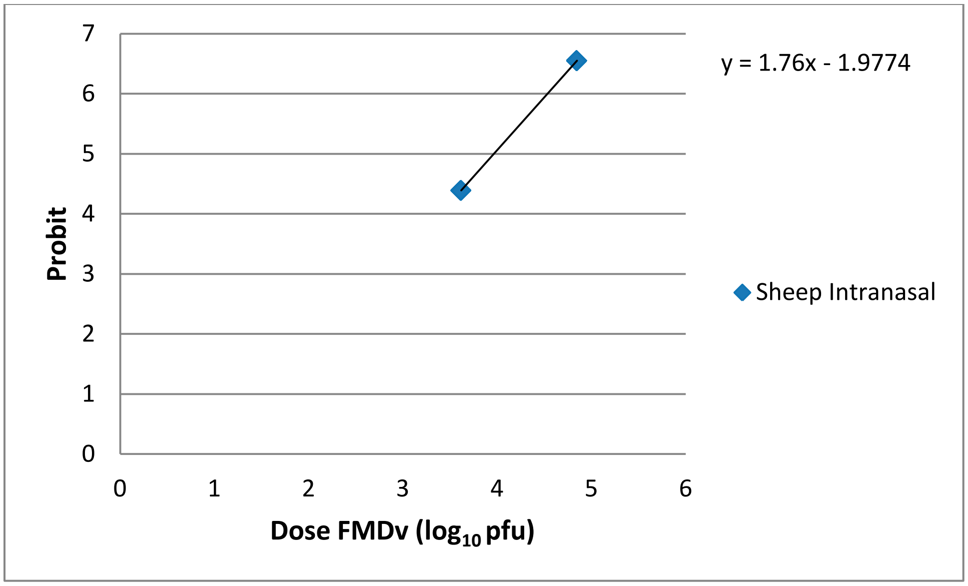


Figure 6: Probit Graph for Intranasal Infection in Sheep

A6.1.3 Oral Infection with FMDv

Very few studies have been published reporting the number of infections in ruminants or swine resulting from a controlled oral exposure to specific doses of FMDv, which made it difficult to ascertain an oral infectious dose. Determining the infectious dose was further complicated because most of the available studies were undertaken before or during the 1970s, so uncertainties or discrepancies within the studies could not be readily clarified. For example, in many of these studies it was unclear what dose of FMDv the animals were exposed to because the inocula were reported in ID_{50} units. Reporting dose as a function of ID_{50} is problematic because the PFU count in a single ID_{50} may change depending on how the ID_{50} was titrated. For example, Orsel et al. [2007] reported that one cattle ID_{50} is equivalent to 25 PFU, as determined by cattle tongue titration; however, in a similar study it was determined one cattle ID_{50} is equivalent to 6.5 PFU when titrated on lamb kidney cells or 4.5 PFU when titrated on pig kidney cells [Bouma et al., 2004]. Therefore, for inocula reported in ID_{50}, two distinct PFU doses were calculated by different methods. The first method assumes that an ID_{50} is equivalent to 25 PFU, as determined by titration on bovine tongue [Orsel et al., 2007]. The second methods assumes that an ID_{50} is a tissue culture infectious dose 50 ($TCID_{50}$), which is equivalent to 0.7 PFU. By calculating the PFU of the inocula by these two methods, a range of uncertainty was defined around the individual doses in an effort to capture the true PFU dose somewhere within this range. These results are summarized in Table 9, and more detailed methods and results are in the following sections. Overall, for all animals that a range of oral infectious doses could be estimated, the lower estimate of the oral infectious dose was greater than the ID_{50} for an intranasal exposure (Table 8). Therefore, of the two modes of infection, intranasal inoculation will be the more likely fomite scenario, as it requires less virus to cause infection. Intranasal inoculation will thus be modeled instead of oral inoculation.

Table 9: Infectious Doses for Cattle, Swine, and Sheep Exposed Orally to FMDv

Animal	Lower Estimate (PFU)	Higher Estimate (PFU)
Cattle	440,000	160,000,000
Swine	5,600	79,000,000
Sheep	NA*	NA

***NA not available.**

A6.1.3.1 Cattle

The only published study describing the infectious oral dose for cattle was that of Henderson and Brooksby [Henderson and Brooksby, 1948]. However, they did not report the dose used to infect the cattle, nor did they identify how many cattle were infected, merely stating that they "found it difficult to infect cattle by feeding virus in glass capillary tubes" [Henderson and Brooksby, 1948]. Both Sellers and Donaldson later cited this paper in their own reviews and reported that the cattle in Henderson and Brooksby's study were inoculated with $10^{6.5}$ ID_{50} and none became infected [Donaldson, 1986; Sellers, 1971]; however, it is unclear how they determined both the dose and number of animals infected from the original study, and so this information was excluded from the present assessment. Within those same reviews, Sellers and Donaldson reported that results from an experiment by Burrows demonstrated that some cattle (<50%) were infected by oral doses of $10^{5.8}$-$10^{6.8}$ ID_{50} of FMDv [Donaldson, 1986; Sellers, 1971]. Although the Burrows results were cited as unpublished, and therefore could not be verified, it was the only experimental oral infectious dose reported for cattle identified in the literature, other than the Henderson and Brooksby study, and so it was used to estimate an oral infectious dose for cattle.

As mentioned previously, the use of ID_{50} to quantify the inocula is problematic. Therefore, to best estimate the range of possible oral infective doses for cattle, the infectious dose was calculated in two ways. Assuming an ID_{50} is equivalent to 25 PFU results in a low-end cattle oral infectious dose of $10^{7.2}$ PFU and a high-end dose of $10^{8.2}$ PFU. Alternatively, assuming an ID_{50} is equivalent to 0.7 PFU equates to a low-end cattle oral infectious dose of $10^{5.6}$ PFU and a high-end dose of $10^{6.6}$ PFU. Together, the overall range of a cattle infectious dose is $10^{5.6}$-$10^{8.2}$, or 440,000-160,000,000, PFU.

A6.1.3.2 Swine

Although the data on oral infectious doses for swine are limited overall, there are more studies published for swine than for cattle. Data were collected from both experimental data [de Leeuw et al., 1978; Terpstra, 1972] and reviews [Donaldson, 1986; Sellers, 1971]. The lowest reported dose to cause infection was $10^{3.9}$ ID_{50} [Donaldson, 1986; Sellers, 1971]; however, there is some ambiguity surrounding the dose PFU content because the dose was expressed in terms of ID_{50}. Assuming an ID_{50} is equivalent to 0.7 PFU, the lowest infectious dose was $10^{3.7}$ PFU, while assuming it is equal to 25 PFU results in an infectious dose of $10^{5.3}$ PFU. The greatest dose to result in infection was $10^{7.9}$ mouse ID_{50} (Terpstra, 1972). Assuming that one mouse ID_{50} is equivalent to approximately one PFU (Richmond, 1971), the greatest tested oral dose resulting in infection is $10^{7.9}$ PFU. Together, the overall range for an oral infectious dose in swine is $10^{3.7}$-$10^{7.9}$, or 5,600-79,000,000, PFU.

A6.1.3.3 Sheep

There were no studies or experiments identified reporting an oral infectious dose in sheep.

A6.2 NAADSM Parameter Development and Data Collection Supplementary Material

The data in this Appendix Section are organized in the order in which they are first referenced in the main report. Subsections may describe data collection, details of parameter development or analysis of parameters or datasets produced for the Updated SSRA. This Appendix is not meant to stand alone, and makes the most sense when used as a reference for the main epidemiological modeling chapter.

A6.2.1 Subject Matter Experts (SMEs) Consulted for Parameter Development

USDA Parameters SMEs

Dr. Mike Sanderson, Kansas State University
Dr. Kim Forde-Folle, Centers for Epidemiology and Animal Health, USDA

NAADSM SMEs

Aaron Reeves, Colorado State University
Neil Harvey, University of Guelph
Dr. Mo Salman, Colorado State University
Dr. Sangeeta Rao, Colorado State University

Backyard Facilities SMEs

Greg McClure, Riley County Extension Agent
John Forshee, River Valley District, District Director
Robin Slattery, Washington County Livestock Specialist
Glenn Brunkow, Pottawatomie County Extension Agent
Michael Vogt, Marshall County Extension Agent

Animal Movement and Location SMEs

Marysville Livestock, Inc. - Marysville, Kansas
Washington Livestock Market - Washington, Kansas
Herington Livestock Market - Herington, Kansas
Rezac Livestock Commission Company - St. Marys, Kansas
J.C. Livestock Sales - Junction City, Kansas
Clay Center Livestock Market - Clay Center, Kansas
Manhattan Commission Co. - Manhattan, Kansas
Nancy Robinson, Livestock Marketing Association
George Blush, Dairy Program Manager, Kansas Department of Agriculture
Matt Teagarden, Kansas Livestock Association
Tim Stroda, Kansas Pork Association
Julie Ehler, Program Manager Kansas Department of Agriculture

Terry Medley, Chief of the Livestock Waste Management Section for KDHE

Detection SMEs

SES, Inc. SMEs
Jim Carroll, Vice President, Quality Assurance and Regulatory Affairs for Fluid Milk, Dairy Farmers of America
Dr. Elizabeth Walker, Professor, Missouri State University
George Pat Badley, DVM, Arkansas State Veterinarian
Survey of Kansas Veterinary Medical Association Large Animals and Mixed Practice Veterinarians
Dr. Royce Wilson, USDA
Dr. Larry Forgey, Missouri State Field Veterinarian
Dr. Dane Henry, USDA

Destruction of Animals SMEs

Dr. William Brown, Kansas Animal Health Commissioner
Karen Domer, Kansas Administrative Specialist
Dr. Taylor Woods, Missouri State Veterinarian
Dr. Randy Wheeler, Iowa Assistant State Veterinarian
Mikki Nienhueser, Nebraska Animal Emergency Coordinator
Rodney White, National Veterinary Stockpile
Dr. Lee Meyers, National Veterinary Stockpile
Thomas M. Cunningham (APHIS), NAHERC
Steve Dalton, 3D contactor
QC Supply
Brunzl
Dr. Sam Graham, Retired Kansas District Veterinarian
Dr. Steve Van Wie
Jeffery Hill, Livestock Welfare Specialist, Alberta Agriculture and Rural Development

Movement Control SMEs

SES, Inc. SMEs
Sandy Johnson, Kansas Emergency Management Coordinator
Karen Domer, Kansas Animal Health Planner
Dr. Taylor Woods, Missouri State Veterinarian
Dr. Randy Wheeler, Iowa Asst. State Veterinarian
Mikki Nienhueser, Nebraska Animal Emergency Coordinator

State Specific Parameters SMEs

Iowa Pork Producers (name withheld by request of interviewee)
Curt Rush, President, Iowa Meat Goat Association
Dr. Randy Wheeler, Iowa Assistant State Veterinarian
George Pat Badley, Arkansas State Veterinarian

Don Nikodim, Missouri Pork Producers Council
Jeff Windett, Missouri Cattlemen's Association
Jim Carroll, Vice President Quality Assurance and Regulatory Affairs for Fluid Milk, Dairy Farmers of America.

Wildlife SMEs

Shane Hesting and Lloyd Fox, Kansas Department of Wildlife and Parks
Dr. Dale Garner, Iowa Department of Natural Resources
Scott Taylor, Nebraska Game and Parks Commission's Wildlife Division

A6.2.1.1 General NAADSM Setup

Number of Iterations

In NAADSM, hundreds of user-defined parameters, many defined as ranges or distributions, dictate the course of a disease outbreak for a scenario. Parameters, such as the distance an animal travels between farms when it is sold, cannot be defined as a single point value because a single point does not represent the true range of values. The model samples from each distribution to select different parameter values for each iteration. Given this variability in inputs, the model must be run repeatedly to capture the range of possible outbreak courses. The number of iterations of each NAADSM scenario necessary to adequately capture the uncertainty was determined experimentally.

A suite of five premises was chosen near the NBAF that represented the major production types used in the model. These premises included large feedlots, small swine operations, cow-calf operations, and dairies, representing the range of sizes and producer behaviors of facilities near the NBAF. Moreover, more than 80% of outbreak starting locations due to modeled release events occurred in facilities of these types used in this analysis. An outbreak was modeled starting at each location and the model was run with 100, 500, and 1,000 iterations. The p5, p95, and p75 iteration outputs for "duration" and "total head culled" were compared to the p50 outputs to obtain an understanding of how the number of iterations affected the smallest and greatest outputs relative to the median (Figure 7). This analysis seeks to understand the relationship between the median and the extreme cases considered in the analysis to determine if this relationship changes significantly as a function of the number of iterations performed. The results were remarkably similar across runs with varying iterations. That being said, runs with 100 iterations predict a greater difference between the smallest (p5) and the median output cases. For large cases, runs with 100 iterations predict a slightly smaller difference between the most extreme cases (p95) and the median but predict a larger difference between the p75 and median output. For this reason, 100 iterations were considered adequate to represent the uncertainty inherent in the NAADSM model for the dataset used in this study; moreover, the information presented above suggests that outputs would be similar if more than 100 iterations were performed.

The relatively small size of the p95 outputs compared to the median reflects a difference in the median outputs across model runs with varying iterations. Directly comparing the median output of runs with 100, 500, and 1,000 iterations showed a larger percentage difference in the median output than in the p95, which were usually within 1%. For this reason, runs with 100 iterations would not underestimate the largest plausible epidemiological outputs.

Even though 100 iterations were considered adequate, in the Updated SSRA, **200 iterations were used** for almost all model runs because the computational power was available. Moreover, most release events involved many model runs (up to 400) of 200 iterations each that represent the various possible starting locations. In this way, many release pathways are described by several thousand NAADSM iterations.

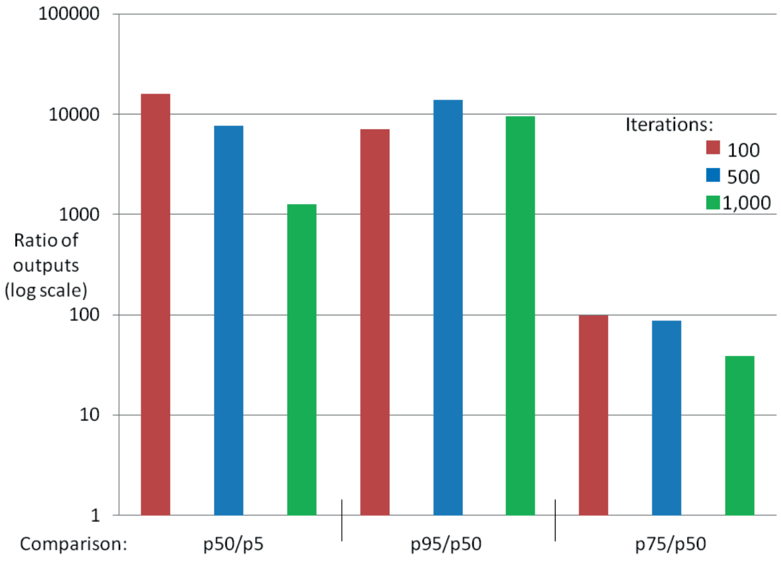


Figure 7: Average Ratio of Median Output to p5, p75, and p95 Results for Head Culled across Modeling Runs with Five Different Starting Locations

Runs with 100 iterations (red), 500 iterations (blue), and 1,000 iterations (green) are shown.

Random Number Generator Seed

A random number generator was used to generate the seed for Updated SSRA modeling, as directed by the NAADSM user's guide:

"In the box labeled Random number generator seed, make sure that the option Generate seed automatically is selected."[Hill and Reeves, 2006]

A6.2.1.2 Kansas Wildlife Data Collection

Although wildlife parameters were not developed, several species of wildlife were identified that could impact a FMD outbreak in Kansas.

Elk

Elk were not considered a substantial concern in Kansas because of their small number. Free-ranging elk herds were introduced into the wild at only two sites in Kansas, with total numbers estimated at less than 200 [Conrad et al., 2006].There are approximately 100 elk in the Fort Riley, Kansas, area [Fox, 2011]. Additional elk sightings are reported around the state; however, most are limited to the occasional sighting of a single or pair of animals [Conrad et al., 2006].

Pronghorn

Pronghorn are also likely to have a minor impact on a FMD outbreak in Kansas. There are estimated to be 50-60 pronghorn in central Kansas, primarily around the Emporia area, about 70 miles south of Manhattan, Kansas. An additional 1,000 pronghorn are estimated to inhabit western Kansas (Manhattan is in the eastern portion of Kansas) [Fox, 2011].

Feral Swine

There are currently less than 500 feral swine in the state of Kansas [Johnson, 2011a; Johnson, 2011b]. Feral swine transportation, release, and sport hunting are prohibited in Kansas. The Wildlife Services Feral Swine Control Program monitors and controls emerging populations and twelve known populations across the state (Figure 8). Several of these populations are replenished by movement of feral swine across state borders from Missouri and Oklahoma and are unlikely to be eradicated. Another persistent population is the result of illegal introduction of feral swine by a group of private landowners and is also unlikely to be eradicated. Most feral swine populations are more than 100 miles away from the NBAF. The closest population is east of Topeka, Kansas, around 75 miles away [Johnson, 2011a; Johnson, 2011b].

Figure 8: Locations of Feral Swine Populations in Kansas (green) and Approximate Location of Manhattan, Kansas, NBAF Site (red star)

Deer

Deer are the most abundant FMD-susceptible wildlife population in Kansas. Kansas is divided into 19 deer management units that are monitored for deer density. Deer density data are expressed as deer per square mile per deer management unit [Fox, 2005]. Two surveys reported deer population in Kansas. The first survey was conducted by the Docking Institute of Public Affairs; their estimates of deer densities were derived from the average number of deer reported on private properties through telephone surveys (rather than an established method of deer sighting) [Zollinger, 2004; Zollinger, 2010; Zollinger and Wheeler, 2007]. The Kansas Department of Wildlife and Parks also collects data on deer densities. Both surveys present data as deer density per deer management unit [Parks, 2010]. Deer management units are vast and do not coincide with county borders, making the mapping of these units difficult. Additionally, the deer densities within these units do not discriminate between rural and urban areas or agricultural land and forests. High densities of deer may occur in specific small areas, while other areas may be devoid of deer [Parks, 2010]. Data were also available from a limited number of deer check stations, and deer-related vehicle accident data [Parks, 2010]. Based on these data, the density of deer in the two deer management units near the NBAF is 5 to 14 deer per square mile [Fox, 2011]. While these data may be sufficient to develop crude parameters to incorporate deer into an FMD model, no one has developed a method that enables NAADSM to model wildlife yet.

A6.2.2 Backyard and Small Scale (BY-SS) Producer Interviews and Data

A6.2.2.1 Interview

In 2011, BY-SS production types were developed from interviews conducted with 29 producers at state fairs in Kansas and interviews with county extension agents and SMEs. Exhibitors and fair attendees were interviewed so that the dataset would not be biased toward small producers raising animals for show; nevertheless, interviews with SMEs indicated that a large proportion of Kansas backyard producers would be raising animals for show or 4H projects.

A standard interview was given to producers, which included the following questions:

- How many animals of the following production types do you have on your farm?
    - Beef Cattle
    - Dairy Cattle
    - Swine
    - Small Ruminants (Sheep and Goats)
- Species contact on a multispecies farm (Answered the following series of questions for each species on their farm)
    - What percentage of animals has free direct contact with an animal(s) of another species on site?
    - For those animals that do not directly contact other species freely, how often would direct contact occur?
    - Do you use the same equipment to handle/interact with multiple species?
        - Do you wash your equipment betweenuse with different species?
        - How often do you use this equipment with multiple species?
    - How often do you visit one species of animal and then a second species of animal without taking a break or taking decontamination steps?
- Animal purchase (for each species)
    - How many different farms/vendors to you purchase animals from each year?
        - Describe the farm/vendor (i.e., cow-calf, sales barn)
            - If purchased through sales barn, do you know what type of farm was selling?
        - How many animals do you purchase at a time?
        - How close is the point of purchase from your farm?
    - Were animals mixed with other animals during transportation from point-of-purchase to farmstead?
- Animal sale (for each species)
    - Do you keep any animals on your farm that will not be sold to any other facility (i.e., pet, brush control, direct to slaughter)?
    - Do you sell animals to be raised elsewhere?

    - Do you show animals?
    - Do you sell the animals' by-products (i.e., wool, milk)?
- How many times per year, if any, would you move your cattle from your farm to another site and then bring the animal back to your farm?
    - Which destinations are the animals transported to?
- Do your animals come into contact with any persons other than yourself during the year?
    - How often do they come into contact with each person?
- How often do you inspect your animals each week?
    - Which of your animals do you inspect?
    - Would you recognize the symptoms of FMD in your animals?
        - What would your response be to symptoms of FMD?

Results and Discussion

Interviews were conducted with 29 producers at 5 Kansas county fairs; 24 of these producers qualified as small-scale producers (they had 10 or fewer animals of each species on site). The remaining 5 interviewees had between 11-50 animals on site. Survey responses from these farmers were indistinguishable from the small-scale producer responses.

Sixty-nine percent of backyard and small-scale producers owned cattle, with an average herd size of 8.9 head. 38% owned small ruminants, with an average herd size of 5.4 head. 38% owned swine, with an average herd size of 6.45 head. 52% (15 of 29) of the production sites had more than one species on site.

Direct Contact

All producers interviewed answered questions relating to direct contact rates. Interviews showed that production types on single-species backyard or small-scale farms never came into contact with other species on the farm. Most production types in multi-species farms (17 of 19; 89%) had daily contact with other species on the farm, as shown in Table 10 .

Most producers (78.9%) purchased livestock from breeders or single-species operations. Other livestock were raised by the producers or purchased from other sources, such as dairy farms and private individuals. Purchase locations are presented in Table 11. Producers also provided estimated distances the purchase locations. The median travel distance for any production type was 42.5 miles (Swine median travel distance: 50 mi; Cattle median travel distance: 25 mi; Small Ruminant median travel distance: 41 mi).

Most swine producers (80%) and small ruminant producers (67%) did not sell these production types. The swine and small ruminants were used as pets, show animals for county fairs and/or direct slaughter.

The destinations of sold animals included other backyard or small-scale farms, small ruminant production sites and feedlots, as detailed in Table 13.

Producers sold to feedlots through sales barns. Movement with return to the farm, such as the movement to the county fairs, is discussed below. Producers also provided estimated distances of facilities that bought their livestock. The median travel distance for any production type was 40 miles (Swine median travel distance: 42.5 mi; Cattle median travel distance: 25 mi; Small Ruminant median travel distance: 62.5 mi).

Backyard and small-scale farm livestock could make direct contact with other livestock when being transported for a short time to another site and returning to the farm. Producers were asked about the frequency of visits to fairs and shows, veterinarians, rodeos, insemination and other farms for brush suppression. Two producers transported cattle or small ruminants for insemination; two transported cattle for hoof trimming; no producers reported rodeo transportation. Table 15 presents livestock movement to and from fairs or shows and veterinarians.

Table 10: Species that Come into Contact with Other Species on Farm (Percentage)

	Production Type		
Frequency of Direct Contact with Other Species	Cattle	Swine	Small Ruminants
Daily	40%	18%	54%
Every Six Weeks	5%	9%	0%
Never	55%	72%	46%

Table 11: Obtaining Livestock: Percent of Producers of Each Production Type

Source	Cattle	Swine	Small Ruminants
Producer Raises	18.75%	10.00%	0.00%
Breeder	18.75%	50.00%	50.00%
Cow Calf	50.00%	0.00%	0.00%
Swine Operation	0.00%	40.00%	0.00%
Small Ruminant Operation	0.00%	0.00%	33.30%
Other	12.50%	0.00%	16.70%

Table 12: Transportation when Purchased: Percent Contact with Other Species

Production Type Purchased	Mixed with other species during transportation	Unmixed
Cattle	14%	86%
Swine	11%	89%
Small Ruminants	55%	45%

Table 13: Selling Livestock: Percent of Producers of Each Production Type

	Production Type		
Destination	Cattle	Swine	Small Ruminants
Feedlot	55%	0%	0%
Backyard Farm	25%	10%	0%
Small Ruminant Operation	0%	0%	33%
Other	5%	10%	8%
Not Sold	25%	80%	67%

Table 14: Transportation when Sold: Percent Contact with Other Species

Production Type Sold	Mixed with other species during transportation	Unmixed
Cattle	15%	85%
Swine	80%	20%
Small Ruminants	60%	40%

Table 15: Moving Livestock from and Returning to the Farm: Median Times per Year

	Production Type		
Destination	Cattle	Swine	Small Ruminants
Show/Fair	1	2.5	3
Veterinarian	1	1	1

Indirect Contact

One producer had stopped responding before indirect contact data could be collected. Also, the number of producers answering these interview questions fluctuated (from 28 to 12). Indirect contact questions included contact with people other than the producer, the producer, and equipment. Most producers reported no livestock contact with people other than themselves, but most reported daily handling of more than one species.

Table 16: Indirect Contact: Median Contacts per Year			
Contact	Cattle	Swine	Small Ruminants
Veterinarian	1	1	1
Feed/Feed Truck Deliveries	0	0	0
Milk Truck Pick ups	0	0	0
Salesmen	0	0	0
A.I. Technicians	0	0	0
Hoof Trimmers	0	0	0
Employee/Contractor	0	0	0
Neighbors	11	142.5	0
Commercial Haulers	0	0	0

Table 17: Producer Contact with Two Different Species Consecutively: Percentage of Multi Species Farm Producers	
Frequency	Multi-species farm producers
Once per Week	3.6%
Once to Twice per Day	75.0%
Several Times per Day	7.1%

Table 18: Use of the Same Equipment for Different Species: Percentage of Producers of Each Production Type			
Frequency	Cattle	Swine	Small Ruminants
Once per Year	5.8%	0%	9.0%
A Few Times per Year	5.8%	10.0%	2.7%
Once per Week	0%	0%	9.0%
Daily	5.8%	0%	18.0%
*Columns do not add to 100% because many producers did not respond			

Producer Surveillance of Livestock

Twenty-eight (of 29; 97%) producers reported frequency of observation, shown in Table 19. Three producers (10%) reported an increase in observation according to season. Table 19 reflects the lowest frequency for each producer.

Five (of 29; 17%) producers were able to identify FMD. An additional three were somewhat able to identify FMD or had close relations who could.

Table 19: Frequency of Observation: Percentage of Producers of Each Production Type

Frequency of Observation	Cattle	Swine	Small Ruminants
Several Times per Week	15%	9%	0%
Once to Twice per Day	70%	55%	67%
Several Times per Day	15%	36%	33%

Producer Reporting (Contacting Veterinarians for Ill Animals)

Twenty-seven (of 29; 93%) producers described whether they contact a veterinarian regarding livestock health. 100% of these producers reported that they always contact a veterinarian after observing that an animal is sick. One producer was a veterinarian and therefore treats his own animals.

A6.2.3 Producer Interviews for All Private Facilities within 6.2 Miles of the NBAF

Precise data were collected on all animal populations within a 6.2-mile radius of the NBAF site, including the location (lat and lon), herd size, and production type of every herd in the region. Herds identified for the Updated SSRA were confirmed and additional herds were identified through interviews and by driving around the entire area and looking for animals.

A6.2.3.1 Interview

Producers and Kansas State University (K-State) officials were interviewed to collect the following information for each herd identified:

- Current herd location (GIS coordinates collected by interviewer)
- Herd size
- Seasonality of herd (how many animals are typically on site in each of the four seasons)
- Production type (feedlot, cow-calf, dairy, etc.)
- Are there plans to relocate/downsize the herd when the NBAF opens? If so, if possible, obtain the new location and new size.
- Where animals are typically sold? (Are they sold through a market? To a single producer through a direct arrangement? If so, where is that producer located?)
- What biosecurity procedures are currently in place at this location?
- How often are animals observed? In what level of detail?
- Can observers identify critical conditions and do they know how to report them?

- What does a producer do when an animal becomes sick?

A6.2.3.2 Results

Eleven producers were identified in Pottawatomie County and 34 producers were identified in Riley County within a 6.2-mile radius of the NBAF, some producers house multiple production types or had multiple herds at different sites (Table 20). An additional four pastures were identified that could potentially be used for livestock grazing, but the owners of these properties could not be contacted and their use could not be determined. Twenty-eight producers agreed to interviews (62%).. Only one active swine operation was identified in the area and only one dairy with two cows was identified. The majority of livestock operations were cow-calf beef operations, with a few backgrounder operations. There are no true feedlots in this area. This survey probably accounted for between 75% and 90% of privately held livestock in this area. No producers were planning to change production practices or relocate as a result of the NBAF's presence.

Table 20: Summary of Species and Number of Head on Private Farms

Production Type	Head of Animals
Cow Calf	11
Cow Calf	24
Cow Calf	180
Feedlot(L)	2
Cow Calf	72
Cow Calf	71
Cow Calf	17
Cow Calf	50
Cow Calf	130
Cow Calf	175
Swine(S)	100
Swine(S)	100
Feedlot(S)	11
Swine(BY SS)	9
Sheep	8
Goats	15
Cow Calf	21
Cow Calf	79
Cow Calf	75
Cow Calf	45
Cow Calf	280
Cow Calf	136
Cow Calf	40
Cow Calf	30
Cow Calf	36
Cow Calf	104

Table 20: Summary of Species and Number of Head on Private Farms

Production Type	Head of Animals
Cow Calf	20
Cow Calf	30
Cow Calf	110
Cow Calf	8
Goats	40
Goats	3
Goats	3
Cow Calf	7
Cow Calf	9
Cow Calf	11
Dairy	2
Beef(BY SS)	5
Cow Calf	30
Cow Calf	448
Cow Calf	449
Cow Calf	250
Cow Calf	45
Cow Calf	725
Feedlot(S)	350
Cow Calf	1
Cow Calf	230
Beef(BY SS)	10
Cow Calf	4
Cow Calf	1000
Cow Calf	265
Cow Calf	500

Direct Contact

The degree of specificity provided when describing the source and destination of livestock varied by producer. About half of the producers interviewed (19 of 31; 61%) identified the source of their livestock, usually by city name(s) or specifying that they raised calves to replace cattle. Most of the producers (26 of 31; 84%) identified the destination of the livestock and did so with more specificity than identification of source. The destinations were described by city, county or state names, locker plant, sale barn, or retained by the producer. The producers rarely could provide information about where the livestock travelled after being sold at a sale barn. Table 21, therefore, gives the location of livestock immediately before or after residence on the interviewee’s farm. Columns do not sum to 100% because producers may obtain or sell livestock to multiple other facilities. A “destination of livestock” entry corresponding to “producer” indicates that the producer raises the livestock for slaughter.

Table 21: Obtaining and Selling Livestock: Percent of Producers Who were Interviewed and Provided Data

	Cattle		Swine	
	Source of Livestock	Destination of Livestock	Source of Livestock	Destination of Livestock
Producer	72.2%	44.0%	50.0%	0%
Same/Nearby County	33.3%	68.0%	50.0%	0%
Kansas	22.2%	28.0%	0%	
Out of State	16.6%	20.0%	0%	100.0%
Slaughter	0%	12.0%	0%	50.0%

Producer Surveillance of Livestock

All producers interviewed reported frequency of observation, shown in Table 22. Eleven producers (of 31; 35%), mostly cow-calf facility operators, reported that the frequency of observation increases to daily during calving season or winter. The data recorded in Table 22 reflects the lowest frequencies for each producer.

Producers also reported symptoms they routinely looked for. The most common included livestock neglecting feed, lameness, standing alone, drooping ears, and pink eye. According to FADD interviews, cattle with FMD would display some of these symptoms. Producers looked for the same symptoms in cattle and small ruminants. The single swine producer checked for coughing or wheezing.

Table 22: Frequency of Observation: Percent of Production Type Producers

	Cow-Calf	Other Cattle	Swine
Twice a Month	8.0%	0%	0%
Weekly	56.0%	50.0%	0%
Several Times/Week	16.0%	16.7%	0%
Daily	20.0%	16.7%	0%
Twice Daily	0%	16.7%	100.0%

Producer Reporting (Contacting Veterinarians for Ill Animals)

All producers interviewed described when they contact a veterinarian regarding livestock health, shown in Table 23. Most producers vaccinated their livestock and treated minor illnesses, calling a veterinarian for more serious or unrecognized illnesses. Some used veterinarians for all animal care while others only resorted to veterinarians after widespread illness or livestock death.

Table 23: Frequency of Reporting: Percent of Production Type Producers

	Cattle	Swine
Producer is a veterinarian	6.70%	0%
Veterinarian called for all animal care	23.30%	0%
Veterinarian called for ill animals	53.30%	0%
Veterinarian called for large number of ill animals	3.30%	100.00%
Veterinarian called after animals die	13.30%	0%

Biosecurity

All producers interviewed described the extent of their biosecurity measures, shown in Table 24. Biosecurity measures varied very little and tended to be security measures. Producers reported no biosecurity, visual, or hearsay observation of people entering the production site or more formal biosecurity measures such as gates or registering hunters, fishermen, or visitors.

Table 24: Biosecurity

	Cattle	Swine
No biosecurity	43.30%	0%
Observes people entering the site	33.30%	0%
Formal biosecurity measures	23.30%	100.00%

A6.2.4 Kansas State University Data Collection

Kansas State University (K-State) faculty and staff were interviewed to collect data on all university animal populations (Table 25). Location data were collected for all thirteen campus affiliated facilities housing livestock. K-State does not plan to relocate any of their operations when the NBAF opens [Odde, 2011].

Table 25: Summary of Species and Number of Head Located at Each K State Facility

Facility name	Production Type Assigned	Head of Animal Assigned	Species
Veterinary Hospital	Beef (BY-SS)	88	bovine
	Swine(BY-SS)	3	swine
	SmRu(BY-SS)	8	goat/sheep
K State Dairy Unit	Dairy	500	bovine
K State Stocker Unit	Cow-Calf	720	bovine
K State Feedlot Unit	Feedlot(L)	1400	bovine
K State Purebred Unit	Feedlot(S)	100	bovine
K State Cow Calf Unit Location 1	Cow-Calf	416	bovine
K State Cow Calf Unit Location 2	Cow-Calf	416	bovine
K State Sheep and Goat Unit	Sheep	130	sheep
	Goats	238	goats
K State Swine Unit	Swine(L)	1507	swine
K State Early Weaning Unit	Swine(L)	400	swine
Reynolds Ranch Location 1	Cow-Calf	448	bovine
Reynolds Ranch Location 2	Cow-Calf	449	bovine
Kansas Artificial Breeding Service Unit (KABSU)	Cow-Calf	17	bovine
Large Animal Research Facility (LARF)	Beef (BY-SS)	25	bovine
	Swine(BY-SS)	25	swine

Veterinary Hospital

K-State Veterinary Hospital provided data on the number of animals of each species admitted to their facility over the course of one week, and the zip codes from which animals originated. This dataset is FOUO and cannot be provided in this report. The data were used to estimate the number of animals of each species to be placed at the veterinary hospital in the NAADSM model. In the 2010 SSRA, the K-State Veterinary Hospital was included in the animal population dataset, but this was not specifically stated in the write-up. The Updated SSRA improves on the treatment of this facility by including an evidence based population, but the dataset is smaller than would be desired. Furthermore, mixed species production types were not developed for the Updated SSRA. So, when multiple species of animals were reported at the same facility, these were incorporated into the model as individual production type populations sharing a geographic location (see Table 26). This approach significantly underestimates the spread of FMD between species because the production type parameterization does not typically allow for contact between different species. For example, cows and sheep at the veterinary hospital would not be able to contact each other and spread disease because they are parameterized as Beef (BY-SS) and Small Ruminant (BY-SS), which have no contact with each other.

K-State Dairy Unit

Based on 2009 data, the dairy unit numbers vary from 484 to 515. The unit keeps a consistent number of animals on site for most of the year. The facility is open for public tours and is used for teaching. It is likely that a sick animal would be quickly identified[Hollis, 2011].

K-State Stocker Unit

Based on 2009 data, the stocker unit numbers vary from 0 (January to March) to 720 (July). The unit includes 1,120 acres. Animals are purchased at various area markets by Pratt Feedyard, who provide the animals to K-State for their use but ownership remains with Pratt Feedyard. The animals are returned to Pratt Feedyard for finishing. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

K-State Feedlot Unit

Based on 2009 data, the feedlot unit numbers varies from 300 (November to February) to 1400 (May to August). Animals are purchased at various area markets by Ward Feedlot and brought to K-State for finishing. They are owned by Ward Feedlot and managed by the K-State staff. They are shipped to the Tyson plant in Garden City, Kansas. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

K-State Purebred Unit

Two locations make up the Purebred unit.

One unit is located next to the NBAF, and this facility typically houses about 100 head and is used to finish bulls and for the annual purebred sale in March. In 2011, 127 head were sold at the sale [Hollis, 2011].

The second facility, referred to as Cedar Creek, houses the remaining animals: 700-750 cows, calves, bulls, steers, and gomers. Between January and April cows calve, and then spend May to November on grass. Between September and December calves are weaned and 200-300 calves are shipped to K-State campus. 300 animals stay at the farm all of the time, but heifers are moving to and from campus on a regular basis. Animals at this location are owned by K-State, are bred at the facility and are sold at an annual sale to producers in multiple states (2011).

K-State Cow-Calf Unit

Based on 2009 data, the Manhattan cow-calf unit numbers varies from 219 to 613. The K-State herd numbers are fairly consistent with the variation in numbers occurring because K-State utilizes ground in Geary and Ellis counties. The Geary county property is used from June through November and the Ellis county property is used in November and December. Numbers increase during calving season. Animals are owned by K-State and are bred at the facility. Animals are sold at by private sale and through markets to various states. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

K-State Sheep and Goat Unit

In May 2011, the sheep and goat unit housed 329 sheep and 40 goats; seasonal information was not obtained but the monthly inventory numbers would likely increase during lambing and kidding season. A new facility for the goat and sheep unit is currently under construction in roughly the same location and the flock is likely to increase in size once this building is complete. Animals are owned by K-State and are bred at the facility. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

K-State Swine Unit

Based on 2009 data, the K-State Swine unit numbers vary from 1,383 to 1,808, with an average of 1507 per month. The facility is used year round and hog numbers remain fairly consistent month to month. This is a farrow to finish unit. It includes indoor and outdoor animal production facilities. Animals are shipped to slaughter once they reach market weight. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

K-State Early Weaning Unit

This unit is run separately from the K-State Swine unit. No human or animal movement occurs between the two sites. Four hundred piglets are housed at the site. Piglets remain there for 9 weeks. Once a batch is moved out, a new batch of 400 arrives. Animals are owned and provided by a commercial hog operation in Kansas, and they are returned to the commercial operations for finishing. The facility is used for teaching, and animal disease would be identified and reported quickly [Hollis, 2011].

Reynolds Ranch

Reynolds Ranch is split by highway 177; the herd on the east side runs around 900 head of cattle and the herd on the west side runs around 35 head of cattle. As part of grazing studies, half of the east herd grazes from May till October and the other half from May till July. The animals on the west side of the highway graze from May 1 to October 1. Animals are supplied by two private producers, one in Geary County and the other from northeast Kansas. Animals are owned by the producer that provides them, but they are managed by K-State while at Reynolds Ranch. Animals are shipped to private feedlots, with many destined for one feedlot in Beloit, Kansas. Staff observes animals daily to collect data on grazing patterns. While they do check animals health, this is not always their first priority [Owensby, 2011].

Kansas Artificial Breeding Service Unit (KABSU)

KABSU animal numbers are highly variable throughout the year, ranging from 6-25 bulls per month. Bulls come to the facility for semen collection, some stay a few weeks and other stay several months. Almost all bulls at the facility come from Kansas (~95%), although occasionally bulls come to the facility from Montana and Oklahoma. Animals are regularly observed by veterinarians who would recognize and report a FAD immediately. There is some movement of animals between KABSU and the Veterinary School [Taul, 2011].

Large Animal Research Facility (LARF)

The LARF is a research facility that does not maintain a herd of animals. The number of animals at the LARF varies depending on research needs. The average head of cattle on site is around 20-25, but could range from 0-60. Cattle will stay for weeks or months. There are months when no cattle will be on site. The monthly average for head of pigs is between 25-30, with a range from 0-200. Goats are seldom kept on site, but five goats could be on site [Marlow, 2011].

A6.2.5 Concentrated Animal Feeding Permit (CAFO) Data Collection and Standardization

CAFO datasets were obtained from Kansas, Oklahoma, Nebraska, Iowa, Missouri, Texas, and Colorado through communication with responsible state agencies (Table 26).

Table 26: CAFO Datasets and Sources

State	Source	# Listings
KS	Kansas Department of Health and Environment	1,705
OK	Oklahoma Department of Agriculture, Food, and Forestry	279
TX	Texas Commission on Environmental Quality - CAFO Water Permits Team	513
MO	Missouri Department of Natural Resources, Water Protection Program	269
NE	Records Management Section Nebraska Dept of Environmental Quality	1,139
CO	Environmental Agriculture Program, Colorado Department of Public Health and Environment	177
IA	Iowa Department of Natural Resources	7,554

A6.2.5.1 Formatting

CAFO datasets were uniformly provided as Microsoft Excel spreadsheets; however, each CAFO dataset came uniquely formatted. Therefore, all CAFO datasets were standardized into a format useful for the NAADSM model. The standardized datasets included fields for herd size, latitude, longitude, and a herd ID number (Table 27). CAFO data were occasionally incomplete, and when possible the missing data were extrapolated.

Table 27: Sample of the Standardized CAFO dataset

HerdID	Herdsize	Lat*	Lon*	ProductionType	Status	daysleftinstatus
1	549	40.000	-99.9999	Cow-Calf	S	-1
2	1477	40.000	-99.9999	Cow-Calf	S	-1
3	785	40.000	-99.9999	Cow-Calf	S	-1
4	785	40.000	-99.9999	Cow-Calf	S	-1

***Notional latitude and longitude.**

Some CAFO datasets listed multiple entries for the same permit-holder. In some cases duplicate entries were obviously artifacts from older datasets, and these entries were removed. In other cases, dataset providers indicated that duplicate entries represented single facilities with multiple clusters of buildings or multiple waste storage areas. For these facilities, all livestock were merged onto the location/listing with the greatest headcount.

A6.2.5.2 Herd Size

Another consideration was that CAFO permits specify each facility's livestock capacity rather than the actual number of livestock present at the time of permitting. According to KDHE, dairies typically operate at 97% of maximum permitted capacity, swine facilities at 97.5%, and feedlots at about 85% maximum capacity. The herd size at each of these facilities was reduced accordingly.

A6.2.5.3 Location

Most facilities listed in CAFO datasets were accompanied by geo coordinates in latitude and longitude format. In instances where datasets did not contain latitude and longitude coordinates, but did contain addresses, an online geocoding tool was used (http://www.gpsvisualizer.com/geocoder/) to convert addresses to coordinates. One CAFO dataset listed coordinates in UTM Northing and UTM Easting format. These coordinates were converted to longitude and latitude using the tool available at http://www.uwgb.edu/dutchs/usefuldata/utmformulas.htm.

A6.2.5.4 City-Based Facility Removal

It became apparent that in some cases business addresses were used for CAFO permits and Dunn & Bradstreet (D&B) listings. In an attempt to remove some of these addresses from each dataset, all facilities that fell within the city limits of the ten largest cities for each state (by population, based on U.S. Census data) were removed from the dataset.

Each city was mapped using Google Earth Pro's "overlay image" feature, which is an overlay that provides zip code boundaries of U.S. cities [USNaviguide, 2009]. Because the Naviguide website uses Google Maps to outline cities, the overlay image matched the Google Earth Pro map well.

Figure 9 is an example of a city boundary map generated for Manhattan, Kansas. The city boundary is outlined in dark grey and is based on zip codes. The image was copied from the website using the Snipping Tool and imported into Google Earth Pro as an overlay image. Once the image was adjusted and aligned to the Google Earth Pro map, the polygon tool was used to trace the outline of the city boundary. The overlay image was easily matched to the Google Earth Pro region. This procedure was used to create accurate, complete outlines of the ten most populated cities in each state.

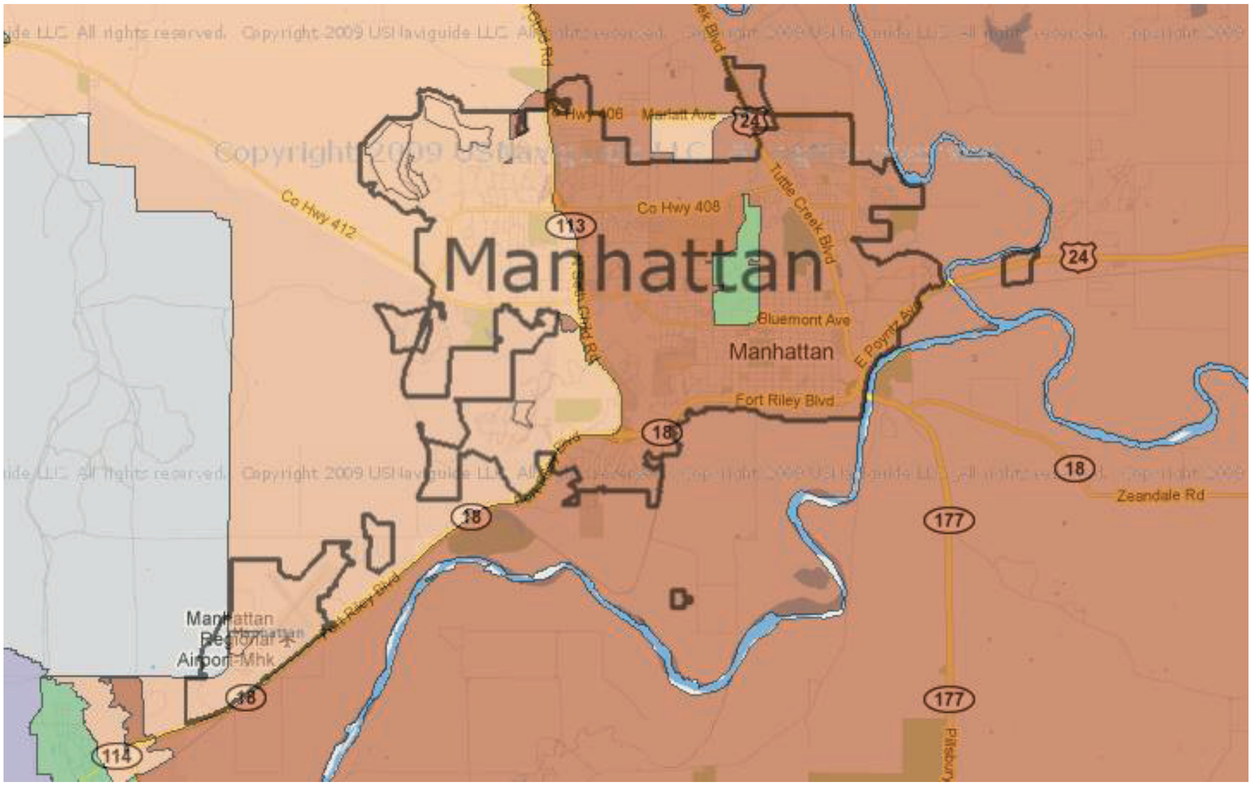


Figure 9: Manhattan, Kansas, outlined by U.S. Naviguide LLC Program

The maptools package in R was used to identify and remove facilities falling within the city limits of the ten most populated cities in each state. The maptools package allowed for a simple assessment of geographic coordinates on the basis of an 'in/out' algorithm.

A6.2.5.5 Production Type

CAFO permit listings specified both the number and type of livestock produced by each permit holder. Facilities without relevant livestock types or location information were removed from all CAFO datasets, and facilities housing multiple livestock types were classified based on the most prevalent livestock type. CAFO facilities were classified as dairies, feedlots, cow-calf facilities, swine producers, or goat and sheep producers. Although most states only require large facilities to obtain permits, some CAFO listings also included small and medium sized CAFOs. Farms with fewer than 250 swine or fewer than 3000 cattle were classified as small swine facilities and small feedlots. Similarly, facilities with fewer than ten animals were classified as backyard swine, backyard beef, or as backyard small ruminant facilities, which produce goats and sheep. However these facilities were extremely rare in CAFO datasets, since they do not produce significant amounts of wastewater runoff.

A6.2.6 Dunn & Bradstreet data collection and standardization

A6.2.6.1 Herd Size

D&B herd sizes were assigned during the merge of the D&B dataset with the Lawrence Livermore National Laboratories (LLNL) dataset, and as described in Appendix Section A6.2.9.3.

A6.2.6.2 Location

Each D&B business listing is accompanied by a set of geo coordinates. As with CAFO permits, it was obvious that some locations were business addresses. As a result, facilities were removed from the dataset if they fell within the borders of the ten largest cities in Kansas, as described in the CAFO data standardization section (Appendix Section A6.2.12.2).

A6.2.6.3 Production Type

In order to assign animal production types to D&B facilities, all listings were first sorted by their SIC codes. Facilities with SIC codes for specific animal types were assumed to derive all revenue from these livestock and were assigned production types accordingly (Table 28). Similarly, facilities with SIC codes denoting general livestock production were assumed to produce some number of cattle, hogs, sheep, and goats.

Table 28: SIC Codes by Livestock Type

SIC Code	SIC Description	Updated SSRA classification
211	Beef Cattle Feedlots	Feedlot
241	Dairy farms	Dairy
212	Cattle, except feedlots, which were assigned as Cow-Calf facilities	Cow-Calf
213	Hogs	Swine
214	Sheep/goats	Sheep/Goat
291	Animal production, NEC	Mixed Livestock
219	General livestock, NEC	Mixed Livestock

Since D&B datasets do not specify how many of each livestock type a general livestock facility holds, these facilities were assigned production types based on the overall composition of livestock farms at the state level. In 2007, LLNL produced datasets for each state, which attempted to account for all livestock and livestock facilities by county and by production type. The LLNL datasets, which were based on the National Agricultural Statistics Service's (NASS) 2007 agricultural census, were used to estimate the proportion of all farms holding cattle, swine, sheep, and goats for each primary region state. These proportions were then applied to the list of D&B general livestock facilities such that the breakdown of facility types in this group mirrored the composition of farms in the statewide LLNL dataset.

As an example, in the Missouri D&B dataset, there were 513 facilities producing multiple livestock types, or whose primary products were not livestock, for which livestock production types needed to be assigned. To do this, all of the farms listed in the Missouri LLNL dataset were broken down by livestock type to determine the proportions of facilities in Missouri that hold cattle, swine, goats, and sheep. The 513 mixed livestock facilities were then multiplied by these state-wide proportions to determine how many facilities should be assigned each production type (Table 29).

Table 29: Assigning Livestock Types to D&B mixed facilities

Livestock Production Type	# of Facilities	Prop of Total	Mixed Facilities	D&B Assignments
Cow Calf	43,393	0.82	=513*0.82	419
Dairy	2,621	0.049	=513*0.049	25
Feedlot(L)	0	0	=435*0	0
Feedlot(S)	892	0.017	=513*0.017	9
Goats	3,091	0.058	=513*0.058	30
Sheep	1,448	0.027	=513*0.027	14
Swine(L)	721	0.014	=513*0.014	7
Swine(S)	913	0.018	=513*0.018	9
Total	53,079	1		513

While it is assumed that SIC codes specify the primary activity of a given facility, D&B datasets provide additional information about secondary products and business activities as short business descriptions. Many facilities that are primarily crop farms according to their SIC codes also list specific or general livestock types in their business description fields. Once facilities with livestock-oriented SIC codes were removed from the master list, the business description fields of the remaining listings were searched by keyword for specific livestock types. Keyword searches were performed for “dairy”, “goat”, “sheep”, “swine”, “except feedlot operations”, and “cattle operations”. Because livestock were not their primary products, facilities identified in this manner were classified as backyard operations. The only exceptions were dairies. Finally, keyword searches were performed on the business description fields of remaining entries for terms indicating general livestock production. General livestock facilities identified in this way were assigned production types based on the overall composition of livestock farms in Kansas.

A6.2.7 LLNL Dataset Assessment

A6.2.7.1 Selecting Sample Counties for Data Analysis

Four states in the modeled region (Kansas, Nebraska, Iowa, and Colorado) were analyzed to determine how accurately the LLNL simulated farm location file matched the NASS data on which it was based. For each state, analysis was performed on the counties with the greatest and least number of cattle, swine, sheep, and goats, as well as counties with the greatest and least number of each facility type. These counties were selected to test how well the LLNL dataset accounted for areas with both high and low animal and facility densities. Additionally, analysis was performed to determine how the LLNL dataset compared to NASS’ Agricultural Census in accounting for facilities of different sizes.

A6.2.7.2 County Level Analysis

For each livestock facility, LLNL lists location information as geo coordinates. In order to compare the LLNL dataset to NASS’s county-level data, it was necessary to place these geo coordinates in the appropriate counties. This was done by drawing polygons around each county of interest in Google Earth Pro, and then using an R script sourcing the maptools package to list all LLNL facilities with coordinates falling inside these polygons. An Excel spreadsheet was then created for each county listing all livestock facilities in that county.

A6.2.7.3 Comparison

County-level data from LLNL and NASS were compared on the basis of both livestock type and herd size. For cattle, swine, goats, and sheep, LLNL and NASS datasets were compared to determine the percentage of NASS livestock population was accounted for by the LLNL dataset. The same was done to determine the percentage of NASS livestock facilities that were accounted for by LLNL. The LLNL and NASS proportions for each county analyzed were calculated and multiplied by 100 to achieve a percentage. The data is presented in Table 30 below, where 100% represents the LLNL and NASS data being equal, percentages greater than 100 represent LLNL accounting for more head of livestock than NASS, and percentages less than 100 represent LLNL accounting for fewer head of livestock than NASS.

Table 30: Comparison of LLNL and NASS by Animal Population (Head of Animal)

Livestock					
		Cattle	Swine	Goats	Sheep
State	County	LLNL/NASS	LLNL/NASS	LLNL/NASS	LLNL/NASS
Kansas	Least	91.93	100	100	100
	Most	99.83	100	100	86.42
	Median	97.82	117.86	100	131.09
Nebraska	Least	98.79	100	100	100
	Most	95.94	95.56	100	85.24
	Median	108.00	99.97	100	100
Colorado	Least	95.24	100	100	100
	Most	99.31	100	100	100.01
	Median	49.35	100	134.33	109.17
Iowa	Least	92.00	123.68	475	129.36
	Most	98.46	98.41	100.26	100.27
	Median	95.77	99.92	99.24	100

The datasets were also analyzed to determine how closely the LLNL and NASS data agreed on the number of facilities. The percentage of NASS facilities accounted for by the LLNL data is presented in Table 31.

As with the livestock data, the facility data showing the greatest disagreement between the two datasets is from the counties with very few facilities. In the Colorado county with the least cattle facilities, the LLNL data account for 300% of the NASS data, yet reflect a difference of only 2 facilities.

Table 31: Comparison of LLNL and NASS by Facility Number

Facilities					
		Cattle	Swine	Goats	Sheep
State	County	LLNL/NASS	LLNL/NASS	LLNL/NASS	LLNL/NASS
Kansas	Least	75.68	100	100	100
	Most	95.37	100	98.67	100
	Median	99.22	104.17	100	100
Nebraska	Least	83.72	100	100	100
	Most	98.75	99.38	100	100
	Median	93.88	115.38	100	100
Colorado	Least	300	100	100	100
	Most	99.81	100	100	100
	Median	73.53	100	100	100
Iowa	Least	81.32	100	50	128.57
	Most	100	100	100	101.04
	Median	84.64	101.45	100	100

A6.2.8 LLNL Dataset Standardization

A6.2.8.1 Herd Size

No conversion was needed for the LLNL herd size.

A6.2.8.2 Location

No conversation was needed for LLNL location.

A6.2.8.3 Production Type

The LLNL dataset was created with production types that were similar to the production types used for the Updated SSRA, but some translation was necessary (Table 32).

Table 32: Translation of LLNL Production Types into Updated SSRA Production Types

LLNL Production Types	Converted to Updated SSRA Production Type
Any cattle production type with less than 10 animals (Beef, Feedlot, Cow calf)	Beef (BY-SS)
Cow calf(10+ animals)	Cow-calf
Dairy	Dairy
Stocker	Cow-calf
Markets	Removed from set
Feedlot (10 3,000 animals)	Feedlot(S)
Feedlot (3,000+ animals)	Feedlot(L)
Swine (less than 10 animals)	Swine(BY-SS)
Swine (10 250 animals)	Swine(S)
Swine (250+ animals)	Swine(L)
Goats (less than 10 animals)	SmRu(BY-SS)
Goats (10+ animals)	Goats
Sheep (less than 10 animals)	SmRu(BY-SS)
Sheep (10+animals)	Sheep

A6.2.9 Modeling File Compilation

The LLNL dataset simulates the total population and number of facilities with a high degree of accuracy at a regional level, as shown in the analysis above. In order to maintain this accuracy and take advantage of the increased accuracy of facility locations provided by the other datasets collected, a multistep merge process was performed. For each facility that was added from the CAFO, D&B, K-State, and local survey datasets, one facility was removed from the LLNL dataset. The methods used aimed to choose a facility for removal that matched the herd size, location, and production type for the facility that would replace it as closely as possible. The exception to this approach was the procedure followed for the facilities identified within a 6.2-mile radius of the NBAF site. That survey should have identified every location in that region, so all LLNL, CAFO, and D&B farms were removed from that area and replaced with the locations identified near the NBAF.

A6.2.9.1 Creating Local Area Population Files

Each dataset was broken down into a local area population file, which accounted for about 1/12 of the area of each state. This helped to maintain the regional accuracy of the LLNL population file as it was merged with the datasets used in this assessment. Shape files were generated in Google Earth Pro, which roughly divided each state into 12 regions using a 3X4 grid (Figure 10). These shape files were imported as KML files into the R environment, a free software environment for statistical computing and graphics [Team, 2011]. The point.in.polygon function from the R maptools package was applied to each population file to established which geographical locations fell within the boundaries of the generated polygon.

Figure 10: Google Earth Pro 3x4 Generated Grid

A6.2.9.2 Dunn & Bradstreet and CAFO duplicate check

R was used to remove D&B facilities that duplicated CAFO facilities based on geo-coordinates. Each state was divided into 12 local populations as described above. For each CAFO and D&B facility a "farm area" was approximated; if two farm areas overlapped, one of the farms was removed (the D&B farm), as it was likely a duplicate. To determine farm area, the plotrix package in R was used to draw circular areas around each. The radii of these areas were calculated using herd sizes and animal densities specific for each production type (Table 33). Densities were calculated using NASS 2007 Census State Data reporting average farm size (acres) and median herd size for each production type for the state of Kansas. An example of this process can be seen in Figure 11, which shows the generation of simulated farm areas in the R environment.

Table 33: Head to Area Ratio

# Cow-Calf / acre	# Beef cattle/ acre	# Dairy / acre	# Swine / acre	# Small Ruminants / acre
0.2169893	0.13001	0.252163	2.945886	0.985614

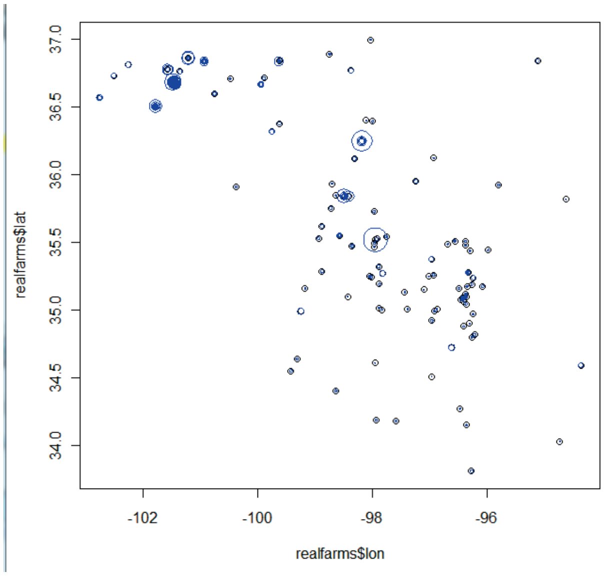


Figure 11: Representative Farm Area Generation

A6.2.9.3 The Dunn & Bradstreet and LLNL Merge

For each production type in each local area population file (generated as described above), the D&B and LLNL facilities were sorted by revenue and herd size, respectively, and the corresponding percentiles were calculated. For example, the largest LLNL facility is the 100th percentile and the smallest facility is the 0th percentile. Likewise, the D&B facility with the highest revenue is the 100th percentile and the facility with the lowest revenue is the 0th percentile. For each D&B facility, an LLNL facility of the same production type, percentile, and grid was identified, and the D&B coordinates were assigned to that LLNL facility. On rare occasions there were more D&B facilities for a specific production type than LLNL facilities. D&B facilities that could not be matched with LLNL facilities of the appropriate size and production type were removed from the dataset.

A6.2.9.4 Division of CAFO into Large and Small Subsets

CAFO operations were divided into two subsets: small CAFOs and large CAFOs. Small CAFOs were permitted facilities that fell below the legal cutoff for that operation type, whereas all large CAFOs were at or above the permitted population (Table 34). Dairies with less than 700 head were classified as small CAFOs and dairies with more than 701 head were classified as large CAFOs. In terms of cattle facilities, including feedlots and cow-calf, facilities ≤ 1000 head were designated as small CAFOs; facilities > 1001 head were designated as large CAFOs. Often CAFO datasets characterized goats and sheep in a single category defined as small ruminants or the equivalent. The final Updated SSRA distinguishes between goats and sheep given the practices affecting contact rate and other parameters associated with these production types. As a means of establishing distinct production types for these facilities, statewide percentiles were established based on the LLNL dataset following production type translation. For example, in Kansas, goats and sheep were often combined into a single production type. By definition, CAFO facilities were large enough to cause waste runoff, making a designation of BY-SS production type inappropriate. Based on LLNL state specific percentiles, 70% of facilities combining the small ruminant population in Kansas were sheep and 30% of the small ruminant population were attributed to goats.

Table 34: CAFO Operation Division for Population File Creation

Small CAFO subset	Large CAFO subset
Dairy < 700	Dairy > 700
Cattle < 1000	Cattle > 1000
Swine< 10000	Swine > 10000
Rum < 10000	Rum > 10000

CAFO cutoffs were established using data generated through SES interviews. Sorting datasets into small and large CAFOs utilized the Microsoft Excel sort function. Generated small CAFO and large CAFO datasets subsequently underwent alternative merge methods. The small CAFO and large CAFO interim datasets were subjected to individual merge processes described in detail below.

A6.2.9.5 Small CAFO Addition

Each state was broken into 12 regions by drawing a 3x4 grid, as described above. For each CAFO facility in a grid sector, an LLNL facility with the same production type and herd size from that grid was removed. If there were no exact matches, the size requirement for facilities larger than 85 animals was relaxed from an exact match to a ± 1% range, ± 5% range, ± 10% range, and finally a ± 20% range if needed. The size requirement for facilities smaller than 85 animals was relaxed from an exact match to a ±1 range, ±5 range, ±10 range, and finally a ±20 range. The size ranges of specific production types were ignored so that, for example, a KDHE Feedlot(S) facility with a herd size close to the Feedlot(L) cutoff could be matched with either a Feedlot(S) or Feedlot(L) LLNL facility. Any KDHE facilities not able to be matched even at a ±20 or ±20% size range remained in the final dataset. While this resulted in a greater number of animals and facilities in the final Updated SSRA population file, this was determined to be an acceptable discrepancy given the evidence basis supporting the addition of these locations.

A6.2.9.6 Large CAFO Addition

Following the percentile based merge all facilities in the subset LLNL and D&B dataset over the established large CAFO cutoff were removed and replaced with the subset large CAFO dataset. This step was justified given that at a specific size facilities are legally required to have a state permit. Legal requirements for state livestock permits provide an evidence basis for the exclusion of LLNL and D&B facilities over the established cutoff in favor of large CAFO facilities.

A6.2.9.7 Backyard Addition

As described above, the LLNL and D&B population files were broken into 12 regions, for BY-SS production types in each dataset, coordinates corresponding to D&B facilities falling within the same geographically distinct areas were used to randomly replace LLNL coordinates.

A6.2.9.8 Adjustment of Overlapping CAFO and LLNL Farms

Using the same approach described above to identify duplicate D&B locations, LLNL locations that “overlapped” with newly added D&B and CAFO locations were identified. The maptools package was used to identify any LLNL facilities falling within approximated areas of the CAFO facilities. The longitude and latitude of LLNL facilities falling within the area of were adjusted by the diameter of the CAFO facilities’ areas such that they moved away from the state border. For example, facilities in the northeast quadrant of the state were moved in a southwest direction; facilities in the northwest quadrant of the state were moved in a southeast direction; facilities in the southeast quadrant of the state were moved in a northwest direction; and finally, facilities in the southwest quadrant of the state were moved in a northeast direction.

A.6.2.9.9 Replacement of 6.2-Mile Survey Region

In order to provide the most accurate information regarding the potential risk posed by the release of FMDv, all facilities within 6.2 miles of the proposed NBAF site were removed and replaced with the facilities identified by surveys and K-State interviews (described earlier in this section). The maptools package in R was used to identify and remove facilities falling within 6.2-miles of the NBAF. This code was nearly identical city based facility removal (discussed above). A 6.2-mile radius was generated using the NBAF coordinates as the centroid with the "circle-draw" tool of Google Earth Pro. Sixty facilities were removed and replaced with 54 facilities, represented by 66 herds.

A6.2.10 Analysis of Final Population Files vs. NASS and LLNL Files

The final Updated SSRA population file for Kansas was compared to the NASS census results and the LLNL dataset, to show that the Updated SSRA file maintains the animal populations and total facilities described in these datasets (Table 35, Figure 12, and Figure 13). In terms of total number of facilities, the Updated SSRA matches both LLNL and NASS quite closely. For both cattle and swine, the Updated SSRA includes a greater number of animals in the population dataset than predicted by LLNL or NASS. This is almost entirely due to concentrated animal feed operation dataset, which is the most accurate dataset available on large animal populations. It was impossible to incorporate the CAFO dataset in the Kansas population without exceeding the NASS population estimate. While the NASS census has impressive producer participation, it is voluntary (where as CAFO permits are legally required), so the NASS dataset may be underestimating larger producers.

The Updated SSRA file was also compared against the 2010 SSRA file to show the improvement of the population modeled for the Updated SSRA. The Updated SSRA population file is a more accurate representation of animal populations than the 2010 SSRA population file because it incorporates data from additional sources that help capture small producers. The Updated SSRA also incorporates new production types, goats and sheep.

Table 35: Modeling File Analysis

	Total Animals				**Total Facilities**			
	Updated SSRA	LLNL	NASS	SSRA	Updated SSRA	LLNL	NASS	SSRA
Cattle	8,446,124	6,444,551	6,669,163	6,099,617	30,421	28,495	30,017	8,133
Swine	2,921,519	1,885,028	1,885,252	2,737,610	1,778	1,454	1,454	899
Goats	47,319	49,706	49,502	0	1,377	2,050	2,003	0
Sheep	103,814	83,495	84,194	0	766	1,122	1,166	0
Total	11,524,275	8,462,781	8,688,111	8,837,277	35,628	33,122	34,640	9,032

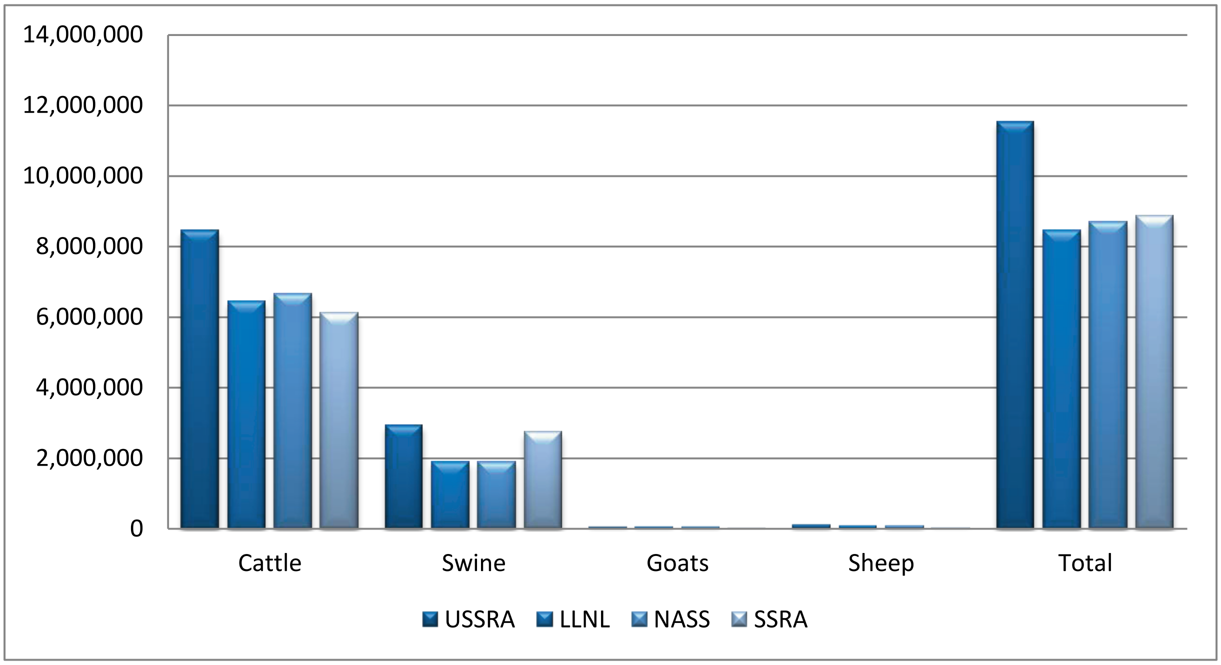


Figure 12: 2011 Updated SSRA Animal Population (head count) Comparison

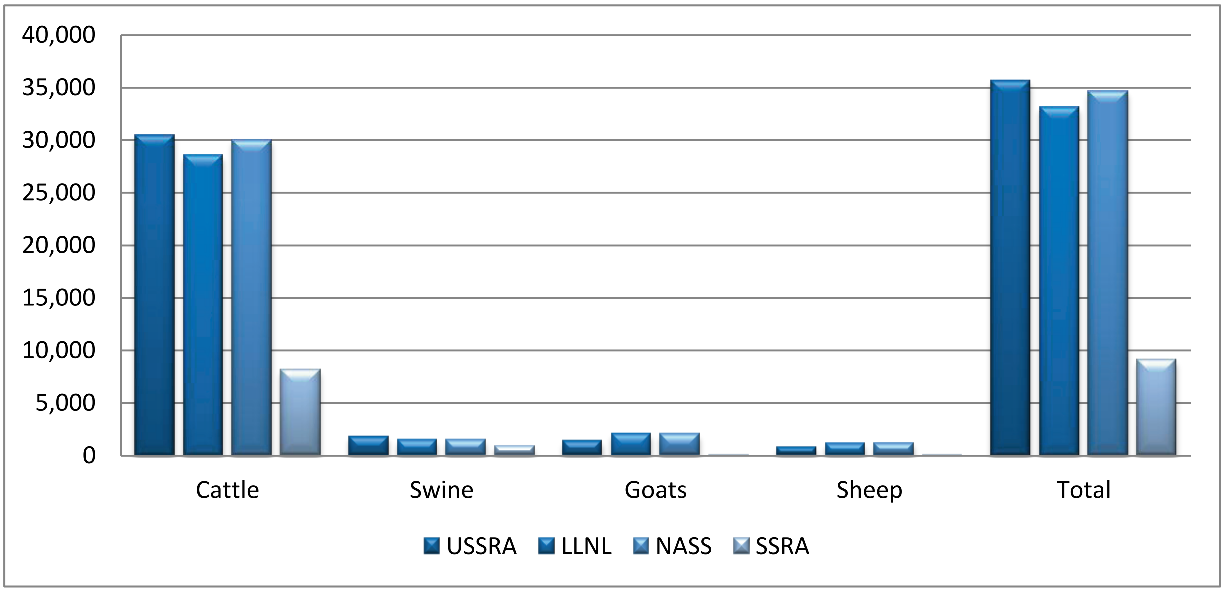


Figure 13: Updated SSRA Facility Count Comparison

A6.2.11 Extrapolation of Clinical Period from Mardones Disease Phase Durations

Mardones et al. report a subclinical period and an infectious period [Mardones, 2010]. The latter encompasses both of what NAADSM refers to as the subclinical and clinical periods. Assuming that the duration of the infectious period is equal to the duration of the subclinical and clinical periods, the difference between the two distributions gives the length of the clinical period. The clinical period was estimated for each species. Using a stochastic simulation, values from the subclinical period distribution and from the infectious period distribution were drawn. For each set of drawn values, the subclinical period was subtracted from the infectious period to give a value for the duration of the clinical period. If this value was negative, then it was invalid, and was discarded. This was repeated until 10,000 valid values were produced, and those values were fitted to a distribution using @Risk. This distribution represents the duration of the clinical period. This approach assumes that the length of the subclinical period is independent of the length of the clinical period, an assumption that is probably not true. However, sufficient information on this relationship was not available, and so it could not be incorporated into this approach.

A6.2.12 Within-Herd Model Generated Parameters

A6.2.12.1 Within-Herd Model

In order to develop unit-level disease spread characteristics appropriate for the production types and populations specific to the datasets used in this assessment, the within-herd model (version 0.9.6) was used. This model captures animal-level variation and within-herd dynamics and was developed by Colorado State University's Animal Population Health Institute. The model was used to develop state-specific disease and detection parameters for each production type.

The within-herd model is a stochastic, state transition model that simulates disease spread through a single herd, taking into account variation in disease phases for individual animals. Like NAADSM, the model operation on daily time steps for a user specified number of iterations. Probability distributions for species specific disease phase durations [Mardones, 2010] state specific production type populations distributions, and within-herd animal-to-animal contact rates (CEAH 2011) are entered into the modeling tool. For every iteration, each infected individual within the herd progresses through the latent, subclinical, and clinical states, and these data are used to determine herd level disease phase durations. Depending on the number of initially infected animals in the latent state, the duration of the latent phase extends from the day of first infection in the herd to the first time any of the latent animals transitions to the subclinical phase. The subclinical phase extends from the day of the first subclinical infection to the first time any of the subclinical animals transitions to the clinical state. The clinical state lasts from the day of first clinical infection to the day that the last animal completes its clinical phase. Then the immune phase for the herd begins. The phase duration values resulting from each iteration are a model output that is then processed in Excel to obtain unit-level latent, subclinical, and clinical phase duration distributions. The within-herd modeling tool also calculates the number of infected individuals per disease phase for each day the herd is considered infected. These outputs were used to calculate the unit-level probability of infection curves and the observation curves.

Setting Up and Running the Model

A within-herd model was developed for each production type population in each state modeled, including: disease phase spread, within-herd prevalence spread, and detection functions. Within-herd model simulations were run for 1,000 iterations for each production type, unless this process took longer than 24 hours to complete, because for this assessment simulations that took longer than this period of time had a high likelihood of crashing. For “slow” (more computationally intensive) models, the Reeves-Talbert approximation was applied (a model setting) or the number of iterations were shortened to 500. The within-unit prevalence output option was set to display data describing infected (latent, subclinical, and clinical) individuals. The within-herd input parameters for Kansas are described in this section; for input parameters for all other states, see Appendix Section A6.2.12.2.

Parameters Entered into Within-Herd Model: Origin and Development

Within-herd model input parameters included: state specific population distributions, initial disease state of each animal (latent, subclinical, clinical), adequate exposures per time step, and animal-level disease phase functions.

Population distribution functions were produced for each state, for each production type, using the population file described in Appendix Section A6.2.12.2.. The statistical program, R, was used to generate population distributions as histogram graphs for each production type in the state. The population distributions used for the Kansas within-herd model are shown in Figure 14 through Figure 24.

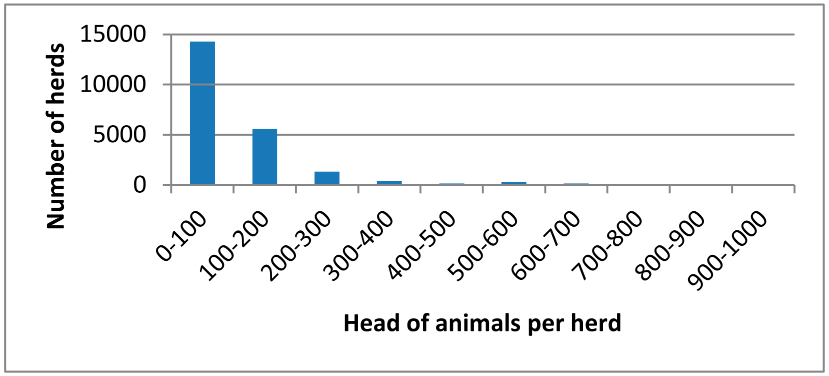


Figure 14: Kansas Cow-Calf Population Distribution: Cut Off After 1,000 head (an additional 449 herds between 1,000 – 60,700 head)

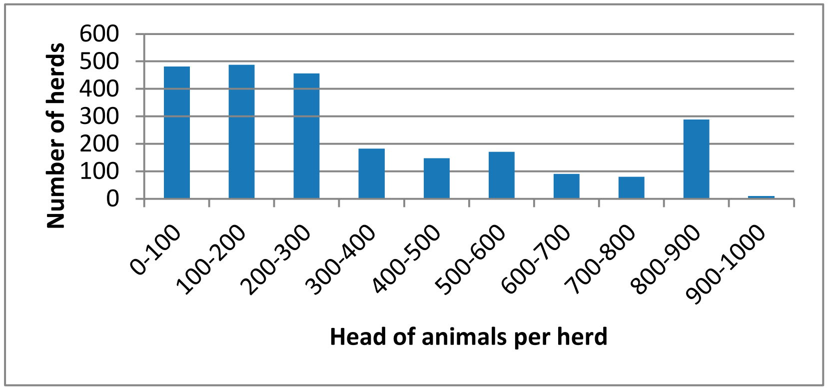


Figure 15: Kansas Feedlot (S) Population Distribution: Cut Off After 1,000 head (an additional 91 herds between 1,000 – 2,600 head)

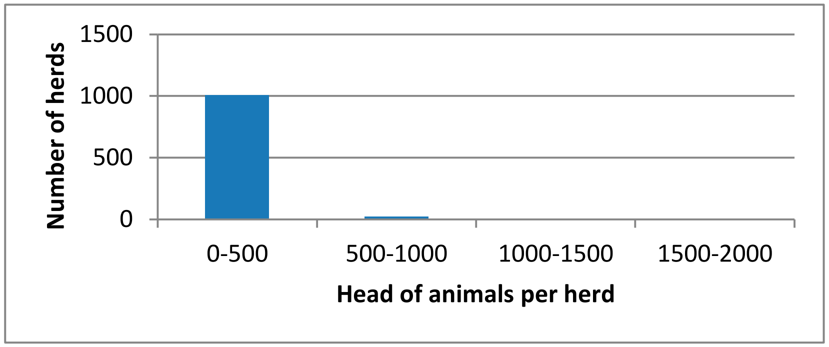


Figure 16: Kansas Dairy Population Distribution: Cut Off After 2,000 head (an additional 27 herds between 2,000 – 47,000 head)

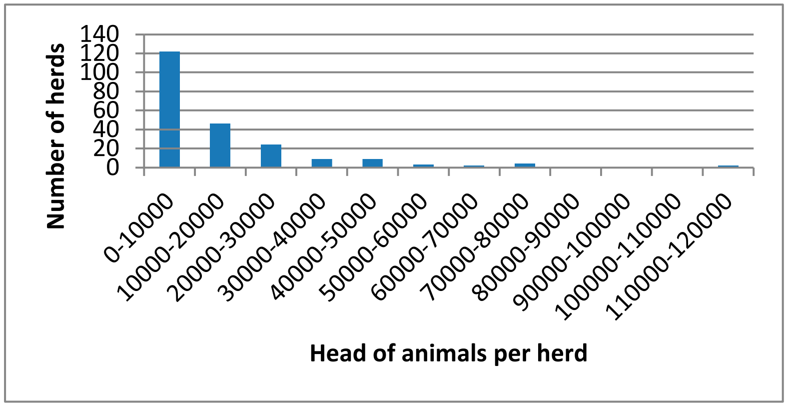


Figure 17: Kansas Feedlot (L) Population Distribution

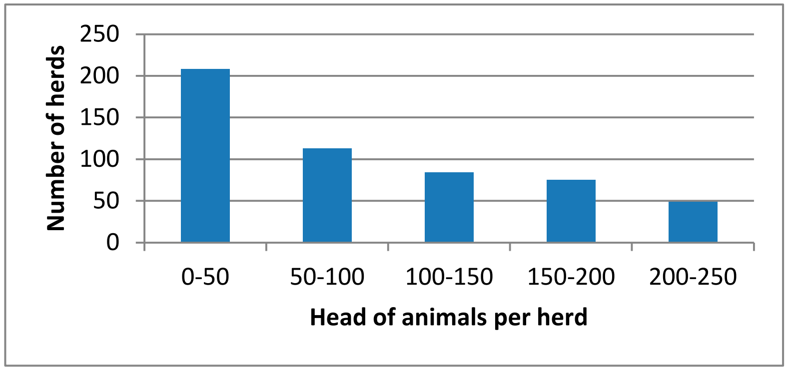


Figure 18: Kansas Swine (S) Population Distribution

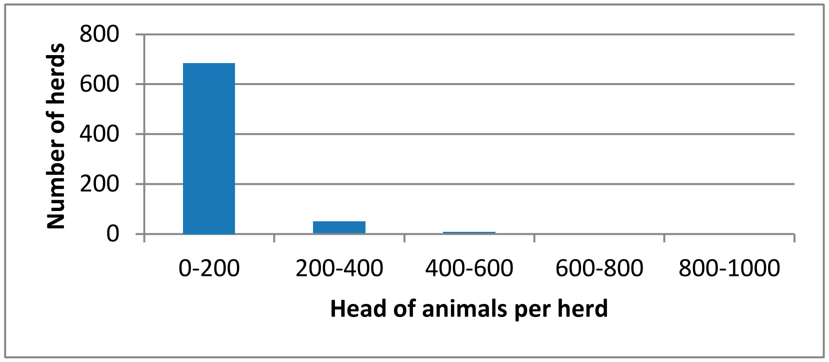


Figure 19: Kansas Sheep Population Distribution: Cut Off After 1,000 head (an additional 20 herds between 1,000 – 10,000 head)

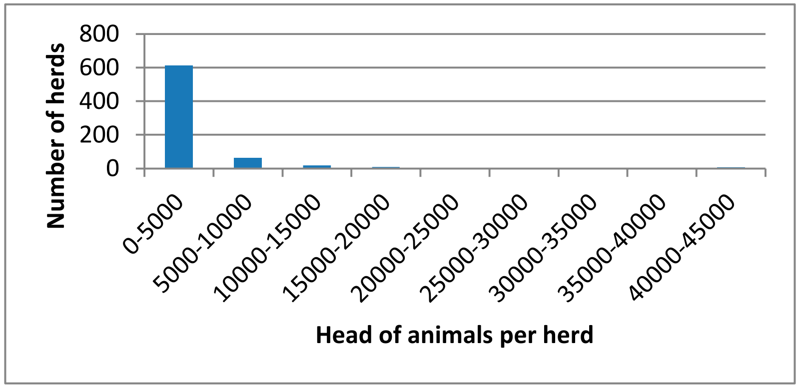


Figure 20: Kansas Swine (L) Population Distribution: Cut Off After 45,000 head (an additional 9 herds between 45,000 – 170,000 head)

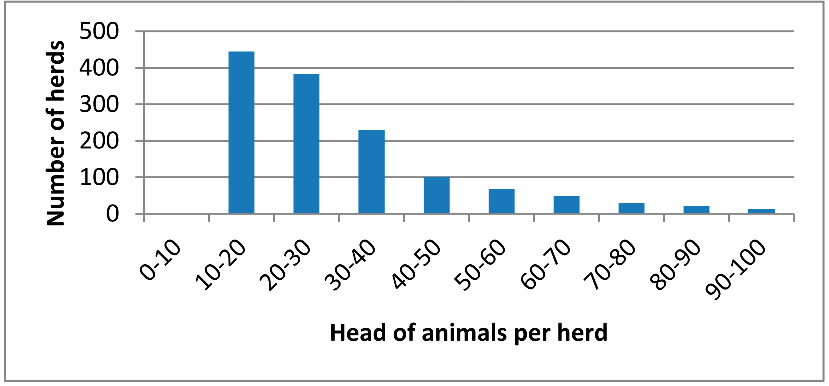


Figure 21: Kansas Goat Population Distribution: Cut Off After 100 head (an additional 40 herds between 100 – 270 head)

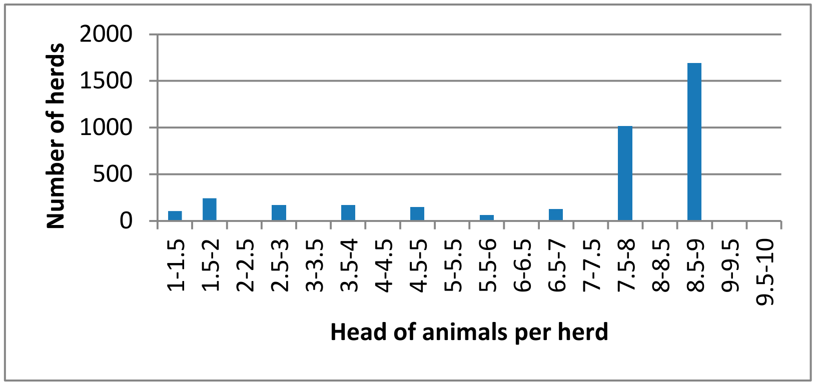


Figure 22: Kansas Beef (BY-SS) Population Distribution: Cut Off After 10 head (an additional 2 herds between 10 – 88 head)

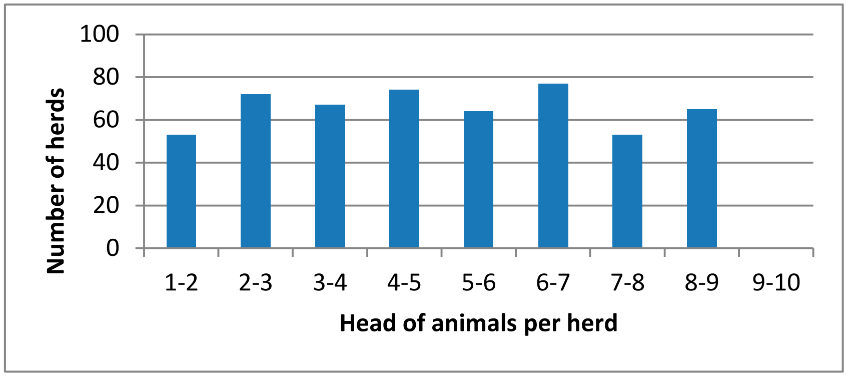


Figure 23: Kansas Small Ruminants (BY-SS) Population Distribution

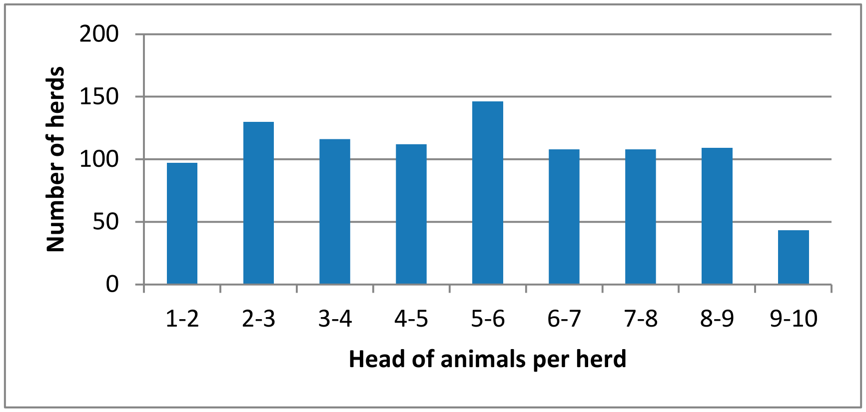


Figure 24: Kansas Swine (BY-SS) Population Distribution: Cut Off After 10 head (an additional 1 herd between 10 – 25 head)

For the initial disease states of animals within the herd, the initially latent, subclinical, and clinical animals were expressed by uniform and fixed functions. Initially latent animals were represented by a uniform function with a range of 1 to 5, which allowed a random selection of one to five latent animals to start the disease outbreak. The selection of a uniform (1,5) function to represent initially latent animals was based on USDA 2011 parameters, based on the assumption that infected shipments of animals may have more than one latent individual. Subclinical and clinical animals were represented with fixed zero-point functions, which established an initial condition of zero subclinical and clinical animals within the herd population. These initial state parameters were the same for every production type and across all states.

The adequate exposures per time step parameters were used universally for each state model. These parameters are specific for each production type and were based on the within-herd contact rate distributions developed in USDA 2011, based on conversations with commodity experts from the National Animal Health Monitoring System (NAHMS). The exposure functions describing each production type used in the Kansas model are shown in Table 36.

Table 36: Adequate Exposures Per Time Step

Production Type	Adequate Exposures Per Time Step
Cow Calf	Beta(10.6,5.25,0,99)
Feedlot(S)	Beta(2.5,4.75,5,900)
Feedlot(L)	Beta(3,4.85,5,900)
Dairy	Lognormal(77.77996,46.339945)
Swine(S)	Weibull(5,200)
Swine(L)	Weibull(5,200)
Sheep	Beta(5,2,1,99)
Goats	Beta(5,2,1,99)
Beef (BY SS)	Beta(5,2,1,49)
Swine(BY SS)	Weibull(5,200)
SmRu(BY SS)	Beta(5,2,1,99)

The animal-level disease phase functions (subclinical, clinical, and immune) were species-specific and taken cumulatively from two expert documents, USDA 2011 and the Mardones paper on the parameterization of FMD [Mardones, 2010]. The animal-level disease phase distributions that were used to develop the Kansas herd-level distributions are shown in Table 37.

Table 37: Animal Level Disease State Parameters

Production Type	Latent Infectious Period	Subclinical Infectious Period	Clinical Infectious Period	Immune Period
Cow Calf	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Dairy	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Feedlot (S)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Feedlot (L)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Swine (S)	Gamma (1.62, 1.91)	Inverse Gaussian (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Swine (L)	Gamma (1.62, 1.91)	Inverse Gaussian (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Sheep	BetaPERT (0.00, 3.96, 13.98)	Gamma (2.40, 0.90)	Weibull (1.23, 2.12)	Gaussian (930.00, 90.00)
Goat	BetaPERT (0.00, 3.96, 13.98)	Gamma (2.40, 0.90)	Weibull (1.23, 2.12)	Gaussian (930.00, 90.00)
Beef (BY SS)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Swine (BY SS)	Gamma (1.62, 1.91)	Inverse Gaussian (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Small Ruminants (BY SS)	BetaPERT (0.00, 3.96, 13.98)	Gamma (2.40, 0.90)	Weibull (1.23, 2.12)	Gaussian (930.00, 90.00)

A.6.2.12.2 Within-Herd Model Data and Herd-Level Parameter Development

The within-herd model data was used to create state-specific parameters that described disease phase, within-herd prevalence, and probability of detection at the herd-level. Hypergeometric calculations were performed in Excel on within-herd model data to develop within-herd prevalence and detection functions. The program, @Risk, was used to create probability distribution functions (PDFs) for latent, subclinical, and clinical disease phases. The state-specific parameters were used as input values for the herd-level modeling in NAADSM.

Disease State Parameters

For each production type, disease phase PDFs were fit to the herd-level state duration data produced by the within-herd model. For each iteration, the model provided the duration in days of each disease phase (latent, subclinical, clinical) for a population sampled from the state-specific animal population distributions. A frequency analysis, in Microsoft Excel 2010, determined how often a particular duration occurred within the modeling set for each disease phase. Data were binned according to duration period (days). For most production types, the latent and subclinical period bins stretched from 0-20 days with single day increments, and the clinical bins ranged from 0-40 days with single day increments. For each disease phase, the @Risk distribution function fitting tool was used to fit PDFs to binned herd-level disease phase duration data, based on minimizing root-mean squared error. The fitted distributions were un-normalized density functions with a lower fixed limit of zero and no bounding on the upper limit. The immune phase functions were taken from USDA 2011, as described in the Section 6.1.4.3 (NAADSM modeling parameter development and data collection). The disease progression parameters developed for Kansas are shown in Table 38.

Table 38: Kansas Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Lognormal(2.55,1.81)	Beta(1.77,2.86,0,3.45)	Beta(18.2,37.14,0,60.11)	Gaussian (μ=1095,σ=180)
Dairy	LogLogistic(0,1.94,2.62)	Uniform(0,2.74)	Beta(28.09,40.32,0,54.65)	Gaussian (μ=1095,σ=180)
Feedlot(L)	Gamma(2.41,0.97)	Beta(2.27,2.69,0,2.27)	Lognormal(94.44,67.72)	Gaussian (μ=1095,σ=180)
Feedlot(S)	LogLogistic(0, 2.02,2.44)	Weibull (1.97,1.31)	Beta(18.14,14.91,0,40.18)	Gaussian (μ=1095,σ=180)
Swine(L)	Pearson5(6.3941,8.1169)	Pearson5(9.9744,12.164)	Lognormal(32.009,4.3721)	Weibull (α=5,β=985)
Swine(S)	Pearson5(5.7556,7.2082)	InvGaussian(1.4895,11.7969)	Beta(13.881,19.284,0,48.730)	Weibull (α=5,β=985)
Goat	Beta(2.55,112.5,0,148.92)	Beta(2.09,4.36,0,5.97)	Gamma(32.13,0.48)	Gaussian(μ=930,σ=90)
Sheep	InvGaussian(3.71,7.3)	Triangular(0,1.41,4.2)	Beta(19.13,19.2,0,36.63)	Gaussian(μ=930,σ=90)
Beef (BY SS)	Lognormal(2.63,2.01)	Weibull(1.6,1.9)	Weibull(3.92,13.50)	Gaussian (μ=1095,σ=180)
Swine(BY SS)	Pearson5(4.4724,5.7095)	Pearson5(4.9380,7.0388)	Weibull(2.9572,12.659)	Weibull (α=5,β=985)
Small Ruminants (BY SS)	Lognormal(4.03,3.27)	LogLogistic(0,2.05,2.59)	Triangular(0,11.51,17.71)	Gaussian(μ=930,σ=90)

Within-Unit Prevalence Curves

Production-type specific within-unit prevalence curves were developed from the within-herd prevalence data produced by the within-herd model. The within-herd prevalence data provided the proportion of infected individuals (latent, subclinical, clinical) at each time step (day). For each day of the outbreak period, an average prevalence of infection (proportion of animals in the herd infected) was calculated across all iterations. An estimated number of infected individuals were calculated for each day by multiplying the mean prevalence of infection by the state-specific median herd size. In order to inform direct contact spread more accurately, the impact that shipments and their size would have on the chance of contact with an infected animal was incorporated into the calculations. The probability of exactly zero clinical animals being shipped on each day was then determined by applying the hypergeometric function in Equation 1 to the estimated number of animals infected.

Equation 1. The hypergeometric calculation provides the probability of at least one clinical animal being shipped each day, *n* is median shipment size, P_t is probability of shipping at least one infected animal given prevalence within the herd, *N* is median herd size, and *t* is a given day.

$$Pt \quad UPr \quad)t \quad \{1 - HYPEt\,GEOMDISTt \qquad Pt\,N)\}t$$

The probability of at least one clinical animal being shipped outside the herd was obtained, for each day, by subtracting the probability of zero clinical animals being shipped from 1. The probabilities, presented as percentages, were plotted against time in days and entered as within-herd prevalence curves in NAADSM (Table 39).

It should be noted that there is an inherent weakness in this approach that may have an effect in the model. The within-unit prevalence curves entered into NAADSM are used to inform spread that is a result of direct contact and airborne. The approach above incorporates the impact of shipments on disease transfer in order to increase accuracy in the model's application of the curve to probability of infection transfer in direct contact. However airborne spread is not limited by shipment size, therefore application of the same curve may be slightly inaccurate for airborne spread. If the hypergeometric function was not applied to account for shipment sizes, the application to direct contact would be less accurate and the application to airborne would be more accurate. The Updated SSRA team assumed that direct contact would have more impact in the model and subsequently decided that it would require the more accurate application of the within-unit prevalence curve.

Table 39: Kansas Within Herd Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
1	98.91	79.92	8.76	91.06	100.00	68.1	17.96	52.99	50.00	60.00	50.00
2	99.79	97.87	30.44	97.49	100.00	100.00	23.43	64.27	50.00	60.00	50.00
3	100.00	100.00	89.68	100.00	100.00	100.00	38.37	85.60	62.50	80.00	66.67
4	100.00	100.00	99.96	100.00	100.00	100.00	71.32	98.67	75.00	80.00	66.67
5	100.00	100.00	100.00	100.00	100.00	100.00	88.3	99.94	87.50	80.00	66.67
6	100.00	100.00	100.00	100.00	100.00	100.00	96.07	100.00	87.50	80.00	83.33
7	100.00	100.00	100.00	100.00	100.00	100.00	98.73	100.00	87.50	80.00	83.33
8	100.00	100.00	100.00	100.00	100.00	100.00	99.51	100.00	75.00	80.00	66.67
10	100.00	100.00	100.00	100.00	100.00	100.00	99.31	100.00	62.50	60.00	66.67
11	100.00	100.00	100.00	100.00	100.00	100.00	98.73	99.98	50.00	40.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	97.37	99.88	37.50	40.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	94.4	99.54	37.50	20.00	33.33
14	100.00	100.00	100.00	100.00	100.00	100.00	88.3	97.87	25.00	20.00	33.33
15	100.00	100.00	100.00	100.00	100.00	100.00	81.06	95.07	12.50	20.00	16.67
16	100.00	100.00	100.00	100.00	100.00	100.00	71.32	85.60	12.50	20.00	16.67
17	99.99	99.91	100.00	100.00	100.00	100.00	58.72	73.21	12.50	0.00	16.67
18	99.91	99.34	100.00	100.00	100.00	100.00	47.16	64.27	12.50		16.67
19	98.91	96.88	100.00	99.83	99.99	100.00	33.63	52.99	0.00		0.00
20	94.80	90.36	99.99	99.33	99.95	100.00	28.65	38.89			
21	88.88	75.92	99.98	97.49	99.63	100.00	17.96	21.43			
22	76.55	65.46	99.96	91.06	97.42	100.00	12.23	21.43			
23	51.25	50.62	99.92	69.49	83.33	100.00	6.25	21.43			
24	51.25	29.62	99.85	69.49	83.33	99.97	6.25	0.00			
25	0.00	16.08	99.73	0.00	0.00	99.58	0				
26		16.08	99.55			97.59					
27		16.08	99.27			92.39					
28		0.00	98.87			82.01					
29			98.35			68.10					
30			97.67			57.54					

Table 39: Kansas Within Herd Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
31			96.89			43.50					
32			95.88			24.82					
33			94.79			24.82					
34			93.52			24.82					
35			92.03			0.00					
36			90.63								
37			88.99								
38			87.21								
39			85.38								
40			83.65								
41			81.62								
42			79.13								
43			77.17								
44			75.03								
45			72.40								
46			70.14								
47			68.20								
48			67.70								
49			66.15								
50			64.52								
51			62.81								
52			62.03								
53			61.43								
54			58.51								
55			56.75								
56			54.92								
57			53.01								
58			50.51								
59			48.68								

Table 39: Kansas Within Herd Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
60			47.61								
61			45.4								
62			45.96								
63			45.68								
64			44.54								
65			43.68								
66			42.80								
67			41.61								
68			41.91								
69			41.00								
70			39.46								
71			38.83								
72			37.88								
73			37.56								
74			36.59								
75			34.94								
76			33.58								
77			32.20								
78			30.80								
79			29.36								
80			28.27								
81			26.40								
82			25.64								
83			24.49								
84			24.10								
85			23.32								
86			23.71								
87			0.00								

Detection Functions

In NAADSM detection is defined by two functions: “probability of observing clinical signs, given the number of days that a unit is clinically infectious” and “probability of reporting an observed clinical unit, given the number of days since the disease was first detected in any unit.” These two functions are multiplied together to give the probability that the unit is detected on that day. The problem with this approach is that both observation and reporting behavior change after an outbreak is announced. The approach used by the Updated SSRA team was to use the “probability of observing” function to describe the relatively complex producer behavior in both observation and reporting in the model prior to the declaration of an outbreak. To avoid confusion this function will be called “obs and rep fx” from this point forward. The obs and rep fx takes into account:

- the prevalence of symptomatic disease in the herd
- the frequency with which producers observe their animals
- the number of animals a producer observes at a time
- the probability that a producer would call a veterinarian after observing symptoms

The detection functions are applied to every herd that becomes clinical. The obs and rep fx will always start on the day the herd moves to the clinical state. To reflect change in producer behavior once an outbreak becomes public knowledge, the “probability of reporting” function in NAADSM is used as a modifier. The modifier function always begins on the day of first detection for all herds and applies a multiplicative value that occurs the number of days the day of observation occurs after the outbreak becomes public knowledge.

obs and rep fx

To determine the prevalence of symptomatic disease, the within-herd model was used to estimate the within-unit prevalence of clinically infectious animals for each state and production type. Similar to within-unit prevalence curve parameter development, for each day of the outbreak period, an average prevalence of clinically infectious animals (proportion of animals in the herd infected) was calculated across all iterations. For each day, the number of clinical animals was calculated by multiplying the average prevalence of clinically infectious animals by the median herd size.

Given the prevalence of clinical animals within the herd, the probability that a producer would actually observe a clinical animal on a given day depends on the frequency with which a producer observes his/her animals and the number of animals a producer observes at a time. Production type specific producer observation behavior (frequency and sample size) was based on SME opinion and a small producer survey dataset shown in Table 40 (see also Appendix Sections A6.2.2, A6.2.13, and A6.2.14).

Table 40: Inspection Periods and Number of Animals Inspected for Each Production Type

Production Type	Inspection Period	Number of Animals Inspected
Cow calf	7 days	All
Dairy	½ herd, 1 day ¼ herd, 2 days (0.15) herd, 1 day (0.1) herd, 3 days	All
Feedlot (S)	Daily (1 day)	All
Feedlot (L)	Daily	All
Swine (S)	Daily	All
Swine (L)	Daily	All
Sheep	½ herd, 1 day ½ herd, 2 days	~80%
Goats	½ herd, 1 day ½ herd, 2 days	~80%
Beef (BY SS)	Daily	All
Swine BY SS	½ herd, 3 days ½ herd, 4 days	~All (1 less than median herd size)
SmRum By SS	Daily	All

First, the probability that a given day is an inspection day, assuming a perfectly regular inspection period was calculated with Equation 2.

Equation 2: Equation estimating the probability that day *t* is an inspection day for a production type with a given inspection period *T*

$$Pt\ I)t \qquad \begin{array}{ll} \dfrac{1t}{Tt-t\ tt-t1)t} & tt\leq tTt \\ 1t\ \ tt & Tt \end{array}$$

For example, the inspection period for a Kansas cow-calf was determined to be weekly (every 7 days). Application of the formula to this weekly rate of inspection is provided in Table 41. If the first day of an outbreak is the inspection day, then the probability of inspection is 1/7. If the producer inspects a clinical herd on the second day, the probability increases to 1/6 and further until day seven when the probability is 1, as the producer is known to definitely inspect the herd at least once a week. Assuming the producer inspects the herd on a regular schedule, the producer will inspect the animals on the same day the next week with a probability of one. With some production types, different parts of the herd were inspected at different times. In these situations, the daily average was taken from the portions inspected and the probability of that portion being inspected on that day.

Table 41: Probability Of Inspection Day

The probability that a given day after a herd first shows clinical signs is an inspection day for a production type that inspects once a week: Start in the upper table and see what the probability is for that day being an inspection day. If the day is an inspection day, then move down to the lower table to determine when the next inspection day is.

		Week 1(days)						
		1	2	3	4	5	6	7
p	Initial	1/7	1/7	1/7	1/7	1/7	1/7	1/7
	(1):If not day 1	0	1/6	1/6	1/6	1/6	1/6	1/6
	(2):If (1) and not day 2	0	0	1/5	1/5	1/5	1/5	1/5
	(3):If(2) and not day 3	0	0	0	1/4	1/4	1/4	1/4
	(4):If (3) and not day 4	0	0	0	0	1/3	1/3	1/3
	(5):If (4) and not day 5	0	0	0	0	0	1/2	1/2
	If(5) and not day 6	0	0	0	0	0	0	1
		Week 2(days)						
		8	9	10	11	12	13	14
p	If day 1	1	0	0	0	0	0	0
	If day 2	0	1	0	0	0	0	0
	If day 3	0	0	1	0	0	0	0
	If day 4	0	0	0	1	0	0	0
	If day 5	0	0	0	0	1	0	0
	If day 6	0	0	0	0	0	1	0
	If day 7	0	0	0	0	0	0	1

The second part of this calculation determines the probability that a producer would see a sick animal if the herd was inspected, taking into account the prevalence of clinical animals in a herd, herd size, and the size of the inspected sample. The herd size was estimated by the median value for each production type, for each state. The probability of exactly zero clinical animals being observed on each observation day was determined by applying the hypergeometric function (Equation 3) to the prevalence of clinical animals. The probability of at least one clinical animal being observed was then obtained by subtracting the probability of zero clinical animals being observed from 1.

Equation 3: The probability of observing a clinical animal, where C_t is the prevalence of clinical signs, *N* is median herd size, and *n* is sample size

$$Pt\ ObsIf)t \quad \{1t - tHYPEt\ GEOMDISTt \qquad N)\}t$$

It was assumed that if a producer observed a clinical animal, they would clearly recognize it as a sick animal based on SME input. Therefore the probability that a producer will observe a sick animal on a given day is the product of the probability that a given day is the inspection day (Equation 2) and the probability a producer will see and recognize a sick animal given that day is the inspection day (Equation 3). This product is represented in Equation 4, where *t* is the given day.

Equation 4: The probability that a producer will observe a sick animal on a given day, *t*

$$Pt\ Obs)t\quad \{Pt\ \ I)t\ \ Pt\ ObsIf)\}t$$

As noted above, the obs and rep fx entered into the probability of observation section in NAADSM was a combination of observing a clinical animal and reporting that the animal was sick. Data that characterized producer delays in notifying a veterinarian once sickness was observed were obtained through a survey administered to large animal and mixed practice veterinarians across Kansas (see Appendix Section A6.2.12.2). Based on these data, producer population was divided into three distinct groups: quick reporting, slow reporting, or non-reporting.

Table 42: Percentage of Each Production Type that Falls Into Quick, Slow, And Non Reporting

Production Type	Quick Reporting	Slow Reporting	Non-Reporting
Cow Calf	20%	80%	-
Dairy	37%	63%	-
Feedlot (S)	34%	66%	-
Feedlot (L)	34%	66%	-
Swine (S)	30%	70%	-
Swine (L)	30%	70%	-
Sheep	10%	30%	60%
Goats	10%	30%	60%
Beef (BY SS)	25%	75%	-
Swine BY SS	25%	75%	-
SmRum By SS	20%	80%	-

Quick reporting was defined as contacting a veterinarian immediately after observing clinical signs, and slow reporting was defined as waiting four days after observation to contact a veterinarian. To account for delays in the veterinarian visiting, and potentially in the veterinarian recognizing the disease as FMD, a two day delay was added to all groups. The probability that a producer will observe a clinical animal on a given day (Equation 4) was weighted according to these reporting behaviors (Equation 5). Table 43 provides an example of how all of these steps were applied to the average cow-calf clinical prevalence data to arrive at an obs and rep fx.

Equation 5: obs and rep fx: This function represented the probability of observing and reporting a sick animal prior to FMD becoming public knowledge, on any day *t* with a given proportion of producers *S* that report slowly and a proportion of producers *F* that report fast: If (*t-6*) or (*t-4*) was less than 1, then $\boldsymbol{P_{tt}}\quad)t$or $\boldsymbol{P_t}\quad \boldsymbol{s})t$was set to 0.01: This constraint was made so that the probability of observing and reporting was never equal to zero.

$$P\quad OR)t\quad \{S\quad Pt\quad Obs)t\quad F\quad Pt\quad Obs)\}t$$

Table 43: Example Of Calculations For Detection In A Cow Calf Herd

Days	Average	Prev. within Herd	p(0)	p(at least 1)	P(day is inspection day)	P(obs)	20% would call at first sign (2 days)	80% would delay 6 days	prob official outbreak starts
1	0.0002	0	1	0	0.14	0.00	0.01	0.01	0.02
2	0.0025	0	1	0	0.17	0.00	0.01	0.01	0.02
3	0.0093	1	0	1	0.20	0.20	0.01	0.01	0.02
4	0.0234	2	0	1	0.25	0.25	0.01	0.01	0.02
5	0.0554	4	0	1	0.33	0.33	0.04	0.01	0.05
6	0.1064	9	0	1	0.50	0.50	0.05	0.01	0.06
7	0.1714	14	0	1	1.00	1.00	0.07	0.01	0.08
8	0.2396	19	0	1	1.00	1.00	0.10	0.01	0.11
9	0.2964	24	0	1	1.00	1.00	0.20	0.16	0.36
10	0.3338	27	0	1	1.00	1.00	0.20	0.20	0.40
11	0.3424	27	0	1	1.00	1.00	0.20	0.27	0.47
12	0.3276	26	0	1	1.00	1.00	0.20	0.40	0.60
13	0.2961	24	0	1	1.00	1.00	0.20	0.80	1.00
14	0.2526	20	0	1	1.00	1.00	0.20	0.80	1.00
15	0.2070	17	0	1	1.00	1.00	0.20	0.80	1.00
16	0.1636	13	0	1	1.00	1.00	0.20	0.80	1.00
17	0.1247	10	0	1	1.00	1.00	0.20	0.80	1.00
18	0.0934	7	0	1	1.00	1.00	0.20	0.80	1.00
19	0.0665	5	0	1	1.00	1.00	0.20	0.80	1.00
20	0.0449	4	0	1	1.00	1.00	0.20	0.80	1.00
21	0.0313	3	0	1	1.00	1.00	0.20	0.80	1.00
22	0.0211	2	0	1	1.00	1.00	0.20	0.80	1.00
23	0.0134	1	0	1	1.00	1.00	0.20	0.80	1.00
24	0.0087	1	0	1	1.00	1.00	0.20	0.80	1.00
25	0.0057	0	1	0	1.00	0.00	0.20	0.80	1.00

Modifier Function

As a stated earlier, the obs and rep fx provides the probability that a producer will observe and report FMD once his herd shows symptoms. Day one of this function is new for each herd, since it begins when the herd becomes clinical. However, if knowledge of the outbreak is public, the probability of a producer observing and reporting once the herd shows symptoms is assumed to increase. The modifier function represents this increase as a multiplicative factor. The value of the factor changes as time progresses from the day the outbreak is common knowledge. In NAADSM, the day the outbreak occurs is equivalent to the day the first herd has been observed and reported; it is the day the first infected herd is detected and when the multiplicative factor is 1. All subsequent herds that are observed and reported will be impacted by the multiplicative factor that occurs later in the modifier function, after the day the first herd was detected.

To create the modifier function, the Updated SSRA team estimated a few functions describing observation and reporting given that an FMD outbreak has been detected and publicized. Based on SME input, it was assumed that knowledge of an outbreak would cause producers to report sick animals immediately to public health officials or a veterinarian and that producers would observe their herds daily. The probability that an infected herd is observed and reported after the outbreak is declared was considered to be equal to the probability of observing a clinical animal given inspection because immediate reporting post outbreak notification was assumed (Equation 4). The maximum effect of a public outbreak announcement on producer behavior was assumed to be the value whose product with Equation 5 approximately equals Equation 4.

A two day delay was added to the modifier function to account for the time required to publicize the outbreak. Thus, the modifying function was 100% for the first two days following an outbreak announcement, to account for the delay in reporting. Following that, it was equal to the multiplier for all remaining days. The value of the multiplier represents the maximum effect of a public outbreak announcement on producer behavior. This modifying function was entered as the state-specific reporting function in NAADSM.

The resultant overall detection probability is thus equal to the probability of detection prior to first detection for the index case and for the first two days after first detection. Beyond the first two days after first detection, the overall detection function includes the maximum effect of public outbreak announcement on producer behavior. Both Kansas observation and reporting functions in raw data form are shown below for each production type.

Table 44: Kansas   obs and rep fxs” (NAADSM observation functions)

Day	Cow-Calf	Feedlot (S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	9.30	2.00
5	5.00	35.00	35.00	2.00	31.00	31.00	2.00	2.00	5.00	16.00	2.00
6	6.00	35.00	35.00	38.00	31.00	31.00	2.00	2.00	26.00	21.00	2.00
7	7.67	35.00	35.00	38.00	31.00	100.00	2.00	8.92	26.00	26.00	2.00
8	11.00	35.00	35.00	38.00	31.00	100.00	8.92	8.92	26.00	50.00	2.00
9	36.00	100.00	100.00	38.00	100.00		10.60	10.60	26.00	70.00	21.00
10	40.00	100.00	100.00	100.00	100.00		10.60	10.99	100.00	85.00	21.00
11	46.67	100.00		100.00			10.99	33.75	100.00	100.00	21.00
12	60.00			100.00			33.75	33.75	100.00	100.00	21.00
13	100.00						38.80	38.80			100.00
14	100.00						38.80	39.97			100.00
15	100.00						39.97	40.00			
16							40.00	40.00			
17							40.00	40.00			
18							40.00	40.00			
19							40.00	39.99			
20							39.99	39.93			
21							39.93	39.60			
22							39.60	39.60			
23							39.60	37.88			
24							37.88				
25							37.71				

Table 45: Kansas Modifier Functions” (reporting functions)

Day	Cow-Calf	Feedlot (S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
4	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
5	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
6	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000

A.6.2.13 Kansas Veterinarian Survey

A.6.2.13.1 Rationale and Methods

A survey was distributed statewide to the members of the Kansas Veterinary Medical Association to collect expert opinion on producer reporting behavior. For each production type, large animal veterinarians were asked estimate the probability that producers would exhibit the following behaviors given they’ve observed an animal infected with foot-and mouth disease in their herd:

- Producer would call a veterinarian at the first signs of sickness
- Producer would try to treat observed symptoms before calling a veterinarian
- Producer would wait to see if the symptoms went away on their own
- Producer would call a veterinarian when the producer-treatment or waiting did not appear to work
- Producer would euthanize a sick animal before calling a veterinarian

The survey also asked how many days it would take, once initial symptoms appeared, for the average producer to call a veterinarian.

A.6.2.13.2 Results and Discussion

Eighteen veterinarians responded to the survey, but all respondents did not respond to all questions. Most producers would try to treat an animal before calling a veterinarian (Table 46). SME interviews with specialists in goat and sheep production suggested that this survey might estimate a higher rate of producer contacting a veterinarian for those production types than would actually occur. In general, the higher value the animal, the faster a veterinarian is predicted to be consulted (Table 47).

Table 46: Median Percent of Producers that would Exhibit Each Behavior After Identifying a Animal in Their Herd Infected with FMD*, Based on SMEOpinion

	Cow-calf	Backgrounder	Feedlot	Dairy	Hogs	Goats	Sheep
Producer would call a veterinarian on first signs	21	25	34	37	30	25	27
Producer would treat him or herself	28	30	26	27	28	31	30
Producer would wait to see if symptoms go away on their own	17	14	10	10	12	14	13
Producer would call a veterinarian if the home treatment did not work	37	38	39	36	39	34	33
Producer would cull sick animal before calling a vet	4	6	4	4	8	8	9

***assumes that producers are unlikely identify disease as FMD and assumes that an outbreak is not underway.**

Table 47: Median Number of Days after FMD Clinical Signs are Observed by a Producer That a Producer would Contact a Veterinarian, Based on SME Opinion

	Cow-calf	Backgrounder	Feedlot	Dairy	Hogs	Goats	Sheep
Days to call a vet	4	5	3	3	4	6	5

A6.2.14 Kansas Foreign Animal Disease Diagnostician (FADD) Interviews on Time to Observable Symptoms

A6.2.14.1 Rationale and Methods

While clinical signs might be apparent to a veterinarian, the Updated SSRA team was concerned about how the clinical period would correspond with symptoms a producer could recognize. Three FADDs were interviewed for their opinion on how long it would take for animals to exhibit symptoms that a producer could observe to tell that the animal was ill.

A.6.2.14.2 Results and Discussion

These results are based primarily on the range of incubation times of FMD. The maximum value reported by FADD1 for beef is based on how long it might take for a producer to observe his animals, not on how long it would take for an animal to exhibit symptoms. Observable symptoms would appear between 10-14 days. All the FADDs interviewed said that sheep and goats are so inconsistent in their presentation of symptoms, that it is likely that a producer would never observe the symptoms. One of the FADDs reported that sheep and goats would need to be carefully examined to detect the disease. All the FADDs interviewed indicated that symptoms of fever from FMD would be general depression, and off feed and water. All FADDS felt that a producer would be able to identify that his animals were ill, but he wouldn’t be able to identify the disease as FMD.

Table 48: Responses from FADD 1

Species	Min. (Days)	Ave. (Days)	Max. (Days)
Beef	4	10	25
Dairy	4	10	14
Swine	No Opinion	No Opinion	No Opinion
Small Ruminants	*	*	*

*FMD in small ruminants is very difficult to detect and therefore may never be detected

Table 49: Responses from FADD 2

Species	Min. (Days)	Ave. (Days)	Max. (Days)
Beef	5	7-10	10
Dairy	5	5-10	10
Swine	5	7-8	10
Small Ruminants	10	15	Never

Table 50: Responses from FADD 3

Species	Min. (Days)	Ave. (Days)	Max. (Days)
Beef	2	3-4	14
Dairy	2	3-4	14
Swine	2	3-4	14
Small Ruminants	*	*	*

*FMD in small ruminants is very difficult to detect and therefore may never be detected

A6.2.15 Direct Contact Reduction for Out Of State Movement

Original direct contact rates were gathered from USDA 2009 and personal communication. However, these contact rates included livestock shipped out of Kansas (outshipments). Because the Updated SSRA model treated livestock moving within and out of Kansas in separate modules, the contact rates needed to be reduced to account for only those livestock remaining within Kansas, with the exception of backyard facility contact rates, which were calculated using a different method and so did not need to be reduced. Using certificate of veterinary inspection (CVI) data, the number of outshipments moving from any production type facility in Kansas to any production type facility in other states was estimated. These outshipments were then subtracted from the total number of annual shipments, as estimated from the original contact rates, to calculate total number of animal shipments moving within Kansas. The total number of intrastate shipments was then used to calculate a new reduced direct contact rate for each facility type-to-facility type combination (e.g. cow-calf to dairy) that excluded the movement of livestock out of Kansas. A summary of these calculations is depicted in Figure 25, while detailed descriptions are in the following sections.

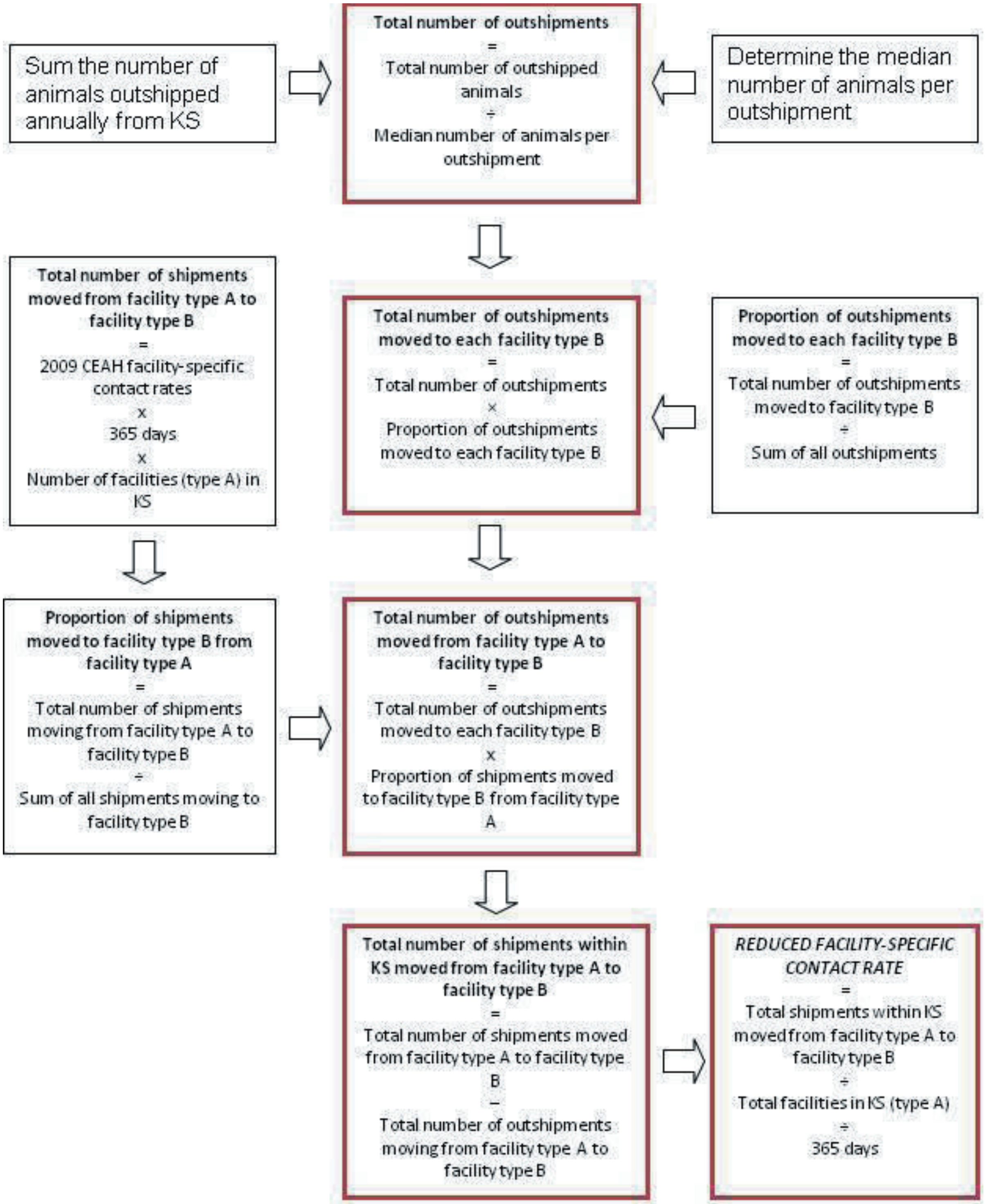


Figure 25: Flow Chart Displaying the Calculations Leading to Reduction of the Production Type Facility-Specific Contact Rates to Exclude Animals Shipped Out of Kansas (outshipments)

Facility type A refers to the type of facility sending animal shipments, while facility type B refers to the receiving facility. For example, if a shipment moves from a dairy facility to a feedlot, the dairy is facility A and the feedlot is facility B. Boxes outlined in red and bolded indicate the main flow of calculations.

A6.2.15.1 Data Sources

The majority of the original contact rates came from the CEAH 2009 document. Exceptions were cow-calf to dairy, cow-calf to small and large feedlots, dairy to cow-calf, small feedlot to large feedlot and dairy to large feedlot, which were provided through personal communication from USDA. Data on the numbers of types of livestock outshipped from Kansas were collected from Kansas CVI data, which listed every livestock shipment out of Kansas for the year of 2010 to any one of the primary states (Missouri, Nebraska, Colorado, Iowa, Oklahoma, and Texas). These CVI data also included the number of animals in each shipment and the production type of each shipment. Generally, these CVI data exclude animals outshipped for immediate slaughter (see Appendix Section A6.2.15).

Verification of the Livestock Movement Report

Although the Livestock Movement Report is dated 2001, the validity of its data were supported by the 2010 CVI data. The total numbers of cattle moving from Kansas to each primary state from the 2010 CVI data were compared to the total number of cattle moving to each state according to the Interstate Livestock Movement Report. The difference between the datasets was expressed as the percent change from the Interstate Livestock Movement Report. The total range in differences was from -60% up to 149%. Colorado and Missouri had decreases in cattle outshipments from Kansas between 2001 and 2010, while Iowa experienced an increase in cattle outshipments. Texas, Nebraska, and Oklahoma outshipments during 2001 and 2010 were essentially unchanged, with percent changes of less than 20%. Overall, five of the six modeled states had a difference of less than one-fold, while all six states were within two-fold. Therefore, the total number of animals outshipped from Kansas reported by the Livestock Movement Report, and used in these calculations, is a reasonable estimate of the number of animals currently outshipped each year.

A6.2.15.2 Method

The method to reduce the contact rates to exclude livestock movement outside of Kansas required multiple inputs and the calculations were performed in a particular order. The flow of calculations and the necessary inputs are outlined in Figure 25, and this section will follow this outline. To distinguish between sending and receiving facility types for these calculations, in this section the term “facility type A” will refer to the facility type that is sending livestock shipments, while “facility type B” refers to the receiving facility type. For example, if a shipment moves from a dairy to a feedlot, the dairy is facility A and the feedlot is facility B.

Total Number of Outshipments

The first type of information needed to calculate the reduced direct contact rates was the total number of annual outshipments for each species (cattle, swine, sheep, and goats). This information was calculated by dividing the total number of animals outshipped per year for each species by the median shipment size of each species. The median number of animals per outshipment was identified from the CVI data. The only shipments excluded for the determination of median shipment size were animals moved for show or slaughter. The total numbers of animals outshipped from Kansas annually for cattle, swine and sheep were obtained from the Livestock Movement Report [Shields and Mathews Jr., 2003].

Outshipments of goats were not included within this report, so the number of goats outshipped was estimated by multiplying the total number of sheep outshipped (from the Livestock Movement Report) by the ratio of goat outshipments to sheep outshipments, as determined from the 2010 CVI data.

Total Outshipments Moved to Each Receiving Facility Type

The two inputs needed to calculate the total number of outshipments to each facility type B were the total number of annual outshipments and the proportion of outshipments to each facility type B. The total numbers of outshipments were calculated as described in the previous section. The proportions of outshipments to each facility type B from each facility type A were calculated from the 2010 CVI data using “reason for shipment” data. The calculations of these proportions are detailed for each species in the following subsections. Both the total number of annual outshipments and proportion of outshipments to each facility type B were multiplied together to calculate the total number of outshipments to each facility type B.

Proportion of Cattle Outshipments

For cattle, the proportion of cattle that were moved for either breeding (i.e., cow-calf), feeding, dairy, show/trail, or sale/others/blanks were calculated by dividing the number of shipments for each specific facility type by the total number of cattle shipments. The proportion of cattle shipments moving to dairy facilities was then increased because some shipments that are marked as moving to breeding move to likely move to dairies instead of cow-calf facilities. Therefore, it was assumed that the percent of cattle shipments that move to dairy facilities are the same for out-of-state movement as they are for overall movement. The percent of cattle shipments that move to dairies overall was calculated by dividing the total number of annual Kansas cattle shipments to dairies (using USDA 2009 contact rates) by the total number of cattle shipments. These extra dairy cattle were then subtracted from the breeding category.

The category for sale/others/blanks was distributed among the other four facility types (breeding, feeding, dairy, and show/trail) because it was unclear which of the four facility types any of the animals within this category would have moved to. The proportions of outshipments to each facility type B were then finalized, with the exception of cattle moving to feeding. This proportion was split into a large feedlot and a small feedlot. To do so, the number of overall shipments to large feedlots and small feedlots was calculated from the USDA contact rates. The proportion of cattle moving to feeding, as determined from the 2010 CVI data, was then multiplied by the percentage of feeding shipments that go to large and small feedlots, to get the proportion of cattle that move to large and small feedlots, respectively.

Proportion of Swine Outshipments

The number of swine outshipments, excluding show outshipments, was divided by the total number of swine outshipments to get the proportion of outshipments. Similar to cattle, the proportion of swine outshipments was split into large and small swine facilities, according to the proportion of shipments that move to large facilities versus small facilities.

Proportion of Sheep and Goat Outshipments

The number of sheep and goat outshipments, excluding show outshipments, was divided by the total number of either sheep or goat outshipments to get the proportion of outshipments.

Total Outshipments Moved in Each Facility Type-To-Facility Type Combination

In order to calculate the total number of outshipments moving from one facility type to another, two types of information were needed. One of these was the total number of outshipments moved to each facility type B, as determined in the previous section. The other type of information needed was the proportion of outshipments moving to each facility type B from the possible facilities type A. For example, of all shipments moving to a dairy facility, what proportion of those shipments originated from a feedlot, dairy, etc. The total number of outshipments moving to a facility B, multiplied by the proportion of outshipments moving to facility B from facility type A, yields the total number of outshipments moving from any single facility type A to any facility type B.

To calculate the proportion of outshipments moving to any facility type B from any facility type A, it was necessary to first calculate the actual number of shipments that move from each possible facility type A to facility type B. Therefore, the USDA 2009 facility-specific contact rates were multiplied by 365 to get annual contact rates. These contact rates were then multiplied by the number of facilities of each production type in Kansas sending out shipments to yield the total number of shipments moving from any facility type A in Kansas to any facility type B. This number was then divided by sum of all shipments moving to the receiving facility (type B), which gave the proportion of shipments that moved to a specific facility type B from the possible facilities type A.

Reduced Facility-Specific Contact Rate

The total number of shipments moved within Kansas was calculated by subtracting the number of outshipments moving from one facility type to another from the total number of shipments moving from one facility type to another. Essentially this removed the number of shipments moving out of Kansas from the total number of shipments, yielding the number of shipments moving within Kansas.

For each facility type combination, the total number of shipments moving within Kansas was divided by the total number of facilities in Kansas according to the originating facility. This equaled the annual contact rate for each facility type combination. The daily rate was calculated by dividing the annual rate by 365. These results are listed in Table 51 and Table 52.

A6.2.15.3 Results

Each of the facility-specific contact rates (or production type specific contact rates) are listed below in Table 51 through Table 53. There is no direct contact between different species of livestock, nor between large and small swine facilities.

A6.2.16 Direct Contact Parameters

The USDA 2009 parameters served as the basis for the Updated SSRA direct contact parameters, however some parameters went through a series of modifications to increase their accuracy and to account for differences in modeling approach between the Updated SSRA and USDA 2009. Additionally, contact parameters were developed to describe BY-SS producer contact. This Appendix Section provides the USDA 2009 evidence basis first, followed by tables listing individual production type combination contact rates. Any modifications to the original USDA 2009 parameters are noted.

A6.2.16.1 Cattle Direct Contact Parameters

USDA 2009 Evidence Basis

The following was provided as the justifications and assumptions for all cattle (cow-calf, dairy, feedlot) direct contact parameters in USDA 2009, which served as the basis for the direct contact parameters listed in the following sections. For more information please see full USDA 2009 report:

> *"According to NAHMS Beef 2008*[1]*, cow-calf producers received an average of 1.1 shipments from another beef operation and 1.2 shipments from auction markets over the previous 12 months. The ultimate source of auction market cattle that a cow-calf operation would buy is another cow-calf operation.*
>
> *Movement of cattle from feedlots, backgrounders, and dairies to cow-calf operations are rare events.*
>
> *Occasionally feedlots will feed cattle not meant for U.S. slaughter. According to Feedlot '99, Part I, 1.1% of feedlot placements are not for slaughter.*
>
> *Backgrounder/stocker operations receive virtually all of their cattle from cow-calf operations. It is estimated that backgrounder/stocker operations receive approximately 20 shipments per year from cow-calf operations.*
>
> *There is no movement of cattle from finish feedlots to backgrounder operations.*
>
> *Movement of cattle from finish feedlots and backgrounder operations to dairy operations are rare events.*
>
> *The median size of a finish feedlot is an estimated 15,000 head. On average, feedlots turn over twice per year. Assuming 200 head pens, there is an estimated 150 shipments from a cow-calf operation to a finish feedlot operation per year.*
>
> *An estimated 85 shipments per year are from an auction market of which 60% (51 shipments) are from a cow-calf operation while 40% (34 shipments) are from backgrounder/stocker operations.*
>
> *An estimated 28 shipments per year are directly from a backgrounder/stocker operation.*
>
> *An estimated 28 shipments per year are directly from a cow-calf operation.*
>
> *An estimated nine shipments per year are directly from a dairy operation.*

> *There is no movement of cattle from finish feedlots to finish feedlots.*
>
> *According to NAHMS Dairy 2007, Part III dairy operations averaged 2.6 and 0.12 shipments of females and bulls, respectively, from one dairy operation to another each year.*
>
> *According to NAHMS Dairy 2007, 1.5% of dairy operations receive beef bulls, 2% receive steers, and 0.9% receive beef heifers from cow-calf operations.*
>
> *According to Feedlot '99, Part I 1.1% of feedlot placements are not for slaughter (0.2% are beef breeding animals, 0.1% are dairy breeding animals, and the other 0.8% are "other" cattle). It was estimated that an average of one shipment is received by a dairy each year.*
>
> *The probability of infection transfer was determined by the within-unit prevalence.*
>
> *Expert opinion was gathered from the following individuals: Drs. Mike Apley, Mike Brouk, Robert Larson, Dan Thomson, Brad White, and Jason Lombard."*

Cow-Calf

The following description of cow-calf contact parameter development was provided in Chapter 6. Since it is important for understanding the development of other contact parameters between USDA 2009 production types and BY-SS production types, the description is reproduced here.

Direct contact parameters for cow-calf facilities were developed for USDA 2009 through subject matter expert interviews and literature review (see previous section).

Parameters describing direct contact between cow-calf and BY-SS facilities were developed from BY-SS producer interviews (described in Appendix Section A6.2.2). Producers were asked how often they purchased new animals and from where they obtained those animals. Animals were often directly purchased from another facility, but in the event animals (typically calves) were purchased at market, they were assumed to originate from a cow-calf facility. Almost all animals originated from within the state. The mean number of purchases per year per producer was calculated and then multiplied by the total number of each type of backyard facility and divided by the total number of cow-calf facilities. For example, there were 14 shipments sold from cow-calf operations to the 18 beef backyard producers interviewed, which averaged to 0.78 shipments to each of those 18 beef backyard facilities. This value was then adjusted for the total number of backyard beef (3,724) and cow-calf (22,929) producers in Kansas and converted, by dividing by 365, from a yearly value to a daily value of 0.00035 shipments per day (Table 54).

Table 51: Direct Contact Originating From Cow Calf Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Cow Calf to Cow Calf	0.0099[B,C]	3.6	USDA 2009 modified by Updated SSRA team
Cow Calf to Dairy	7.0E-06[A,B,C]	.0026	USDA 2009 modified by Updated SSRA team
Cow Calf to Feedlot (S)	0.0051[A,B,C]	1.9	USDA 2009 modified by Updated SSRA team
Cow Calf to Feedlot (L)	0.0076[A,B,C]	2.8	USDA 2009 modified by Updated SSRA team
Cow Calf to Sheep	0	0	USDA 2009
Cow Calf to Goats	0	0	USDA 2009
Cow Calf to Swine (S)	0	0	USDA 2009
Cow Calf to Swine (L)	0	0	USDA 2009
Cow Calf to Beef (BY SS)	0.00035	.13	Updated SSRA team
Cow Calf to Small ruminants (BY SS)	0	0	Updated SSRA team
Cow Calf to Swine (BY SS)	0	0	Updated SSRA

[A] USDA 2009 contact rates were modified by Kansas State University SME.

[B] Contact rates were increased to account for the fact that many cow-calf operations will send one shipment of animals to a sales barn that may then be sold in multiple lots to multiple buyers (described in direct contact section, 6.1.2.8).

[C] Contact rates were modified to account for interstate movement (described in direct contact section, 6.1.2.8).

Dairy

Direct contact parameters for dairy facilities were developed for USDA 2009 through subject matter expert interviews and literature review (see above).

Parameters describing direct contact between dairies and BY-SS facilities were developed from producer interviews as described in the direct contact cow-calf section (interviews are described in Appendix Section A6.2.2).

Table 52: Direct Contact Originating From Dairy Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Dairy to Cow calf	0.0028[A,B,C]	1.02	USDA 2009 modified by Updated SSRA team
Dairy to Dairy	0.0070[B,C]	2.56	USDA 2009 modified by Updated SSRA team
Dairy to Feedlot(S)	0	0	USDA 2009
Dairy to Feedlot (L)	0.064[B,C]	23.4	USDA 2009 modified by Updated SSRA team
Dairy to Sheep	0	0	USDA 2009
Dairy to Goats	0	0	USDA 2009
Dairy to Swine (S)	0	0	USDA 2009
Dairy to Swine (L)	0	0	USDA 2009
Dairy to Beef (BY SS)	0.0016	0.58	Updated SSRA team
Dairy to Small ruminants (BY SS)	0	0	Updated SSRA team
Dairy to Swine (BY SS)	0	0	Updated SSRA team

[A] USDA 2009 contact rates were modified by Kansas State University SME.

[B] Contact rates were increased to account for the fact that many dairy operations will send one shipment of animals to a sales barn that will then be sold in multiple lots to multiple buyers (described in direct contact introduction).

[C] Contact rates were modified to account for interstate movement.

Feedlots

Direct contact parameters for feedlots were developed for USDA 2009 through SME interviews and literature review (see above).

The interviews indicated that BY-SS producers do not purchase livestock from feedlots (interviews are described in Appendix Section A6.2.2).

Table 53: Direct Contact Originating From Feedlot Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Feedlot(S) to Cow Calf	0.00028 [B,C]	0.10	USDA 2009 modified by Updated SSRA team
Feedlot(S) to Dairy	0.00028 [B,C]	0.10	USDA 2009 modified by Updated SSRA team
Feedlot(S) to Feedlot(S)	0	0	USDA 2009
Feedlot(S) to Feedlot(L)	0.0634[A,B,C]	23.1	USDA 2009 modified by Updated SSRA team
Feedlot(S) to Swine (L)	0	0	USDA 2009
Feedlot(S) to Swine (L)	0	0	USDA 2009
Feedlot (S) to Sheep	0	0	USDA 2009

Table 53: Direct Contact Originating From Feedlot Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Feedlot (S) to Goats	0	0	USDA 2009
Feedlot(L) to Cow Calf	0.00028 [B,C]	0.10	USDA 2009 modified by Updated SSRA team
Feedlot(L) to Dairy	0.00028[B,C]	0.10	USDA 2009 modified by Updated SSRA team
Feedlot(L) to Feedlot(S)	0	0	USDA 2009
Feedlot(L) to Feedlot(L)	0	0	USDA 2009
Feedlot (L) to Sheep	0	0	USDA 2009
Feedlot (L) to Goats	0	0	USDA 2009
Feedlot(L) to Swine (S)	0	0	USDA 2009
Feedlot(L) to Swine (L)	0	0	USDA 2009
Feedlot (L) to Swine (BY SS)	0	0	Updated SSRA team
Feedlot (S) to Swine (BY SS)	0	0	Updated SSRA team
Feedlot (L) to Small ruminants (BY SS)	0	0	Updated SSRA team
Feedlot (S) to Small ruminants (BY SS)	0	0	Updated SSRA team
Feedlot (S) to Beef (BY SS)	0	0	Updated SSRA team
Feedlot (L) to Beef (BY SS)	0	0	Updated SSRA team

[A] USDA 2009 contact rates were modified by Kansas State University SME.

[B] Contact rates were increased to account for the fact that some feedlot operations will send one shipment of animals to a sales barn that will then be sold in multiple lots to multiple buyers (described in direct contact introduction).

[C] Contact rates were modified to account for interstate movement.

A6.2.16.2 Swine Direct Contact Parameters

Direct contact parameters for swine facilities were developed for USDA 2009 through subject matter expert interviews with Dr. Steve Dritz, for additional detail see USDA 2009 report.

Parameters describing direct contact between Swine(S) and Swine(L) facilities and BY-SS facilities were developed from producer interviews as described in the direct contact cow-calf section (interviews are described in Appendix Section A6.2.2).

Table 54: Direct Contact Originating From Swine Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Swine (S) to Cow Calf	0	0	USDA 2009
Swine (S) to Dairy	0	0	USDA 2009

Table 54: Direct Contact Originating From Swine Operations			
Production Types	**Kansas mean baseline direct contact rate (shipments/day)**	**Shipments per year**	**Parameter source**
Swine (S) to Feedlot (S)	0	0	USDA 2009
Swine (S) to Feedlot (L)	0	0	USDA 2009
Swine (S) to Sheep	0	0	USDA 2009
Swine (S) to Goats	0	0	USDA 2009
Swine (S) to Swine (S)	0.014[C]	5.0	USDA 2009 modified by Updated SSRA team
Swine (S) to Swine (L)	0	0	USDA 2009
Swine (L) to Cow Calf	0	0	USDA 2009
Swine (L) to Dairy	0	0	USDA 2009
Swine (L) to Feedlot (S)	0	0	USDA 2009
Swine (L) to Feedlot (L)	0	0	USDA 2009
Swine (L) to Sheep	0	0	USDA 2009
Swine (L) to Goats	0	0	USDA 2009
Swine (L) to Swine (S)	0	0	USDA 2009
Swine (L) to Swine (L)	0.29 [C]	104	USDA 2009 modified by Updated SSRA team
Swine (L) to Small ruminants (BY SS)	0	0	Updated SSRA team
Swine (L) to Swine (BY SS)	0.0021	0.75	Updated SSRA team
Swine (L) to Beef (BY SS)	0	0	Updated SSRA team
Swine (S) to Small ruminants (BY SS)	0	0	Updated SSRA team
Swine (S) to Swine (BY SS)	0.0020	0.74	Updated SSRA team
Swine (S) to Beef (BY SS)	0	0	Updated SSRA team

*According to SMEs, very few swine are sold through markets, so no market adjustment was necessary

[C] Contact rates were modified to account for interstate movement

A6.2.16.3 Goat and Sheep Direct Contact Parameters

USDA 2009 Evidence Basis

The following is paraphrased from the USDA 2009 section provided as the justifications and assumptions for all goat and sheep direct contact parameters. For more information, please see the full USDA 2009 report:

Many small ruminants that are removed from various small fenced/farmed small ruminant operations are moved directly to slaughter.

The number of major movements of small ruminants from larger small ruminant operations to backgrounder and/or feedlot operations is one to two per year which is limited by the natural reproductive cycle. The second or third and final move will be directly to slaughter.

The probability of infection transfer was determined by the within-unit prevalence.

Expert opinion was gathered from the following individual: Dr. Brian Faris.

Goats

Direct contact parameters for goat facilities were developed for USDA 2009 through SME interviews and literature review (see above).

Parameters describing direct contact between goat and BY-SS facilities were developed from producer interviews as described in the direct contact cow-calf section (interviews are described in Appendix Section A6.2.2).

Table 55: Direct Contact Originating From Goat Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Goats to Cow Calf	0	0	USDA 2009
Goats to Dairy	0	0	USDA 2009
Goats to Feedlot (S)	0	0	USDA 2009
Goats to Feedlot (L)	0	0	USDA 2009
Goats to Sheep	0	0	USDA 2009
Goats to Goats	0.044[B,C]	156	USDA 2009 modified by Updated SSRA team
Goats to Swine (S)	0	0	USDA 2009
Goats to Swine (L)	0	0	USDA 2009
Goats to Beef (BY SS)	0	0	Updated SSRA team
Goats to Small Ruminants (BY SS)	0.0014	0.50	Updated SSRA team
Goats to Swine (BY SS)	0	0	Updated SSRA team

[B] Contact rates were increased to account for the fact that many goat operations will send one shipment of animals to a sales barn that will then be sold in multiple lots to multiple buyers (described in direct contact introduction).

[C] Contact rates were modified to account for interstate movement.

Sheep

Direct contact parameters for sheep facilities were developed for USDA 2009 through SME interviews and literature review (see above).

Parameters describing direct contact between sheep and backyard facilities were developed from producer interviews as described in the direct contact cow-calf section (interviews are described in Appendix Section A6.2.2).

Table 56: Direct Contact Originating From Sheep Operations

Production Types	**Kansas mean baseline direct contact rate (shipments/day)**	**Shipments per year**	**Parameter source**
Sheep to Cow Calf	0	0	USDA 2009

Table 56: Direct Contact Originating From Sheep Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Sheep to Dairy	0	0	USDA 2009
Sheep to Feedlot (L)	0	0	USDA 2009
Sheep to Feedlot (S)	0	0	USDA 2009
Sheep to Goats	0	0	USDA 2009
Sheep to Swine (S)	0	0	USDA 2009
Sheep to Swine (L)	0	0	USDA 2009
Sheep to Beef (BY SS)	0	0	Updated SSRA team
Sheep to Small Ruminants (BY SS)	0.0025	0.90	Updated SSRA team
Sheep to Swine (BY SS)	0	0	Updated SSRA team

[B] Contact rates were increased to account for the fact that many sheep operations will send one shipment of animals to a sales barn that will then be sold in multiple lots to multiple buyers (described in direct contact introduction).

[C] Contact rates were modified to account for interstate movement.

A6.2.16.4 Backyard-Small Scale Production Type Direct Contact Parameters

Beef (Backyard-Small Scale)

The Beef (BY-SS) description was provided in Chapter 6. Since it is important for understanding the development of other BY-SS Production types, the description is reproduced here.

Parameters describing direct contact originating from BY-SS were developed from producer interviews (interviews are described in Appendix Section A6.2.2). For BY-SS producers, each animal sold or purchased was considered a single shipment. When answers were provided in number ranges, the median value of the range was used. For example, if a producer purchased 2-4 animals per year, he was considered to have purchased three shipments of animals. Producers were asked how often they sold animals and to whom did they sell their animals. Animals were sometimes sent to slaughter and sometimes sold through markets. Animals sold straight to slaughter were excluded. Most producers were able to indicate whether animals sold through market went to slaughter or finishing. The destination was assumed to be feedlots for most cattle sold through markets. If the producer specified other destinations through markets, such as 4-H operations or other small farms, Beef (BY-SS) facilities were selected as the receiving production type. Shipments that went to unspecified feedlots were divided between small and large feedlots according to the ratio of small to large feedlots in Kansas. The same method was used when the destination of backyard swine or small ruminants was not specified between the various small and large swine or goat- and sheep-type locations. All producers surveyed were from Kansas and shipments from these farms were assumed to stay within the state.

The mean number of sales per year per producer was calculated. This mean was then multiplied by the total number of Beef (BY-SS) facilities and divided by the total number of each production type. For example, there were 25.25 shipments sold from the 18 Beef (BY-SS) producers interviewed to small feedlots, which averaged to 1.4 shipments sold by each of the 18 Beef (BY-SS) facilities. This value was then adjusted for the total number of Beef (BY-SS) facilities (3,724) and small feedlot facilities (2,485) in Kansas and converted, by dividing by 365, from a yearly value to a daily value of 0.00576 shipments per day. These contact values were not adjusted for backyard facilities in other states, nor were they adjusted for the complications of market sales because shipment sizes were likely to be so small that they would only be sold as single lots.

Table 57: Direct Contact Originating from Beef (BY SS) Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Beef (BY SS) to Cow Calf	0	0	Updated SSRA team
Beef (BY SS) to Dairy	0	0	Updated SSRA team
Beef (BY SS) to Feedlot(L)	0.0058	2.1	Updated SSRA team
Beef (BY SS) to Feedlot(S)	0.0058	2.1	Updated SSRA team
Beef (BY SS) to Goats	0	0	Updated SSRA team
Beef (BY SS) to Sheep	0	0	Updated SSRA team
Beef (BY SS) to Small ruminant (BY SS)	0	0	Updated SSRA team
Beef (BY SS) to Swine (S)	0	0	Updated SSRA team
Beef (BY SS) to Swine (L)	0	0	Updated SSRA team
Beef (BY SS) to Beef (BY SS)	0.0018	0.64	Updated SSRA team
Beef (BY SS) to Swine (BY SS)	0	0	Updated SSRA team

Swine (Backyard-Small Scale)

Parameters describing direct contact between swine (BY-SS) facilities and other production types were developed from producer interviews as described in the direct contact Beef (BY-SS) section (interviews are described in Appendix Section A6.2.2).

Table 58: Direct Contact Originating from Swine (BY SS) Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Swine (BY SS) to Beef (BY SS)	0	0	Updated SSRA team
Swine (BY SS) to Cow Calf	0	0	Updated SSRA team
Swine (BY SS) to Dairy	0	0	Updated SSRA team
Swine (BY SS) to Feedlot (L)	0	0	Updated SSRA team
Swine (BY SS) to Feedlot (S)	0	0	Updated SSRA team

Table 58: Direct Contact Originating from Swine (BY SS) Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Swine (BY SS) to Goats	0	0	Updated SSRA team
Swine (BY SS) to Sheep	0	0	Updated SSRA team
Swine (BY SS) to Small ruminants (BY SS)	0	0	Updated SSRA team
Swine (BY SS) to Swine (BY SS)	0.0014	0.5	Updated SSRA team
Swine (BY SS) to Swine (L)	1.0E-04	0.036	Updated SSRA team
Swine (BY SS) to Swine (S)	0.00014	0.050	Updated SSRA team

Small Ruminants (Backyard-Small Scale)

Parameters describing direct contact between small ruminants (BY-SS) facilities and other production types were developed from producer interviews as described in the direct contact Beef (BY-SS) section (interviews are described in Appendix Section A6.2.2).

Table 59: Direct Contact Originating from Small Ruminants (BY SS) Operations

Production Types	Kansas mean baseline direct contact rate (shipments/day)	Shipments per year	Parameter source
Small ruminant (BY SS) to Beef (BY SS)	0	0	Updated SSRA team
Small Ruminants (BY SS) to Cow Calf	0	0	Updated SSRA team
Small Ruminants (BY SS) to Dairy	0	0	Updated SSRA team
Small ruminants (BY SS) to Feedlot (S)	0	0	Updated SSRA team
Small ruminants (BY SS) to Feedlot (L)	0	0	Updated SSRA team
Small ruminants (BY SS) to Goats	0.0008	0.29	Updated SSRA team
Small ruminants (BY SS) to Sheep	0.001	0.37	Updated SSRA team
Small ruminants (BY SS) to Small Ruminants (BY SS)	0	0	Updated SSRA team
Small ruminants (BY SS) to Swine (BY SS)	0	0	Updated SSRA team
Small ruminants (BY SS) to Swine (L)	0	0	Updated SSRA team
Small ruminants (BY SS) to Swine (S)	0	0	Updated SSRA team

A6.2.17 Backyard and Small Scale Distance Distributions

Each backyard contact described in interviews was classified as a contact pair for the development of the direct contact rates. For example, if BY-SS producer A raises cows and purchases 2 cows a year (one at a time) from Cow-Calf B, his contact was included in the calculation of the Cow-Calf to Beef (BY-SS) direct contact rate. The typical distance traveled by animals when shipped to or from another producer was collected as part of the BY-SS Interviews (see Appendix Section A6.2.2.1). These distances were organized by contact pairing and used to estimate distance distribution functions.

To estimate overall distance distribution functions, first individual distance distribution functions were estimated for each contributing producer. If a producer gave a range for shipment distance, a uniform distribution was created for that range. If a single point estimate was provided, a normal distribution was used. A triangular distribution was used when a range and most likely value were provided. Using an R program, each function was randomly sampled using a weighted scheme to determine the number of samples taken for each individual distribution. The number of samples taken from a distribution was 1000 multiplied by the number of shipments the producer sent/received. The results from sampling from all distributions were pooled and fit with new distribution using @Risk (Table 60) to come up with the overall distance distribution for each pairing.

Table 60: Backyard and Small Scale Distance Distributions

Production Type	Distance Distribution Function (km)
Beef (BY SS) to Cow Calf	N/A
Beef (BY SS) to Dairy	N/A
Beef (BY SS) to Feedlot(L)	Loglogistic(0,44.241,16.755)
Beef (BY SS) to Feedlot(S)	Invgauss(378.8,18.226)
Beef (BY SS) to Goats	N/A
Beef (BY SS) to Sheep	N/A
Beef (BY SS) to Small Ruminants (BY SS)	N/A
Beef (BY SS) to Swine (S)	N/A
Beef (BY SS) to Swine (L)	N/A
Beef(BY SS) to Beef (BY SS)	Triang(0,47.013,52.438)
Beef(BY SS) to Swine (BY SS)	N/A
Cow calf to Beef (BY SS)	Loglogistic(0,22.439,2.9175)
Cow calf to Small Ruminants (BY SS)	N/A
Cow calf to Swine (BY SS)	N/A
Dairy to Beef (BY SS)	uniform(8,200)
Dairy to Small Ruminants (BY SS)	N/A
Dairy to Swine (BY SS)	N/A
Feedlot (L) to Small Ruminants (BY SS)	N/A
Feedlot (L) to Swine (BY SS)	N/A
Feedlot (S) to Small Ruminants (BY SS)	N/A
Feedlot (S) to Swine (BY SS)	N/A

Table 60: Backyard and Small Scale Distance Distributions

Production Type	Distance Distribution Function (km)
Feedlot (L) to Beef (BY SS)	N/A
Feedlot (S) to Beef (BY SS)	N/A
Feedlot to Beef (BY SS)	N/A
Goats to Beef (BY SS)	N/A
Goats to Small Ruminants (BY SS)	Weibull(1.7902,7.075)
Goats to Swine (BY SS)	N/A
Sheep to Beef (BY SS)	N/A
Sheep to Small Ruminants (BY SS)	Beta(0.6281,1.7056,0,585.04)
Sheep to Swine (BY SS)	N/A
Small Ruminants (BY SS) to Beef (BY SS)	N/A
Small Ruminants (BY SS) to Cow calf	N/A
Small Ruminants (BY SS) to Dairy	N/A
Small Ruminants (BY SS) to Feedlot (L)	N/A
Small Ruminants (BY SS) to Feedlot (S)	N/A
Small Ruminants (BY SS) to Sheep	uniform(16,120)
Small Ruminants (BY SS) to Small Ruminants (BY SS)	N/A
Small Ruminants (BY SS) to Swine (L)	N/A
Small Ruminants (BY SS) to Swine (S)	N/A
Small Ruminants (BY SS) to Swine (BY SS)	N/A
Small Ruminants (BY SS)to Goats	uniform(16,24)
Swine (BY SS) to Beef (BY SS)	N/A
Swine (BY SS) to Cow calf	N/A
Swine (BY SS) to Dairy	N/A
Swine (BY SS) to Feedlot (L)	N/A
Swine (BY SS) to Feedlot (S)	N/A
Swine (BY SS) to Goats	N/A
Swine (BY SS) to Sheep	N/A
Swine (BY SS) to Small Ruminants (BY SS)	N/A
Swine (BY SS) to Swine (BY SS)	uniform(16,160)
Swine (BY SS) to Swine (L)	gaussian(80,2)
Swine (BY SS) to Swine (S)	gaussian(80,2)
Swine (L) to Small Ruminants (BY SS)	N/A
Swine (L) to Swine (BY SS)	Triang(0,32.018,124.88)
Swine (L) to Beef (BY SS)	N/A
Swine (S) to Small Ruminants (BY SS)	N/A
Swine (S) to Swine (BY SS)	Triang(0,32.018,124.88)

Table 60: Backyard and Small Scale Distance Distributions

Production Type	Distance Distribution Function (km)
Swine (S) to Beef (BY SS)	N/A
Swine (S) to Beef (BY SS)	N/A

A6.2.17.1 Sample Calculation

This is a notional example of the distance distribution calculation for shipment of animals from (BY-SS) to cow-calf operations. Interviews identified two producers that send animals from their notional (BY-SS) farm to cow-calf operations every year. Farm A sends 1 shipment of animals about 50 km away each year, so a normal distance distribution was created to describe this producer behavior. Next, 1,000 samples are drawn from this distribution to contribute to the pool that will be used to generate the overall distance distribution for this pairing. Farm B sends two shipments to different farms every year, these farms are typically between 3 and 100 km away. For Farm B a uniform distribution is generated, for which 2,000 samples are drawn because two shipments are sent each year. The 3,000 distances generated are pooled into a single table and a distance distribution is fit using the @Risk distribution fitting tool.

Table 61: Simplified Example of Method Used to Develop BY SS Distance Distributions

	Annual Shipments sent to Cow-calf	Shipment distance	Individual distance distribution	Number of samples taken
Farm A	1	50 km	Normal (50,1)	1000
Farm B	2	3-100 km	Uniform (3,100)	2000

A6.2.18 Indirect Contact Rate Parameters

Indirect contact parameter development is described in Section 6.1.4.3. USDA evidence basis is provided below along with tables listing parameters.

A6.2.18.1 Cattle and Swine

USDA 2009 Evidence Basis

"Indirect contacts considered include veterinarians, feed and feed truck deliveries, milk truck pick-ups (dairy), salesmen, nutritionists, AI technicians (dairy or cow-calf), hoof trimmers, rendering trucks, external contract processors, employee contact, and neighbors. Indirect contacts through contract livestock haulers are included between swine and cattle.

According to NAHMS Beef 2008, the following table represents the percent of herds, by number of visits, during an average month (employees, veterinarians, nutritionists, commercial haulers, etc.):

Table 62: Data from NAHMS Beef 2008 [USDA/APHIS, 2009]

Number of visits per month	Central Region	All Regions
0	10.4%	17.9%
1 2	28.6%	24.7%
3 5	18.6%	21.1%
6 9	7.3%	6.9%
10+	35.1%	29.4%

Expert opinion was gathered from the following individuals: Drs. Mike Apley, Mike Brouk, Steve Dritz, Robert Larson, Dan Thomson, Brad White, and Jason Lombard

Indirect Contact Parameters

Table 63: Indirect Contact Parameters for Cattle and Swine Production Types

Production Type	Indirect Contact Rate (contacts/day)
Cow Calf to Cow Calf	0.02
Cow Calf to Dairy	0.104
Cow Calf to Feedlot (S)	0.147
Cow Calf to Feedlot (L)	1.152
Cow Calf to Swine (S)	0.004
Cow Calf to Swine (L)	0.035
Cow Calf to Sheep	0.005
Cow Calf to Goats	0.005
Dairy to Cow Calf	0.026
Dairy to Dairy	0.172
Dairy to Feedlot (S)	0.199
Dairy to Swine (S)	0.006
Dairy to Swine (L)	0.049
Dairy to Sheep	0.005
Dairy to Goats	0.005
Feedlot (S) to Cow Calf	0.005
Feedlot (S) to Dairy	0.022
Feedlot (S) to Feedlot (S)	0.036
Feedlot (S) to Feedlot (L)	0.266
Feedlot (S) to Swine (S)	0.002
Feedlot (S) to Swine (L)	0.031
Feedlot (S) to Sheep	0.005
Feedlot (S) to Goats	0.005
Feedlot (L) to Cow Calf	0.055
Feedlot (L) to Dairy	0.259
Feedlot (L) to Feedlot (S)	0.395
Feedlot (L) to Feedlot (L)	3.011

Table 63: Indirect Contact Parameters for Cattle and Swine Production Types

Production Type	Indirect Contact Rate (contacts/day)
Feedlot (L) to Swine (S)	0.017
Feedlot (L) to Swine (L)	0.22
Feedlot (L) to Sheep	0.005
Feedlot (L) to Goats	0.005
Swine (S) to Cow Calf	0.003
Swine (S) to Dairy	0.017
Swine (S) to Feedlot (S)	0.023
Swine (S) to Feedlot (L)	0.175
Swine (S) to Swine (S)	0.003
Swine (S) to Swine (L)	0.022
Swine (L) to Cow Calf	0.01
Swine (L)to Dairy	0.033
Swine (L) to Feedlot (S)	0.061
Swine (L) to Feedlot (L)	0.432
Swine (L) to Sheep	0.005
Swine (L) to Goats	0.005
Swine (L) to Swine (S)	0.009
Swine (L) to Swine (L)	0.128

A6.2.18.2 Sheep

USDA 2009 Evidence Basis

Sheep contact rates are from USDA 2009, with the paraphrased evidence basis provided here:

> *"Sheep are a relatively isolated production type, with limited contact with other livestock types. Contact between sheep and professional service providers is also limited. The high cost of veterinary services along with narrow profit margins dictate the restriction of veterinarian visits for serious disease problems only. Many commonly administered vaccines and biological products are purchased and administered by producers from livestock supply companies. In exception to this trend, rams undergo breeding soundness evaluation exams one to two times per year. Producers typically receive Information from health-professional sources at offsite meetings. Professionals are not likely to visit the farm premises. Shearer crews may shear sheep at multiple sites/locations that belong to a single producer. Visits by shearer crews are mostly applicable to large open-range flocks. Finally, only 10% of U.S. sheep producers used livestock haulers during 2001."*

The evidence basis for these parameters was based on NAHMS reports, and USDA 2009 team interpretations of an interview with a single subject matter expert, Dr. Brian Faris. This limited evidence basis is a weakness.

Development of indirect contact rates for BY-SS producers are described in Section 6.1.4.3.

Indirect Contact Parameters

Table 64: Indirect Contact Parameters for Sheep and Small Ruminant Facilities

Production Type	Indirect Contact Rate (contacts/day)
Sheep to Cow Calf	0.005
Sheep to Dairy	0.005
Sheep to Feedlot (L)	0.005
Sheep to Feedlot (S)	0.005
Sheep to Sheep	0.01
Sheep to Goats	0.005
Sheep to Swine (L)	0.005
Sheep to Swine (S)	0.005
Sheep to Beef (BY SS)	0.00274
Sheep to Small Ruminants (BY SS)	0.0136
Sheep to Swine (BY SS)	0.00013
Small Ruminant (BY SS) to Swine (L)	0.00165
Small Ruminant (BY SS) to Swine (S)	0.000235
Small Ruminants (BY SS) to Cow Calf	0.000618
Small Ruminants (BY SS) to Dairy	0.00347
Small Ruminants (BY SS) to Feedlot (L)	0.0340
Small Ruminants (BY SS) to Feedlot (S)	0.00464
Small Ruminants (BY SS) to Goats	0.000154
Small Ruminants (BY SS) to Sheep	0.00014
Small Ruminant (BY SS) to Beef (BY SS)	0.000428
Small Ruminant (BY SS) to Swine (BY SS)	0.00002
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0.00213

A6.2.18.3 Goats

USDA 2009 Evidence Basis

Goat contact rates are from USDA 2009, with the paraphrased evidence basis provided here:

> *"Goats are a relatively isolated production type, with limited contact with other livestock types. Contact between sheep and professional service providers is also limited. The high cost of veterinary services along with narrow profit margins dictate the restriction of veterinarian visits for serious disease problems only. Many commonly administered vaccines and biological products are purchased and administered by producers from*

> *livestock supply companies. In exception to this trend, bucks undergo breeding soundness evaluation exams one to two times per year. Producers typically receive Information from health-professional sources at offsite meetings. Professionals are not likely to visit the farm premises. As mentioned for sheep indirect contact, 10% of U.S. sheep producers used livestock haulers during 2001. It is likely that the percentage of goat producers using haulers is similar, or even lower."*

The evidence basis for these parameters was based on NAHMS reports, and USDA 2009 team interpretations of an interview with a single subject matter expert, Dr. Brian Faris. This limited evidence basis is a weakness.

Indirect Contact Parameters

Table 65: Indirect Contact Parameters for Goat Facilities

Production Type	Indirect Contact Rate (contacts/day)
Goats to Cow Calf	0.005
Goats to Dairy	0.005
Goats to Feedlot (S)	0.005
Goats to Feedlot (L)	0.005
Goats to Swine (L)	0.005
Goats to Swine (S)	0.005
Goats to Sheep	0.005
Goats to Goats	0.01
Goats to Beef (BY SS)	0.00273
Goats to Swine (BY SS)	0.00013
Goats to Small Ruminants (BY SS)	0.0136

A6.2.18.4 Backyard and Small-Scale Indirect Contact Parameters

Table 66: Indirect Contact Parameters for BY SS Facilities

Production Type	Indirect Contact Rate (contacts/day)
Cow Calf to Beef (BY SS)	0.0160
Cow Calf to Small Ruminants (BY SS)	0.0797
Cow Calf to Swine (BY SS)	0.000761
Dairy to Beef (BY SS)	0.0201
Dairy to Small Ruminants (BY SS)	0.100
Dairy to Swine (BY SS)	0.000954
Feedlot (S) to Beef (BY SS)	0.00261
Feedlot (S) to Small Ruminants (BY SS)	0.0130
Feedlot (S) to Swine (BY SS)	0.000124
Feedlot (L) to Beef (BY SS)	0.0226
Feedlot (L) to Small Ruminants (BY SS)	0.112
Feedlot (L) to Swine (BY SS)	0.00107

Table 66: Indirect Contact Parameters for BY SS Facilities

Production Type	Indirect Contact Rate (contacts/day)
Beef (BY SS) to Cow Calf	0.00982
Beef (BY SS) to Dairy	0.0552
Beef (BY SS) to Feedlot (L)	0.540
Beef (BY SS) to Feedlot (S)	0.0737
Beef (BY SS) to Goats	0.00246
Beef (BY SS) to Sheep	0.00222
Beef (BY SS) to Swine (L)	0.0262
Beef (BY SS) to Swine (S)	0.00374
Beef (BY SS) to Beef (BY SS)	0.00680
Beef (BY SS) to Swine (BY SS)	0.000323
Beef (BY SS) to Small Ruminant (BY SS)	0.0338
Swine (S) to Beef (BY SS)	0.00180
Swine (S) to Small Ruminants (BY SS)	0.00893
Swine (S) to Swine (BY SS)	0.000085
Swine (L) to Beef (BY SS)	0.00334
Swine (L) to Small Ruminants (BY SS)	0.0166
Swine (L) to Swine (BY SS)	0.000158
Swine (BY SS) to Cow Calf	0.000741
Swine (BY SS) to Dairy	0.00416
Swine (BY SS) to Feedlot (L)	0.0408
Swine (BY SS) to Feedlot (S)	0.00556
Swine (BY SS) to Goats	0.000185
Swine (BY SS) to Sheep	0.000168
Swine (BY SS) to Swine (L)	0.00198
Swine (BY SS) to Swine (S)	0.000282
Swine (BY SS) to Beef (BY SS)	0.000513
Swine (BY SS) to Swine (BY SS)	0.000024
Swine (BY SS) to Small Ruminants (BY SS)	0.00255
Sheep to Beef (BY SS)	0.00274
Sheep to Small Ruminants (BY SS)	0.0136
Sheep to Swine (BY SS)	0.00013
Small Ruminant (BY SS) to Swine (L)	0.00165
Small Ruminant (BY SS) to Swine (S)	0.000235
Small Ruminants (BY SS) to Cow Calf	0.000618
Small Ruminants (BY SS) to Dairy	0.00347
Small Ruminants (BY SS) to Feedlot (L)	0.0340
Small Ruminants (BY SS) to Feedlot (S)	0.00464

Table 66: Indirect Contact Parameters for BY SS Facilities

Production Type	Indirect Contact Rate (contacts/day)
Small Ruminants (BY SS) to Goats	0.000154
Small Ruminants (BY SS) to Sheep	0.00014
Small Ruminant (BY SS) to Beef (BY SS)	0.000428
Small Ruminant (BY SS) to Swine (BY SS)	0.00002
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0.00213
Goats to Beef (BY SS)	0.00273
Goats to Swine (BY SS)	0.00013
Goats to Small Ruminants (BY SS)	0.0136

A6.2.19 Probability of Infection Given Exposure for Indirect Contact

As mentioned in Chapter 6, USDA 2011 parameters were developed using a different set of production types than the production types used for the Updated SSRA mode. In Table 67, both production type combinations have been provided along with the “probability of infection given exposure by indirect contact” parameter used for the Updated SSRA model.

Table 67: Probability of Infection Given Exposure for Indirect Contact

Updated SSRA Production Type Pair	USDA 2011 Production Type Pair	Indirect Contact: Probability of Infection Given Exposure
Cow Calf to Cow Calf	All Cow-Calf to all cow-calf	0.1263
Cow Calf to Dairy	all Cow-Calf to all Dairy	0.2795
Cow Calf to Feedlot (L)	Cow-Calf to Feedlot	0.1384
Cow Calf to Feedlot (S)	Cow-Calf to Feedlot	0.1384
Cow Calf to Goats	Cow-Calf to Small Ruminant	0.4286
Cow Calf to Sheep	Cow-Calf to Small Ruminant	0.4286
Cow Calf to Swine (L)	Cow-Calf to Swine	0.5937
Cow Calf to Swine (S)	Cow-Calf to Swine	0.5937
Dairy to Cow Calf	Dairy to Cow-Calf	0.1263
Dairy to Dairy	Dairy to Dairy	0.2795
Dairy to Feedlot (L)	Dairy to Feedlot (all)	0.1384
Dairy to Feedlot (S)	Dairy to Feedlot (all)	0.1384
Dairy to Goats	Dairy to Small Ruminant	0.4286
Dairy to Sheep	Dairy to Small Ruminant	0.4286
Dairy to Swine (L)	Dairy to Swine	0.5937
Dairy to Swine (S)	Dairy to Swine	0.5937

Table 67: Probability of Infection Given Exposure for Indirect Contact

Updated SSRA Production Type Pair	USDA 2011 Production Type Pair	Indirect Contact: Probability of Infection Given Exposure
Feedlot (L) to Cow Calf	Feedlot (all) to Cow-Calf	0.1263
Feedlot (L) to Dairy	Feedlot (all) to Dairy	0.2795
Feedlot (L) to Feedlot (L)	Feedlot (all, except company feedlot) to Feedlot (all, except company feedlot)	0.1384
Feedlot (L) to Feedlot (S)	Feedlot (all, except company feedlot) to Feedlot (all, except company feedlot)	0.1384
Feedlot (L) to Goats	Feedlot (all) to Small Ruminant	0.4286
Feedlot (L) to Sheep	Feedlot (all) to Small Ruminant	0.4286
Feedlot (L) to Swine (L)	Feedlot (all) to Swine	0.5937
Feedlot (L) to Swine (S)	Feedlot (all) to Swine	0.5937
Feedlot (S) to Cow Calf	Feedlot (all) to Cow-Calf	0.1263
Feedlot (S) to Dairy	Feedlot (all) to Dairy	0.2795
Feedlot (S) to Feedlot (L)	Feedlot (all, except company feedlot) to Feedlot (all, except company feedlot)	0.1384
Feedlot (S) to Feedlot (S)	Feedlot (all, except company feedlot) to Feedlot (all, except company feedlot)	0.1384
Feedlot (S) to Goats	Feedlot (all) to Small Ruminant	0.4286
Feedlot (S) to Sheep	Feedlot (all) to Small Ruminant	0.4286
Feedlot (S) to Swine (L)	Feedlot (all) to Swine	0.5937
Feedlot (S) to Swine (S)	Feedlot (all) to Swine	0.5937
Goats to Cow Calf	Small Ruminant to Cow-Calf	0.1263
Goats to Dairy	Small Ruminant to Dairy	0.2795
Goats to Feedlot (L)	Small Ruminant to Feedlot	0.1384
Goats to Feedlot (S)	Small Ruminant to Feedlot	0.1384
Goats to Goats	Small Ruminant to Small Ruminant	0.2143
Goats to Sheep	Small Ruminant to Small Ruminant	0.2143
Goats to Swine (L)	Small Ruminant to Swine	0.5937
Goats to Swine (S)	Small Ruminant to Swine	0.5937
Sheep to Cow Calf	Small Ruminant to Cow-Calf	0.1263
Sheep to Dairy	Small Ruminant to Dairy	0.2795
Sheep to Feedlot (L)	Small Ruminant to Feedlot	0.1384
Sheep to Feedlot (S)	Small Ruminant to Feedlot	0.1384

Table 67: Probability of Infection Given Exposure for Indirect Contact

Updated SSRA Production Type Pair	USDA 2011 Production Type Pair	Indirect Contact: Probability of Infection Given Exposure
Sheep to Goats	Small Ruminant to Small Ruminant	0.2143
Sheep to Sheep	Small Ruminant to Small Ruminant	0.2143
Sheep to Swine (L)	Small Ruminant to Swine	0.5937
Sheep to Swine (S)	Small Ruminant to Swine	0.5937
Swine (S) to Cow Calf	Swine to Cow-Calf	0.1083
Swine (L) to Cow Calf	Swine to Cow-Calf	0.1083
Swine (L) to Dairy	Swine to Dairy	0.2396
Swine (S) to Dairy	Swine to Dairy	0.2396
Swine (S) to Feedlot (S)	Swine to Feedlot (all)	0.1186
Swine (L) to Feedlot (S)	Swine to Feedlot (all)	0.1186
Swine (S) to Feedlot (L)	Swine to Feedlot (all)	0.1186
Swine (L) to Feedlot (L)	Swine to Feedlot (all)	0.1186
Swine (L) to Goats	Swine to Small Ruminants	0.4286
Swine (S) to Goats	Swine to Small Ruminants	0.4286
Swine (L) to Sheep	Swine to Small Ruminants	0.4286
Swine (S) to Sheep	Swine to Small Ruminants	0.4286
Swine (L) to Swine (L)	Swine to Swine	0.3299
Swine (S) to Swine (L)	Swine to Swine	0.3299
Swine (L) to Swine (S)	Swine to Swine	0.3299
Swine (S) to Swine (S)	Swine to Swine	0.3299
Beef (BY SS) to Cow Calf	Cow-Calf to Cow-Calf	0.1263
Beef (BY SS) to Dairy	Cow-Calf to Dairy	0.2795
Beef (BY SS) to Feedlot (L)	Cow-Calf to Feedlot	0.1384
Beef (BY SS) to Feedlot (S)	Cow-Calf to Feedlot	0.1384
Beef (BY SS) to Goats	Cow-Calf to Small Ruminant	0.4286
Beef (BY SS) to Sheep	Cow-Calf to Small Ruminant	0.4286
Beef (BY SS) to Small Ruminant (BY SS)	Cow-Calf to Small Ruminant	0.4286
Beef (BY SS) to Swine (S)	Cow-Calf to Swine	0.5937
Beef (BY SS) to Swine (L)	Cow-Calf to Swine	0.5937
Beef (BY SS) to Beef (BY SS)	Cow-Calf to Cow-Calf	0.2795
Beef (BY SS) to Swine (BY SS)	Cow-Calf to Swine	0.5937
Cow Calf to Beef (BY SS)	Cow-Calf to Cow-Calf	0.2795
Cow Calf to Small Ruminants (BY SS)	Cow-Calf to Small Ruminant	0.4286
Cow Calf to Swine (BY SS)	Cow-Calf to Swine	0.5937

Table 67: Probability of Infection Given Exposure for Indirect Contact

Updated SSRA Production Type Pair	USDA 2011 Production Type Pair	Indirect Contact: Probability of Infection Given Exposure
Dairy to Beef (BY SS)	Dairy to Cow-Calf	0.2795
Dairy to Small Ruminants (BY SS)	Dairy to Small Ruminant	0.4286
Dairy to Swine (BY SS)	Dairy to Swine	0.5937
Feedlot (L) to Beef (BY SS)	Feedlot to Cow-Calf	0.2795
Feedlot (L) to Small Ruminants (BY SS)	Feedlot to Small Ruminant	0.4286
Feedlot (L) to Swine (BY SS)	Feedlot to Swine	0.5937
Feedlot (S) to Beef (BY SS)	Feedlot to Cow-Calf	0.2795
Feedlot (S) to Small Ruminants (BY SS)	Feedlot to Small Ruminant	0.4286
Feedlot (S) to Swine (BY SS)	Feedlot to Swine	0.5937
Goats to Beef (BY SS)	Small Ruminant to Cow-Calf	0.2795
Goats to Small Ruminants (BY SS)	Small Ruminant to Small Ruminant	0.2143
Goats to Swine (BY SS)	Small Ruminant to Swine	0.5937
Sheep to Beef (BY SS)	Small Ruminant to Cow-Calf	0.2795
Sheep to Small Ruminants (BY SS)	Small Ruminant to Small Ruminant	0.2143
Sheep to Swine (BY SS)	Small Ruminant to Swine	0.5937
Small Ruminant (BY SS) to Beef (BY SS)	Small Ruminant to Cow-Calf	0.2795
Small Ruminants (BY SS to Goats	Small Ruminant to Small Ruminant	0.2143
Small Ruminants (BY SS) to Cow Calf	Small Ruminant to Cow-Calf	0.1263
Small Ruminants (BY SS) to Dairy	Small Ruminant to Dairy	0.2795
Small Ruminants (BY SS) to Feedlot (L)	Small Ruminant to Feedlot	0.1384
Small Ruminants (BY SS) to Feedlot (S)	Small Ruminant to Feedlot	0.1384
Small Ruminants (BY SS) to Sheep	Small Ruminant to Small Ruminant	0.2143
Small Ruminants (BY SS) to Small Ruminants (BY SS)	Small Ruminant to Small Ruminant	0.2143
Small Ruminants (BY SS) to Swine (L)	Small Ruminant to Swine	0.5937
Small Ruminants (BY SS) to Swine (S)	Small Ruminant to Swine	0.5937
Small Ruminants (BY SS) to Swine (BY SS)	Small Ruminant to Swine	0.5937
Swine (BY SS) to Beef (BY SS)	Swine to Cow-Calf	0.2396
Swine (BY SS) to Cow Calf	Swine to Cow-Calf	0.1083

Table 67: Probability of Infection Given Exposure for Indirect Contact

Updated SSRA Production Type Pair	USDA 2011 Production Type Pair	Indirect Contact: Probability of Infection Given Exposure
Swine (BY SS) to Dairy	Swine to Dairy	0.2396
Swine (BY SS) to Feedlot (L)	Swine to Feedlot	0.1186
Swine (BY SS) to Feedlot (S)	Swine to Feedlot	0.1186
Swine (BY SS) to Goats	Swine to Small Ruminant	0.4286
Swine (BY SS) to Sheep	Swine to Small Ruminant	0.4286
Swine (BY SS) to Small Ruminants (BY SS)	Swine to Swine	0.4286
Swine (BY SS) to Swine (BY SS)	Swine to Swine	0.3299
Swine (BY SS) to Swine (L)	Swine to Swine	0.3299
Swine (BY SS) to Swine (S)	Swine to Swine	0.3299
Swine (L) to Swine (BY SS)	Swine to Swine	0.3299
Swine (S) to Swine (BY SS)	Swine to Swine	0.3299
Swine (L) to Beef (BY SS)	Swine to Cow-Calf	0.2396
Swine (S) to Beef (BY SS)	Swine to Cow-Calf	0.2396
Swine (S) to Small Ruminants (BY SS)	Swine to Small Ruminant	0.4286
Swine (L) to Small Ruminants (BY SS)	Swine to Small Ruminant	0.4286

A6.2.20 State Estimates on Movement Control Capabilities

A6.2.20.1 Rationale and Methods

Phone interviews were conducted with representatives of the Departments of Agriculture of Kansas, Nebraska, Missouri, and Iowa. For both direct and indirect movement, the representatives were asked to estimate the ability over time of the state to control movement. In particular, the representatives were asked to provide estimates in the form of percentages of ‘normal’ movement over time relative to the declaration of an FMD outbreak. Movement control here refers to the restriction of travel within and out of a 10-km zone around an infected premise.

A6.2.20.2 Results and Discussion

All four representatives provided quantitative data for the first day through two weeks after the declaration of an FMD outbreak. For both movement types, all state representatives predict that movement will sharply decline immediately after the outbreak declaration and then rise back up over time (Table 68 and Table 69). These data indirectly informed the movement control parameter implemented for the Updated SSRA, because zoned movement control was not used, as explained in Section 6.1.4.3. Individual state responses are not provided because this information is considered sensitive because it reveals strong and weak points in the nation's preparedness for an agricultural emergency.

Table 68: State Estimates of Direct Movement Control Efficacy

The percent of normal direct movement by state achieved days after the declaration of an FMD outbreak, based on SME opinion.

State	Day's after FMD outbreak declaration								
	1	2	3	4	5	6	7	8	9
Maximum movement control	100	0	0	0	0	0	0	0	0
Minimum movement control	100	30	30	30	30	30	50	50	50
Average movement control	95	20	14	15	15	15	25	25	25

Table 69: State Estimates of Indirect Movement Control Efficacy

The percent of normal indirect movement by state achieved days after the declaration of an FMD outbreak, based on SME opinion. N.p: implies information not provided.

State	Day's after FMD outbreak declaration								
	1	2	3	4	5	6	7	8	9
Minimum movement control	100	30	30	30	30	30	50	50	50
Maximum movement control	100	50	25	5	5	5	5	5	5
Average movement control	93	27	18	22	22	22	35	35	35

A6.2.21 USDA Vaccination Interviews

A6.2.21.1 Rationale and Methods

In order to inform vaccination parameters for the NAADSM model, a conference call was held with members of the NBAF SSRA team (Signature Science, Gryphon Scientific, SES), CEAH, and at least 5 experts from USDA Animal and Plant Health Inspection Service (USDA APHIS) who could share knowledge on state vaccination strategies and producer response. The purpose of the conversation was to obtain expertise regarding triggering and deploying a vaccination response that might reflect current U.S. policy. Specifically, the following questions were posed:

- How many confirmed detections of FMD would trigger a vaccination response?
- What deployment processes would take place between triggering a response and physically vaccinating an animal?
- What influences or affects the amount of animals or herds that can be vaccinated in a day?

A follow-up data validation email was sent requesting additional comments on the values of other parameters not discussed during the call. Specifically, a timeline and datasheet listing the parameter values was sent. Additional questions were added for clarification and comment:

- Factors that will affect the number of animals vaccinated in an hour/day:
- Vaccine Resources
  - The quantity of vaccines distributed to a producer?
- Human Resources
  - How many people are needed to vaccinate and tag one animal?
  - How many animals can be tagged in an hour?
- Equipment Resources
  - Which facilities have chutes (How many to what size of facility)?
  - How many animals can be vaccinated per chute in an hour?
  - How many animals can be vaccinate without a chute in an hour?
- Factors that will affect the number of herds vaccinated in an hour/day:
  - What is the quantity of vaccines in the stockpile?
  - What is the quantity of vaccines that can be manufactured and supplied a regular rate?

A6.2.21.2 Results and Discussion

Discussion during the conference call focused on current and future policy regarding the three questions listed above. These discussions provided data that contributed primarily to the development of the triggering herd value and the vaccination capacity. Details regarding what affected vaccination rates were further elaborated on in follow-up correspondence.

USDA noted that the FMD vaccine bank and the type of FMD vaccine available for use may be different than what is currently available based on vaccine technology and policy changes. However, under current plans, Commissioners of the North American FMD Vaccine Bank (NAFMDVB) have instituted a policy that activates the NAFMDVB when the FMD virus serotype and subtype have been confirmed and vaccine matching determines which specific vaccine should be used. (The NAFMDVB is managed by the U.S. for the three member countries, Canada, Mexico and the U.S.). The length of time to determine what vaccine to use depends on the serotype. If it is a serotype with limited antigenic differences, the determination will be made rapidly, however, some serotypes have multiple strains requiring additional laboratory work that may take several days.

Vaccine bank activation would take place prior to an official decision being made by any of the member countries to actually use vaccine. This activation would provide for the current vaccine antigen concentrates of the selected vaccine to be shipped to the manufacturer for production of finished vaccine. It is expected that this activation would take place regardless if the FMD detection was related to a release from NBAF or some other type of introduction. It was generally agreed that the first confirmed case of FMD and therefore the first detected herd would trigger a vaccination response.

The NAFMDVB uses a decision matrix that takes into account both outbreak (contact rate, host or species affected/at risk, status of outbreak and environmental) and mitigation (physical resources, human resources, socio-political) factors to make a decision on use of vaccine. Therefore, the vaccination strategy employed relies heavily on the actual situation and the vaccine available. A preliminary delivery of vaccination supplies and vaccine would occur with supplementary vaccine production orders placed concurrently. Once the vaccine was obtained and on location, the vaccination process would begin.

Specific elements of deployment were discussed such as the quantity and availability of stockpiled vaccine, human resources and equipment. While serotype matching and vaccine selection was estimated to take 48 hours, deployment of the vaccine supply would take several days unless finished vaccine that matches the outbreak strain is available through commercial contracts.

To minimize the time to conduct vaccination of designated animals and make maximal use of governmental resources, USDA officials indicated that a vaccination strategy would include plans in conjunction with the Incident Command in the area to allow producers with appropriate oversight to administer vaccines to their own herds. The number of people required to administer vaccine was suggested that 2-4 people would be needed at cow-calf operations, 4-5 at a feedlot, and 2-3 at a dairy. The rate of vaccination and tagging would depend on the availability of equipment and personnel.

A6.2.21.3 Assumptions

Though the discussion provided elaboration on vaccination processes and deployment capabilities, the availability of vaccine is a key part of response. For security purposes, the stockpile quantity or current capability to procure vaccines was not provided. Therefore, it was decided that vaccine availability would not be considered a limiting factor in vaccination capacity.

A6.3 Estimating Probability of Spread to States Other than Kansas

A6.3.1 Wildlife Data Collection (states other than Kansas)

While most states maintain harvest data on wildlife species in their state, estimates of total population or population density were not always available. All states modeled had significant deer populations. Elk and pronghorn were only present in some states; these populations tend to be small compared to deer populations. Nebraska also has two bighorn sheep populations with between 100-200 animals total [Taylor, 2011].

Feral swine could play a significant role in an FMD outbreak in several states modeled. Texas, Oklahoma, and Missouri all have significant, uncontrolled feral swine populations (Figure 26). Colorado, Iowa, and Nebraska have small feral swine populations. Feral swine would likely play a minor role in an FMD outbreak in these states. All three states have task forces to eradicate introduced swine [Garner, 2011; Pelzer, 2011]. Iowa has trapped and killed a total of 181 feral swine since 2006 [Garner, 2011].

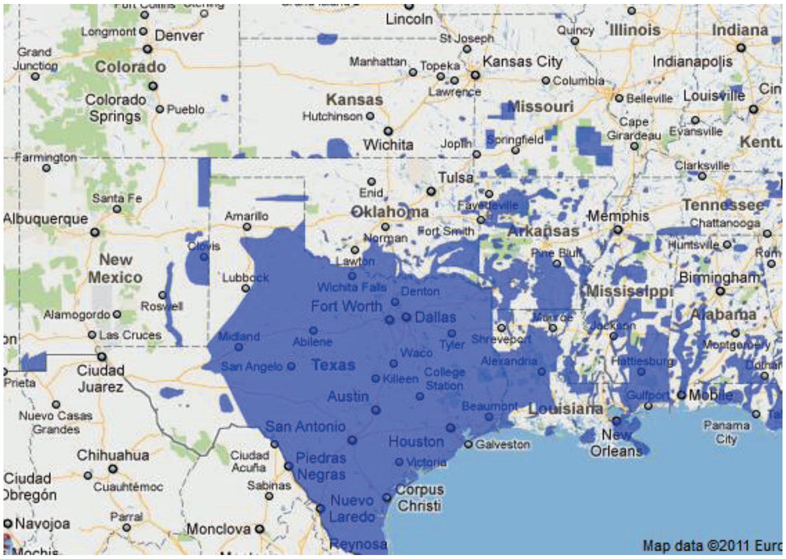


Figure 26: National Feral Swine Mapping System Swine Populations in the Modeled Region [College of Veterinary Medicine, 2007]

A6.3.2 State Within-Herd Model Data and Herd-Level Parameter Development

A6.3.2.1 Setting Up and Running the Model

A within-herd model was developed for each production type population in each state modeled, as described in Appendix Section A6.2.12.1.

Parameters Entered into Within-Herd Model: Origin and Development

Within-herd model input parameters included: state specific population distributions, initial disease state of each animal (latent, subclinical, clinical), adequate exposures per time step, and animal-level disease phase functions.

Population distribution functions were produced for each state, for each production type, using the population file described in Appendix Section A6.2.1.2. The statistical program, R, was used to generate population distributions as histogram graphs for each production type in the state. The population distributions for Oklahoma (Figure 27 through Figure 37), Iowa (Figure 38 through Figure 48), Texas (Figure 49 through Figure 59), Nebraska (Figure 60 through Figure 70), Missouri (Figure 71 through Figure 81), and Colorado (Figure 82 through Figure 92) are shown below.

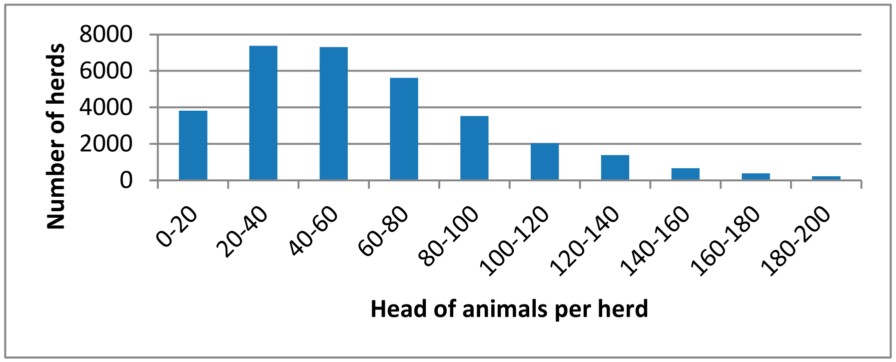


Figure 27: Oklahoma Cow-calf Population Distribution: Cut off after 200 head (an additional 770 herds between 200 – 5,880 head)

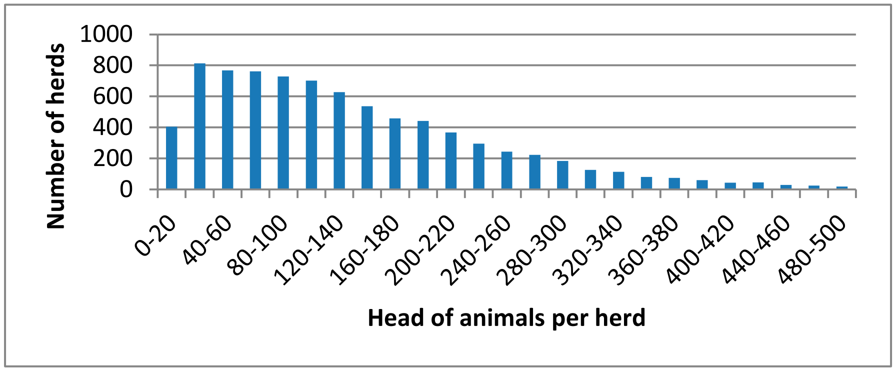


Figure 29: Oklahoma Feedlot (S) Population Distribution: Cut off after 500 head (an additional 26 herds between 500 – 2,560 head)

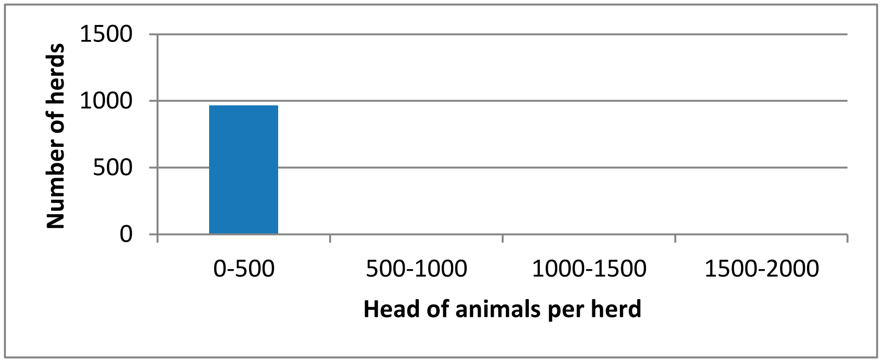


Figure 28: Oklahoma Dairy Population Distribution: Cut off after 2,000 head (an additional 3 herds between 2,000 – 34,000 head)

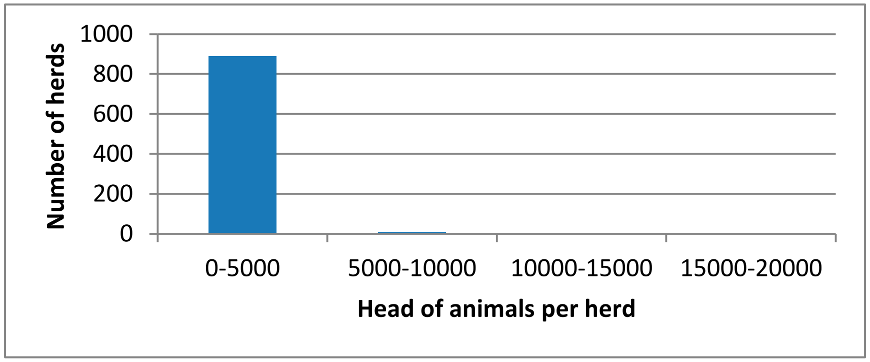


Figure 30: Oklahoma Feedlot (L) Population Distribution: Cut off after 2,000 head (an additional 9 herds between 2,000 – 250,000 head)

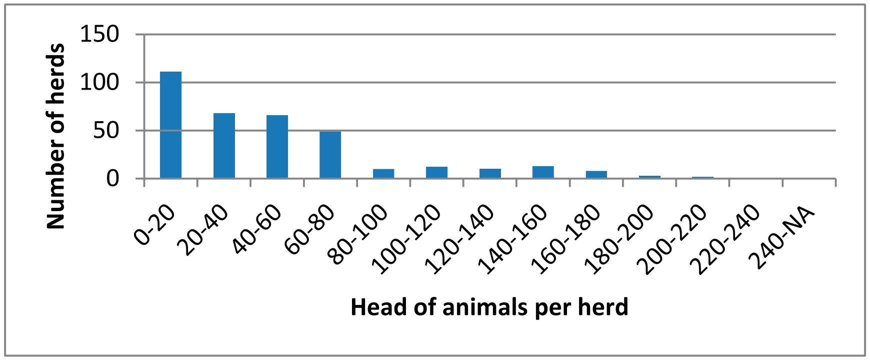


Figure 31: Oklahoma Swine (S) Population Distribution

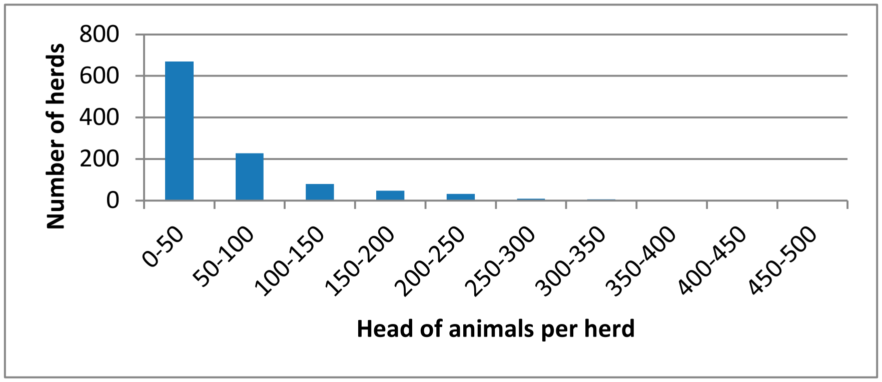


Figure 33: Oklahoma Sheep Population Distribution: Cut off after 500 head (an additional 5 herds between 500 – 1,900 head)

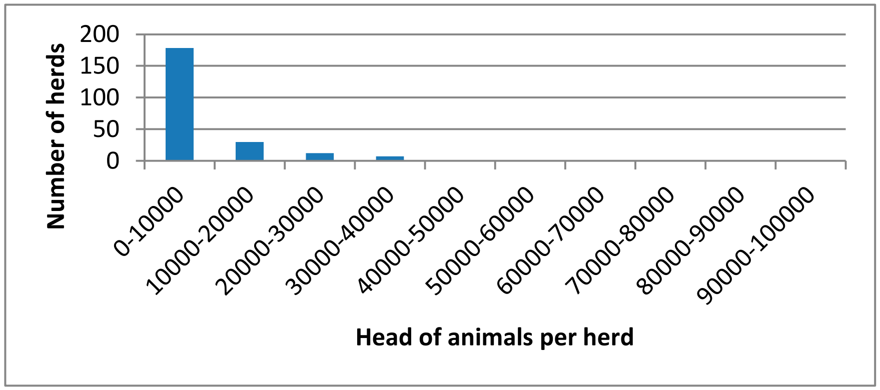


Figure 32: Oklahoma Swine (L) Population Distribution: Cut off after 100,000 head (an additional 2 herds between 100,000 – 190,000 head)

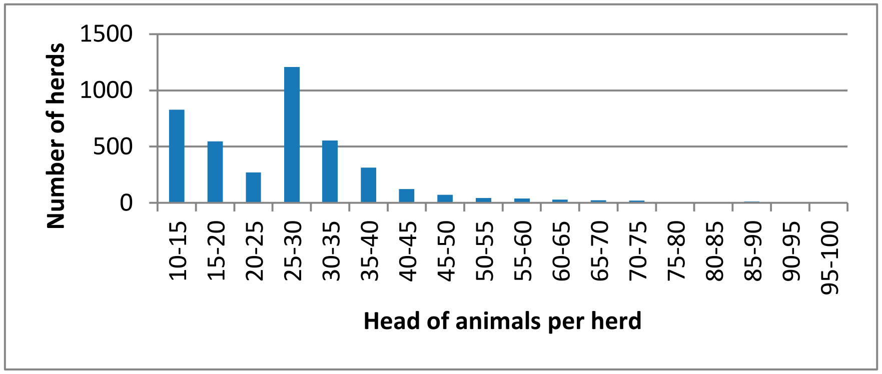


Figure 34: Oklahoma Goats Population Distribution: Cut off after 100 head (an additional 30 herds between 100 – 190 head)

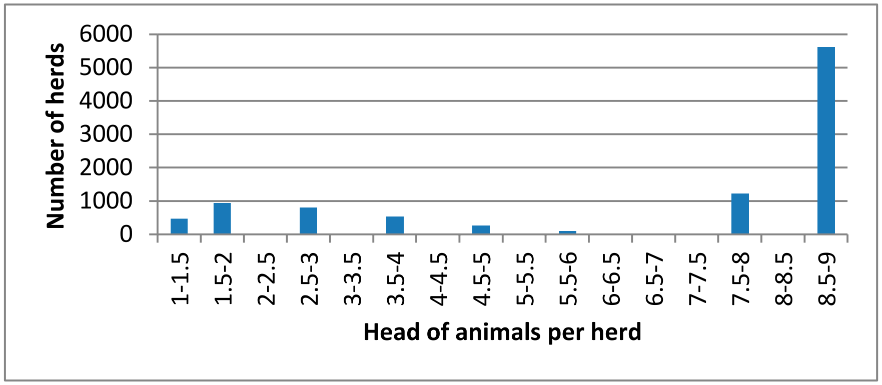


Figure 35: Oklahoma Beef (BY-SS) Population Distribution

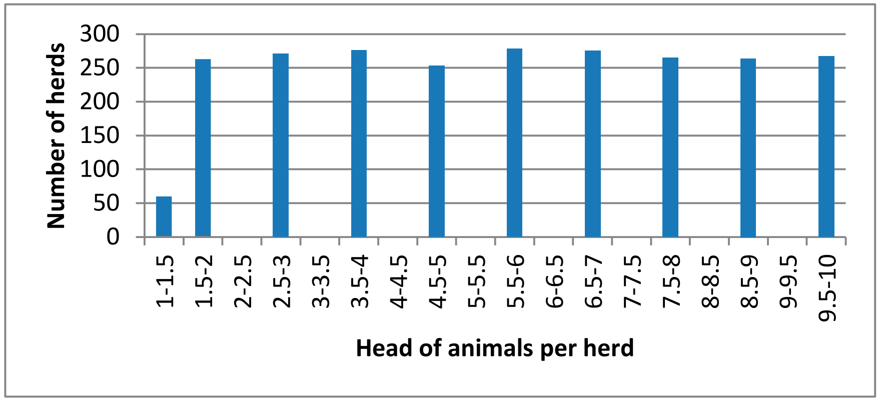


Figure 37: Oklahoma Small Ruminant (BY-SS) Population Distribution

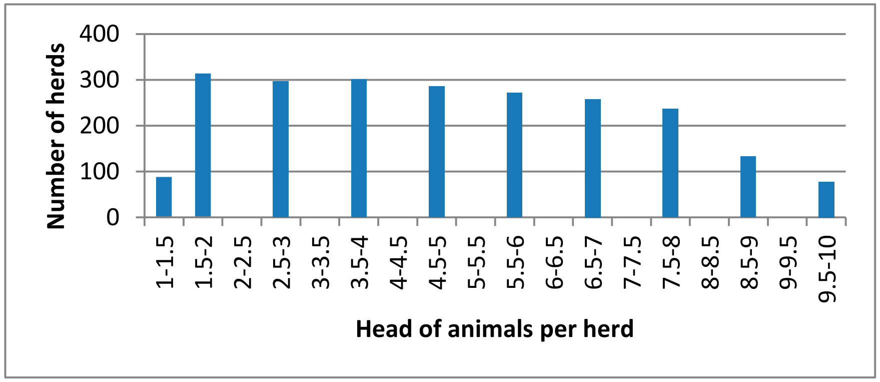


Figure 36: Oklahoma Swine (BY-SS) Population Distribution

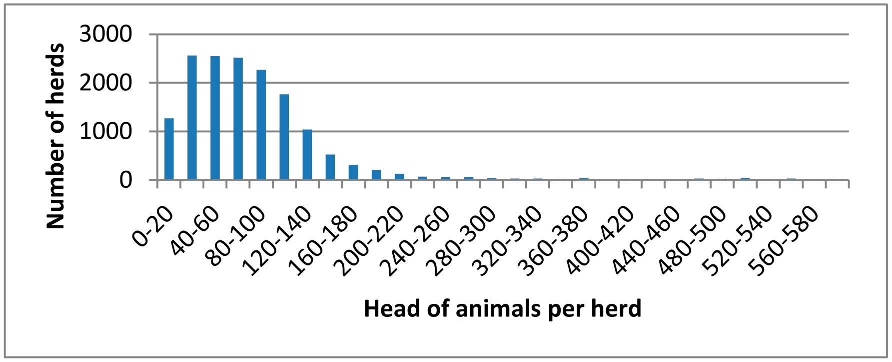


Figure 38: Iowa Cow-calf Population Distribution: Cut off after 600 head (an additional 263 herds between 600 – 3,240 head)

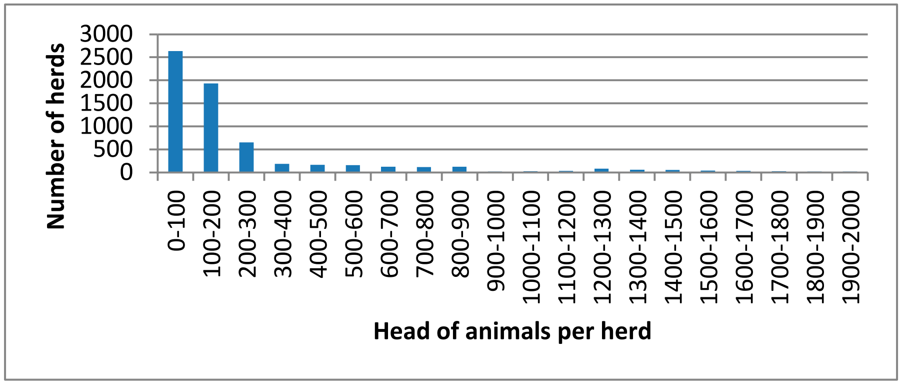


Figure 40: Iowa Feedlot (S) Population Distribution: Cut off after 2,000 head (an additional 66 herds between 2,000 – 3,000 head)

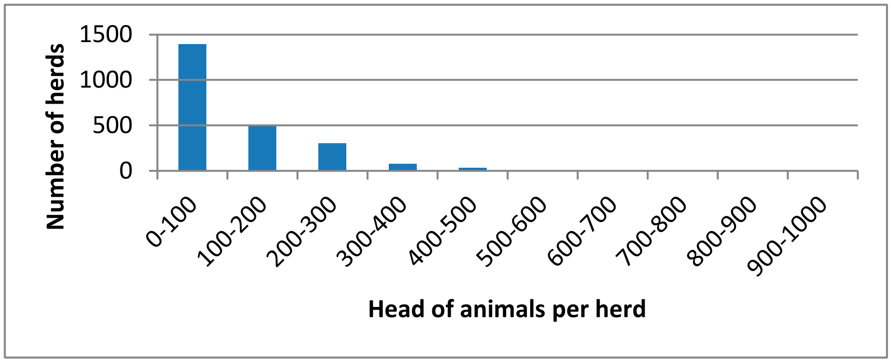


Figure 39: Iowa Dairy Population Distribution: Cut off after 1,000 head (an additional 53 herds between 1,000 – 3,400 head)

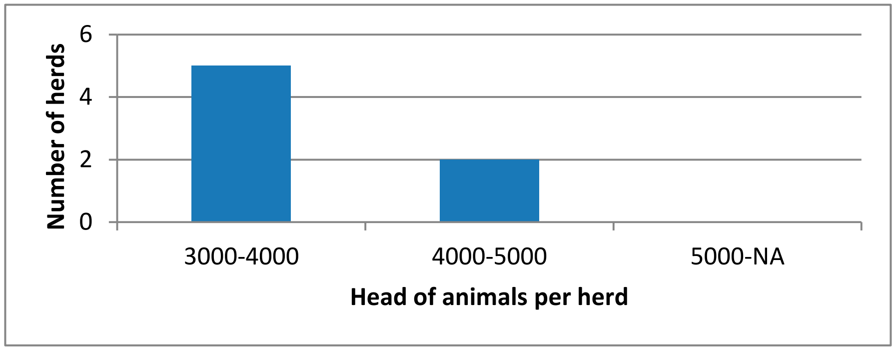


Figure 41: Iowa Feedlot (L) Population Distribution

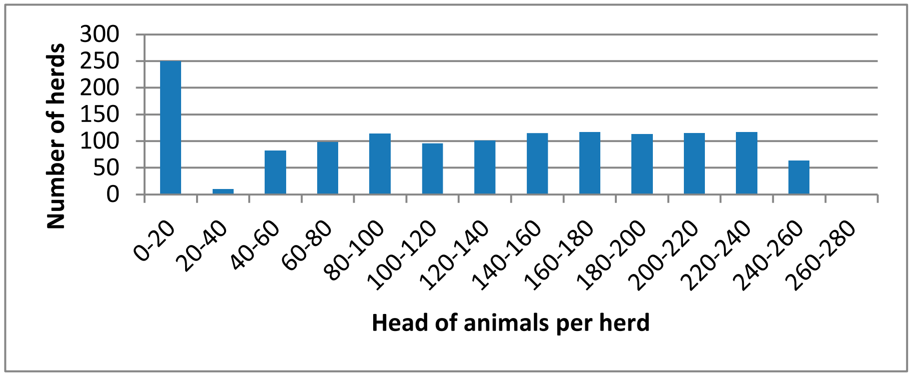


Figure 42: Iowa Swine (S) Population Distribution

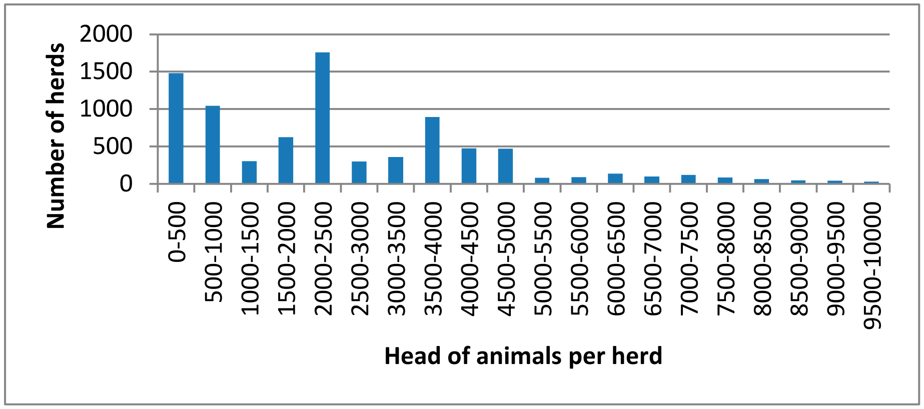


Figure 43: Iowa Swine (L) Population Distribution: Cut off after 10,000 head (an additional 142 herds between 10,000 – 64,000 head)

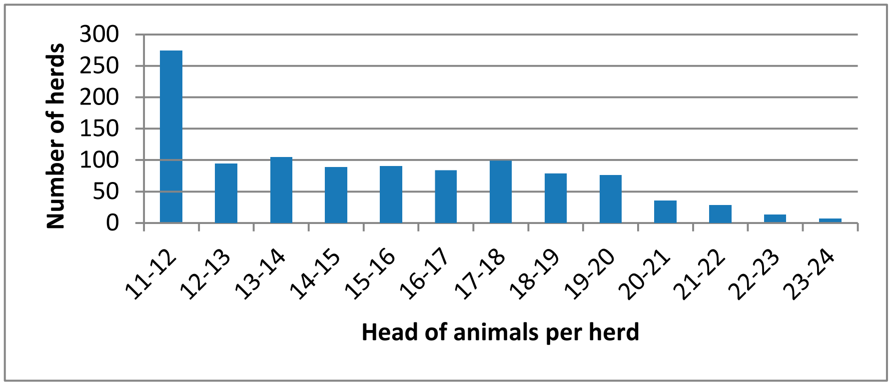


Figure 44: Iowa Sheep Population Distribution

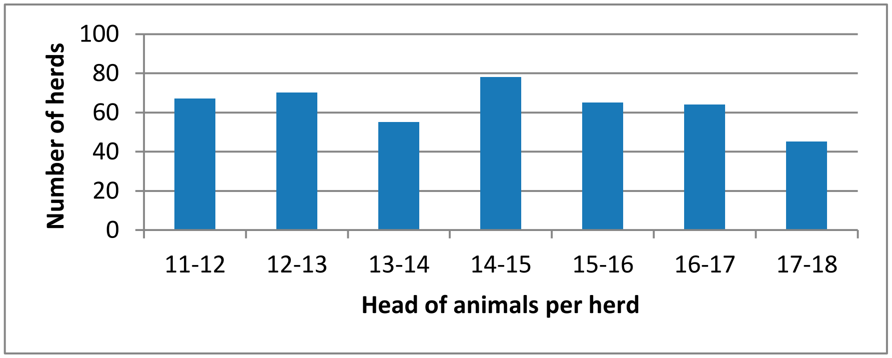


Figure 45: Iowa Goats Population Distribution

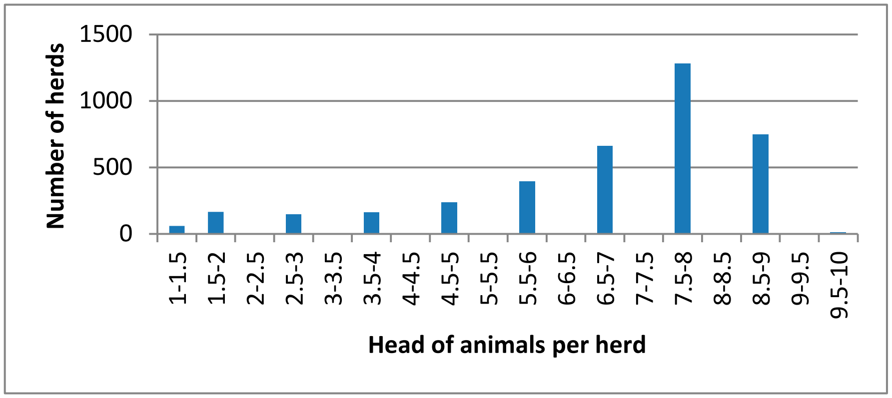


Figure 46: Iowa Beef (BY-SS) Population Distribution

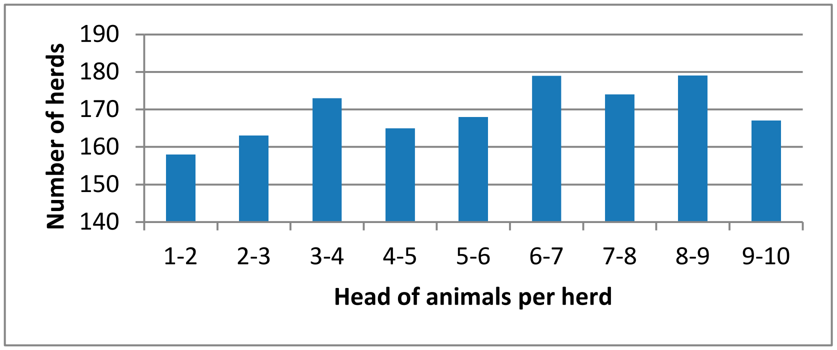


Figure 48: Iowa Small Ruminants (BY-SS) Population Distribution

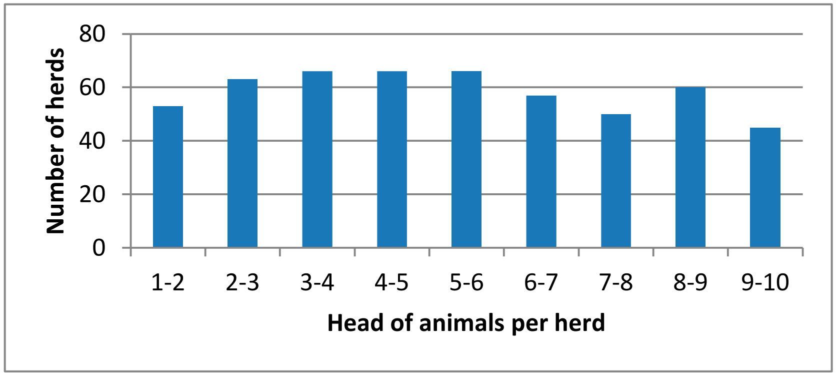


Figure 47: Iowa Swine (BY-SS) Population Distribution

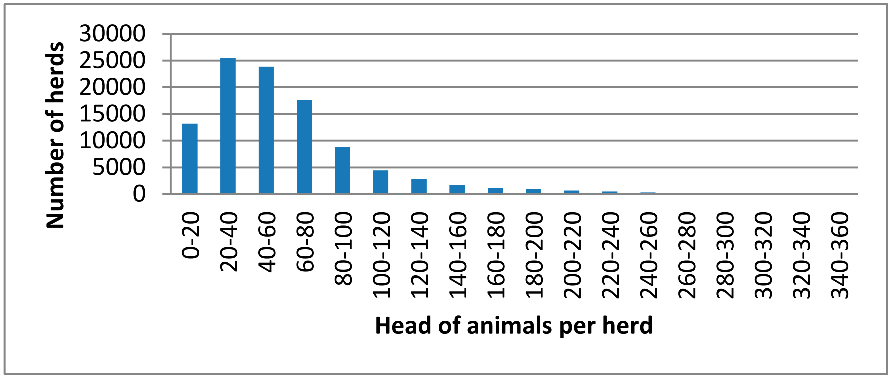


Figure 49: Texas Cow-calf Population Distribution: Cut off after 360 head (an additional 2594 herds between 360 – 17,180 head)

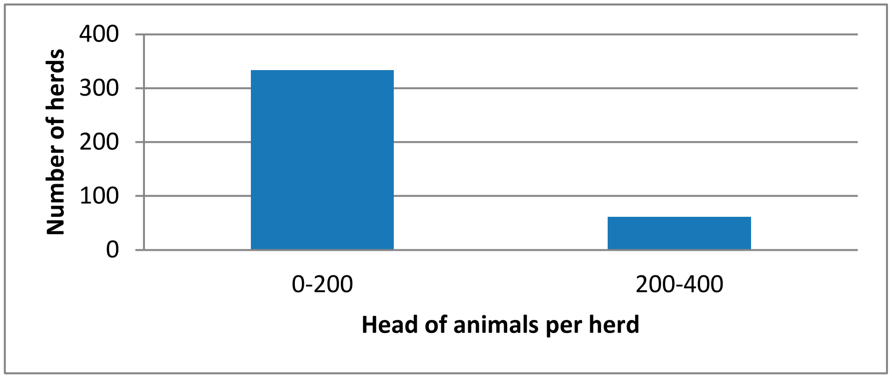


Figure 51: Texas Feedlot (S) Population Distribution: Cut off after 360 head (an additional 15 herds between 400 – 2,600 head)

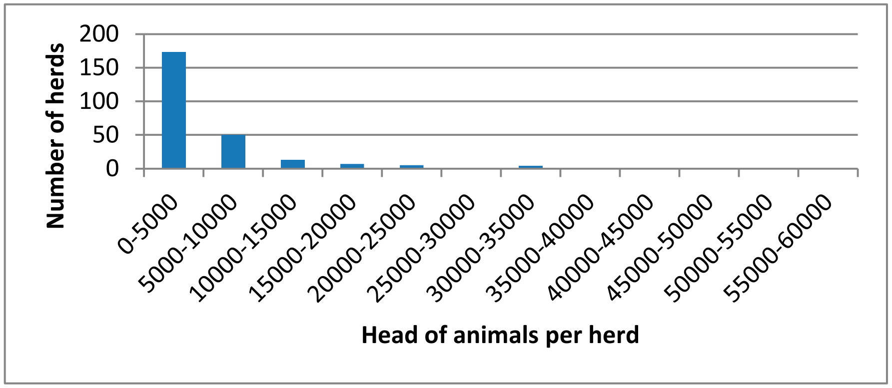


Figure 50: Texas Dairy Population Distribution

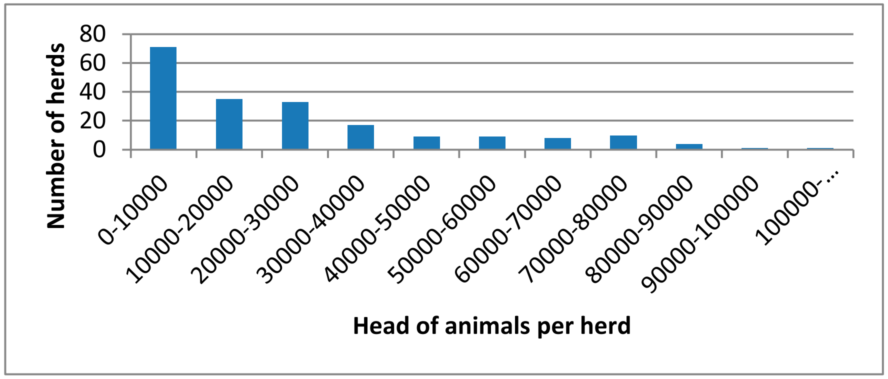


Figure 52: Texas Feedlot (L) Population Distribution

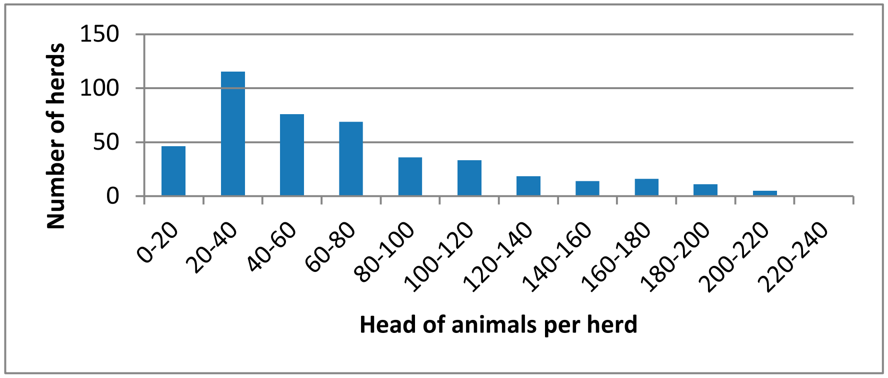


Figure 53: Texas Swine (S) Population Distribution

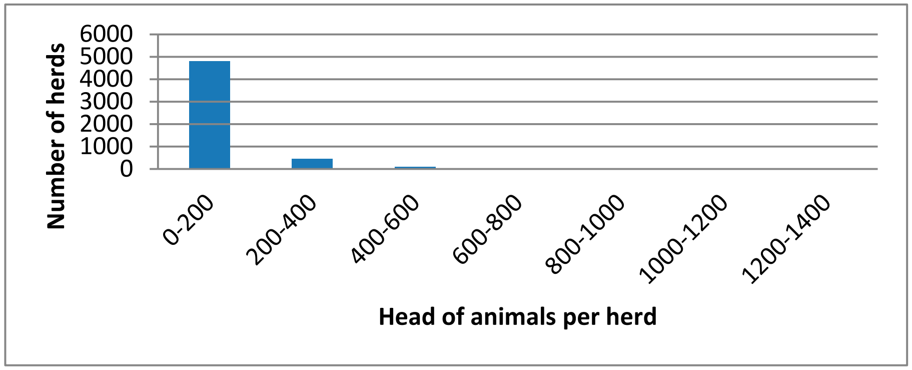


Figure 55: Texas Sheep Population Distribution: Cut off after 1400 head (an additional 157 herds between 1400 – 50,000 head)

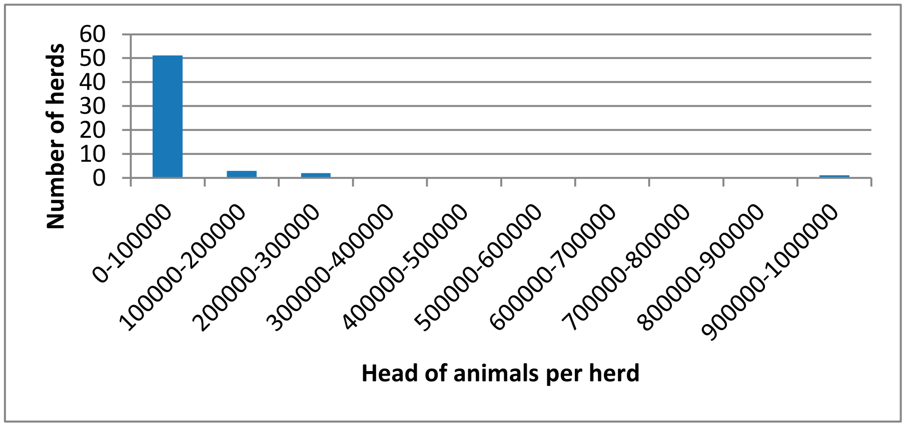


Figure 54: Texas Swine (L) Population Distribution

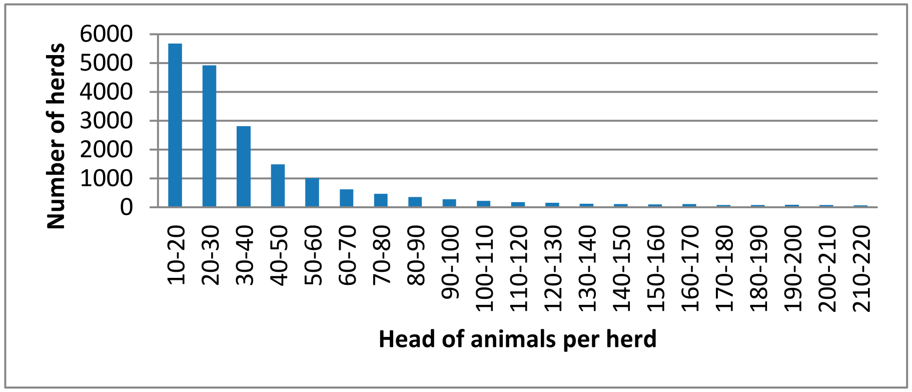


Figure 56: Texas Goats Population Distribution: Cut off after 220 head (an additional 817 herds between 220 – 2,250 head)

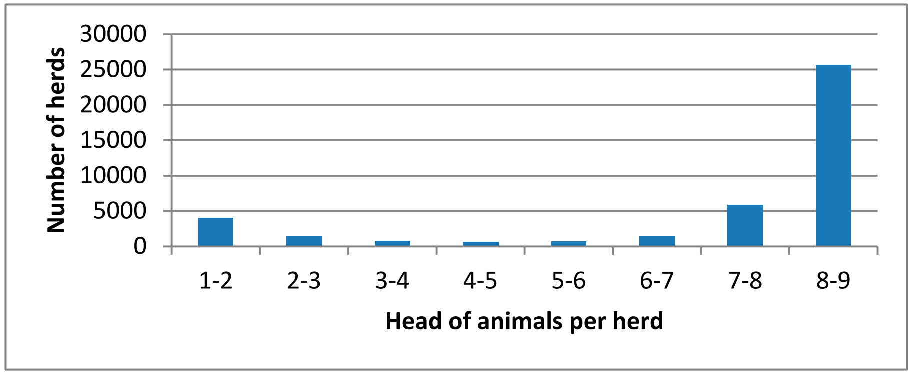


Figure 57: Texas Beef (BY-SS) Population Distribution

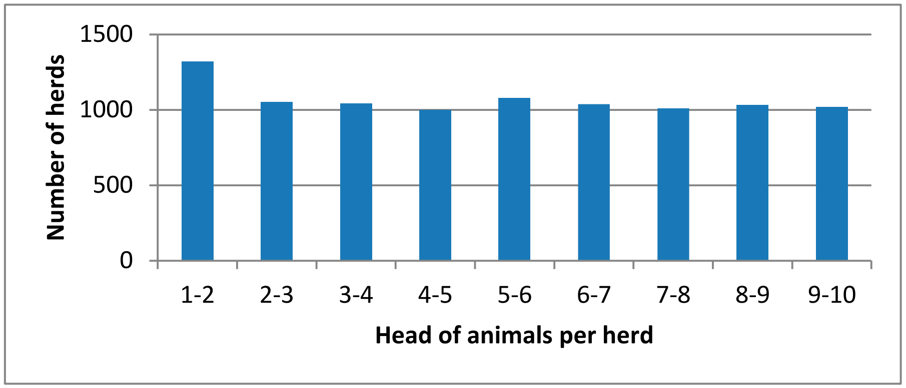


Figure 59: Texas Small Ruminants (BY-SS) Population Distribution

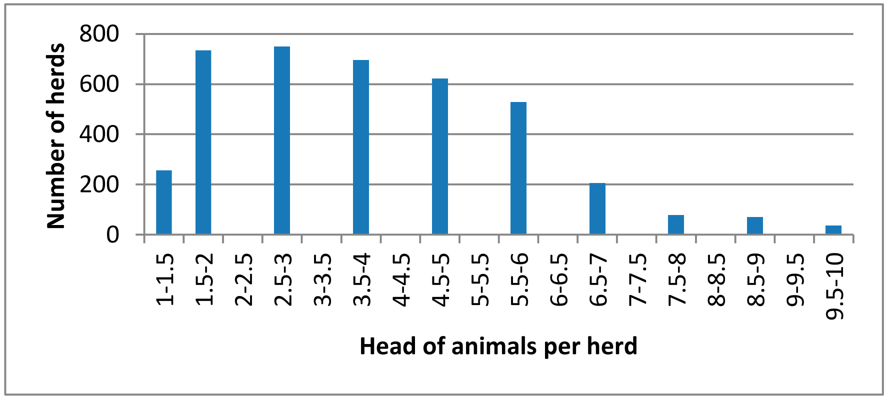


Figure 58: Texas Swine (BY-SS) Population Distribution

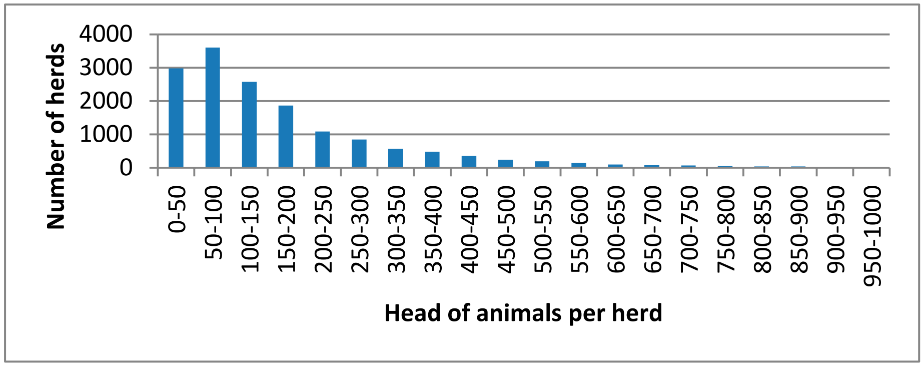


Figure 60: Nebraska Cow-calf Population Distribution: Cut off after 1,000 head (an additional 451 herds between 1,000 – 12,400 head)

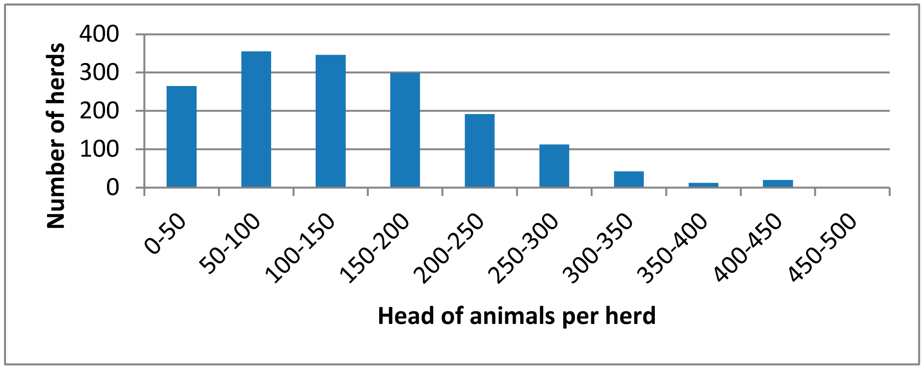


Figure 62: Nebraska Feedlot (S) Population Distribution: Cut off after 500 head (an additional 74 herds between 500 – 1,100 head)

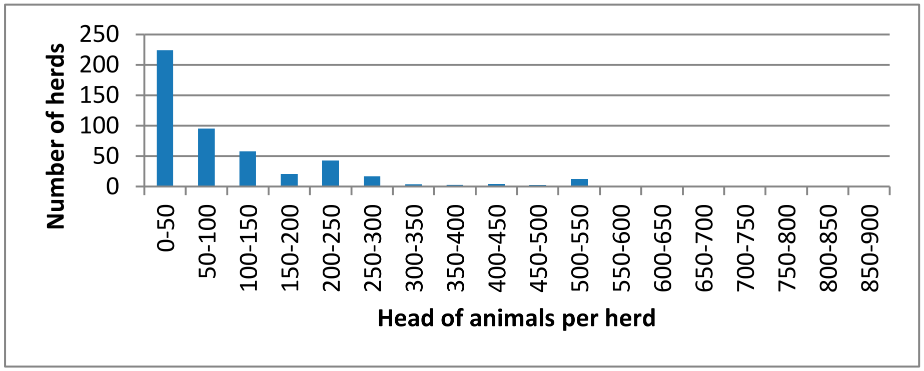


Figure 61: Nebraska Dairy Population Distribution

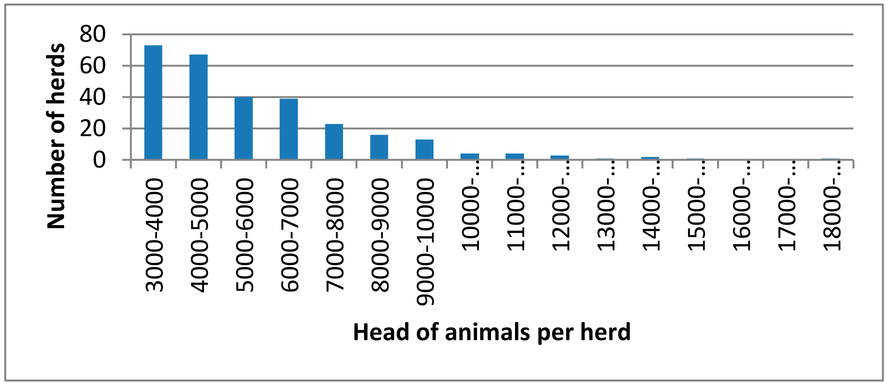


Figure 63: Nebraska Feedlot (L) Population Distribution

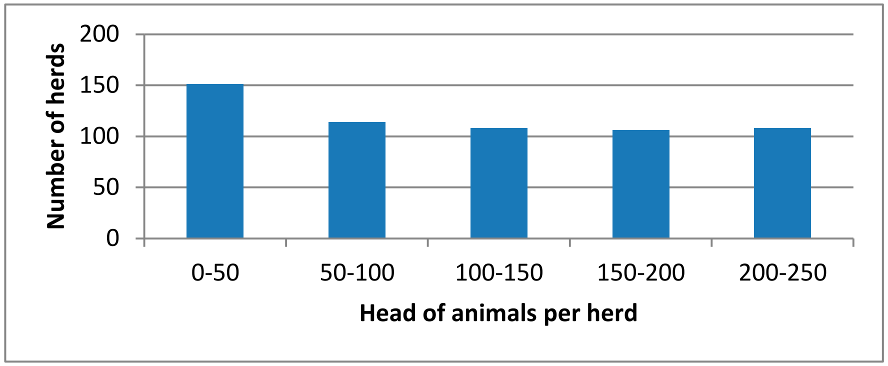


Figure 64: Nebraska Swine (S) Population Distribution

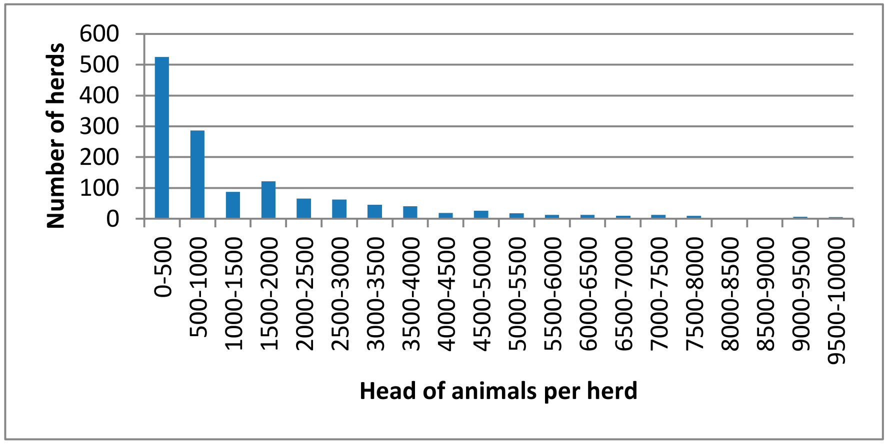


Figure 65: Nebraska Swine (L) Population Distribution

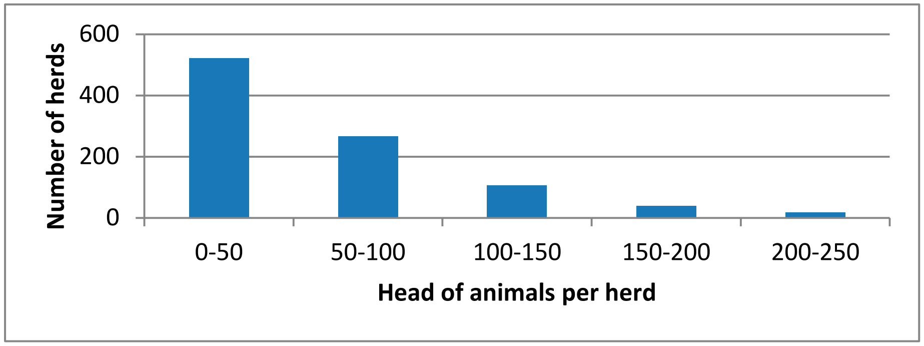


Figure 66: Nebraska Sheep Population Distribution: Cut off after 250 head (an additional 26 herds between 250 – 2,800 head)

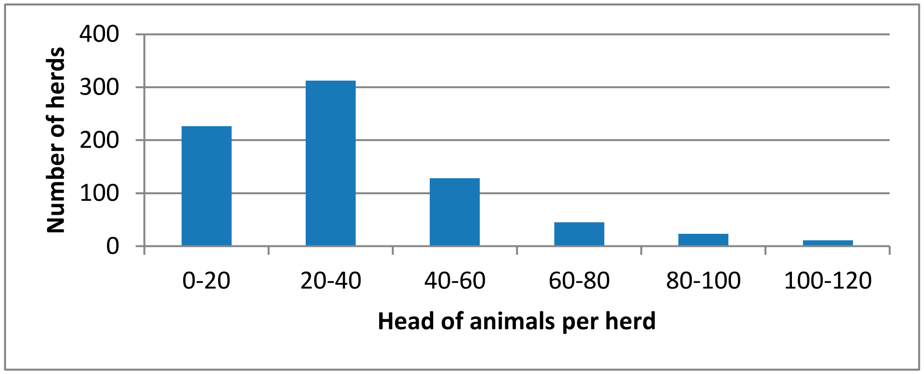


Figure 67: Nebraska Goats Population Distribution: Cut off after 120 head (an additional 35 herds between 120 – 440 head)

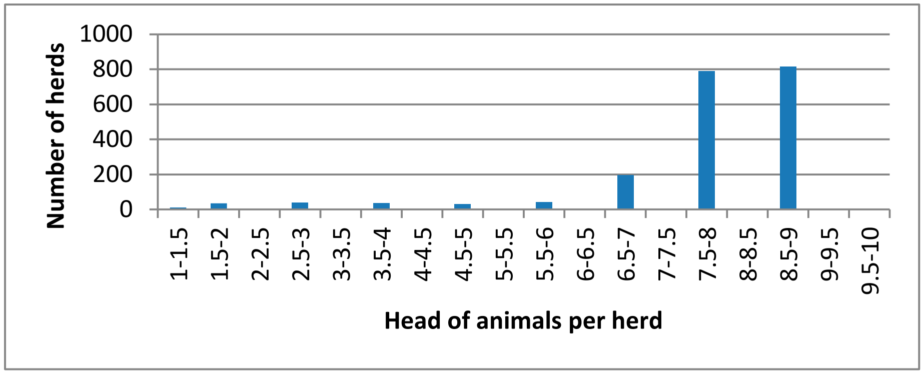


Figure 68: Nebraska Beef (BY-SS) Population Distribution

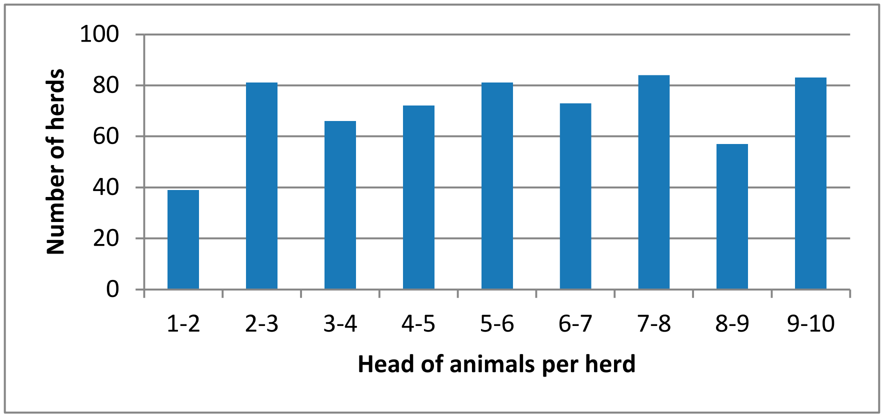


Figure 70: Nebraska Small Ruminants Population Distribution

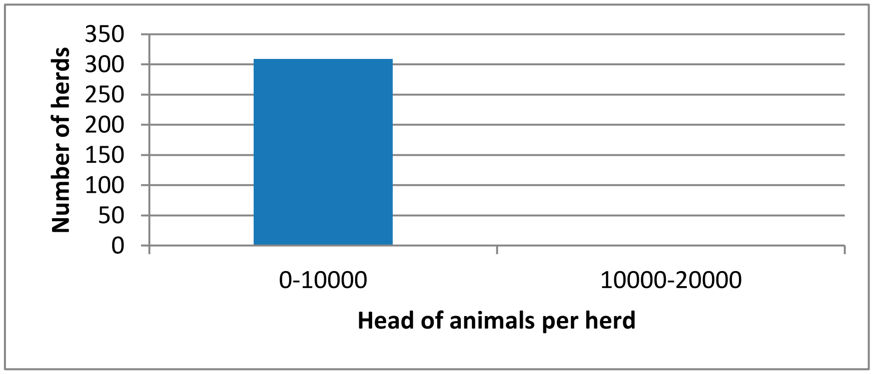


Figure 69: Nebraska Swine (BY-SS) Population Distribution: Cut off after 20,000 head (and additional 1 herd between 20,000 – 440,000 head)

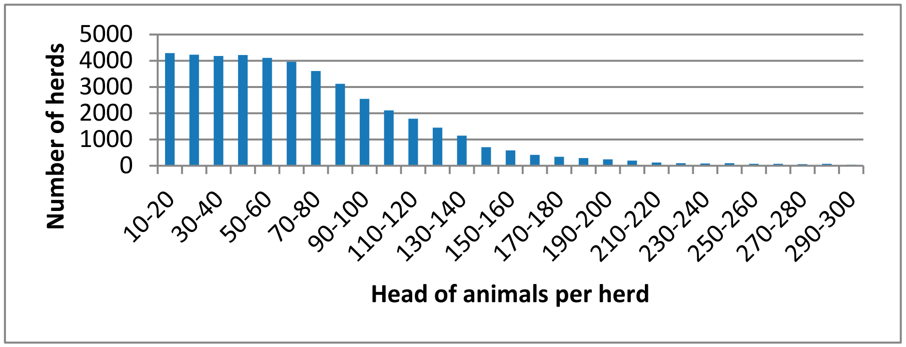


Figure 71: Missouri Cow-calf Population Distribution: Cut off at 300 (an additional 776 herds between 300 -2480 head)

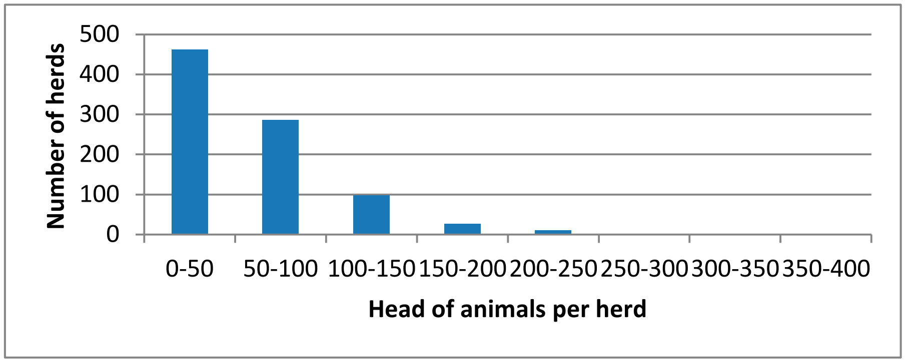


Figure 73: Missouri Feedlot (S) Population Distribution: Cut off at 400 (an additional 10 herds between 400-1050 head)

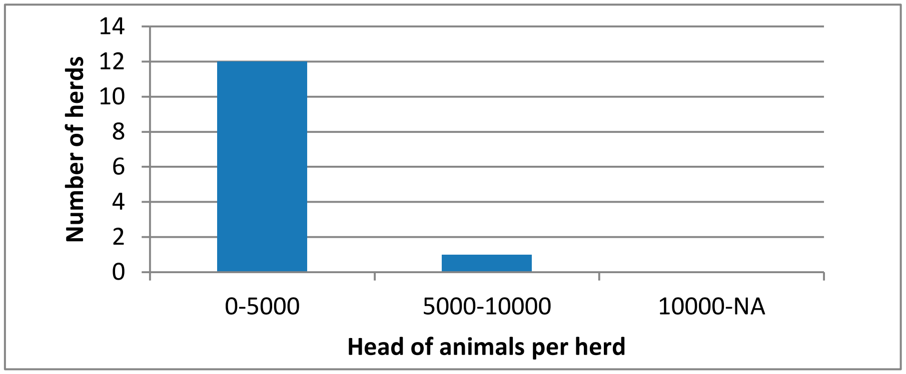


Figure 72: Missouri Dairy Population Distribution: Cut off at 300 (an additional 776 herds between 300 -2480 head)

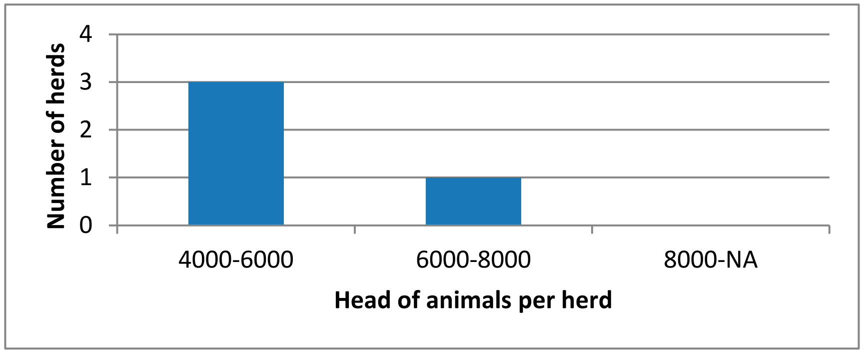


Figure 74: Missouri Feedlot (L) Population Distribution

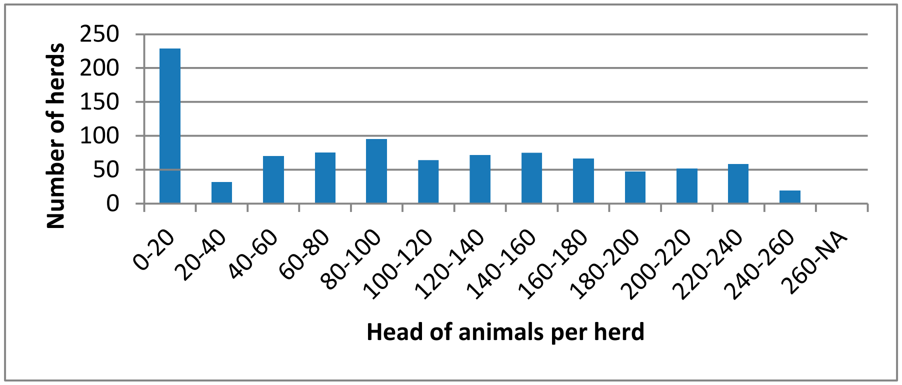


Figure 75: Missouri Swine (S)

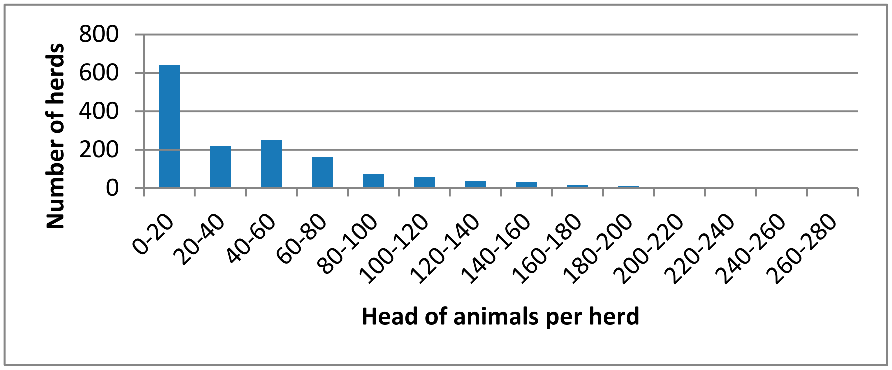


Figure 77: Missouri Sheep Population Distribution: Cut off at 280 (an additional 7 herds between 280-1080 head)

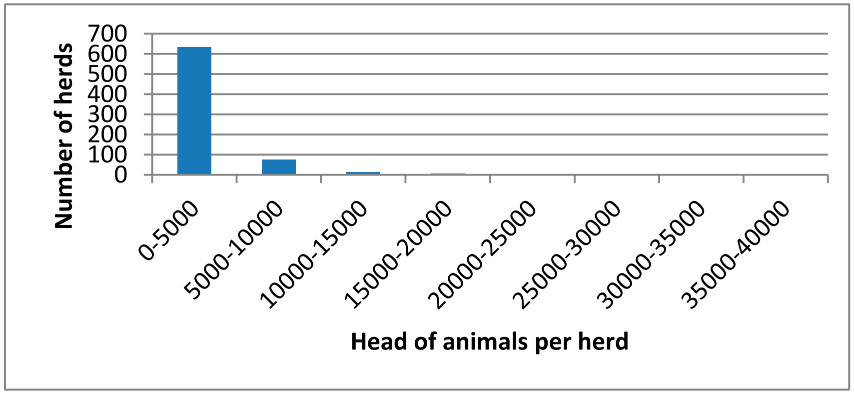


Figure 76: Missouri Swine (L) Population Distribution: Cut off at 40,000 (an additional 13 herds between 40,000 -150,000 head)

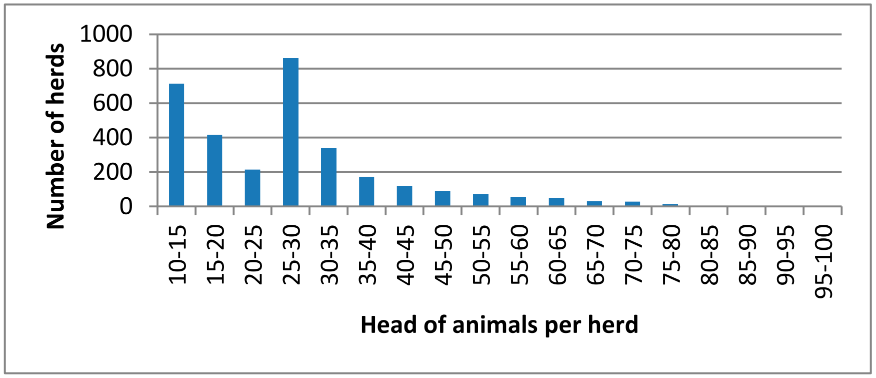


Figure 78: Missouri Goats Population Distribution: Cut off at 100 (an additional 13 herds between 100-225 head)

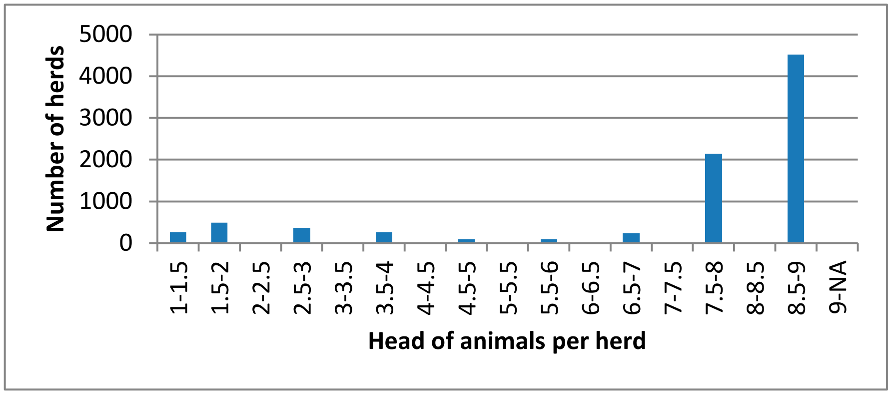


Figure 79: Missouri Beef (BY-SS) Population Distribution

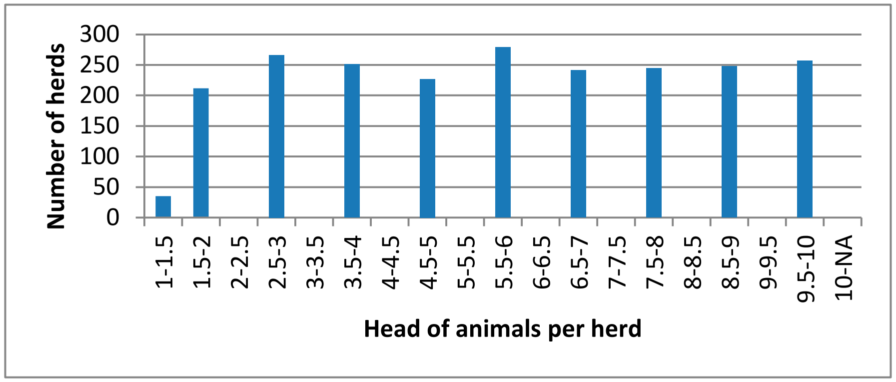


Figure 81: Missouri Small Ruminants (BY-SS) Population Distribution

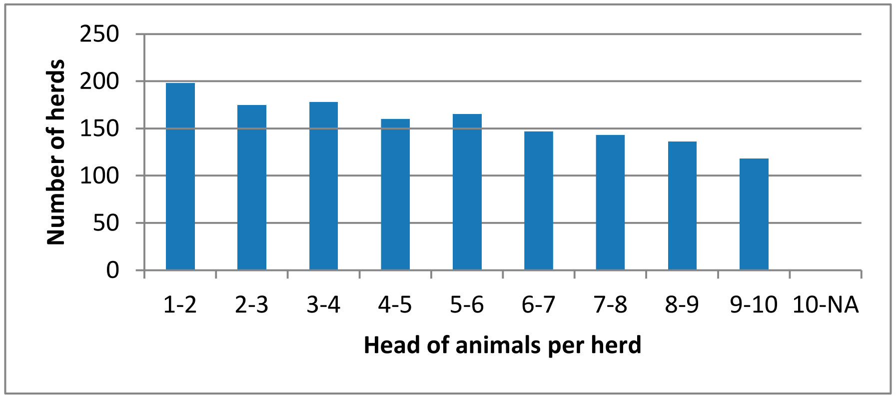


Figure 80: Missouri Swine (BY-SS) Population Distribution

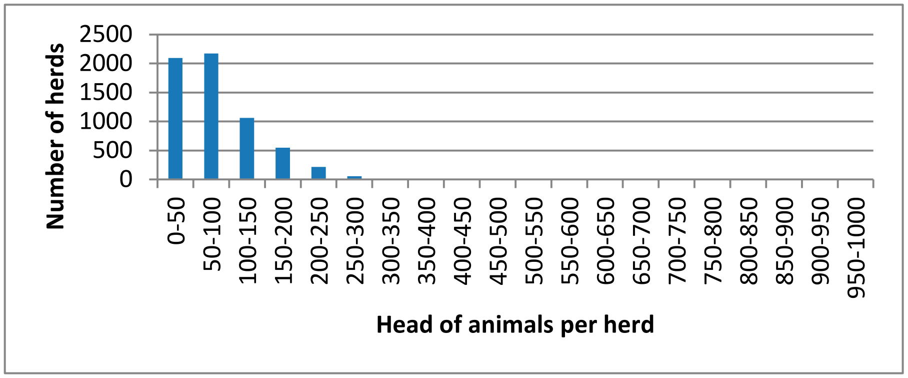


Figure 82: Colorado Cow-calf Population Distribution: Cut off after 1000 head (an additional 105 herds between 1000-3250 head)

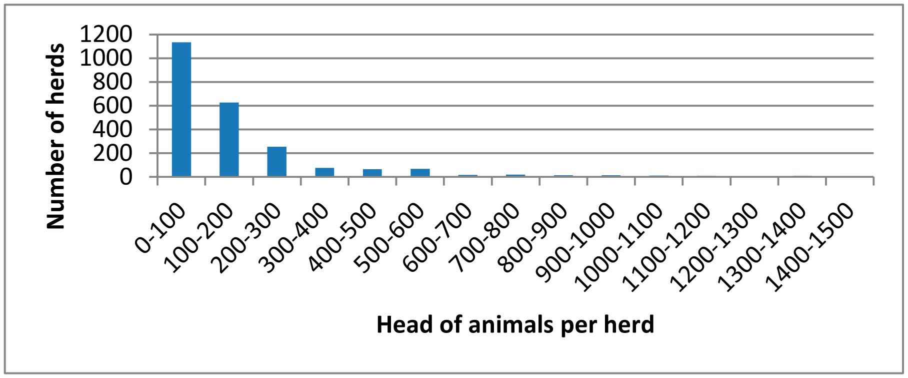


Figure 84: Colorado Feedlot(S) Population Distribution: Cut off after 1500 head (an additional 68 herds between 1500-3000 head)

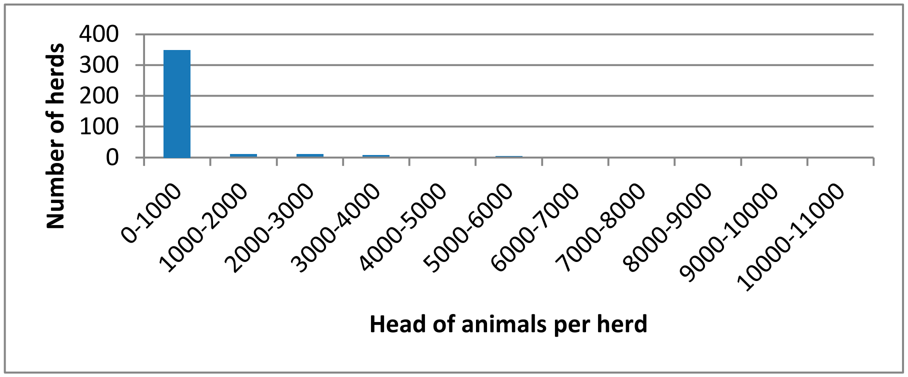


Figure 83: Colorado Dairy Population Distribution

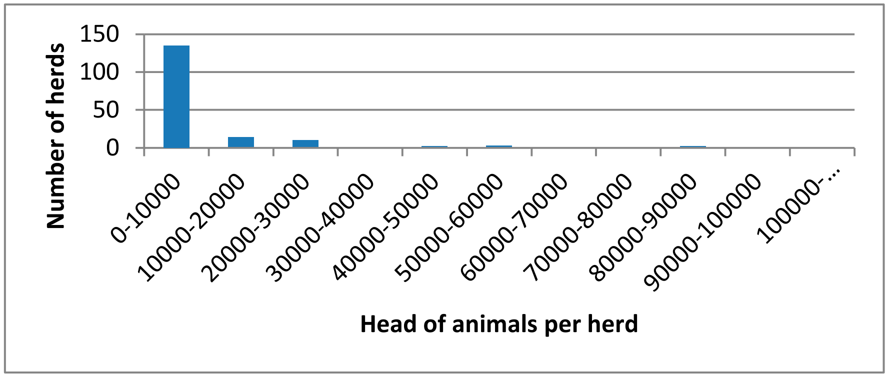


Figure 85: Colorado Feedlot (L) Population Distribution

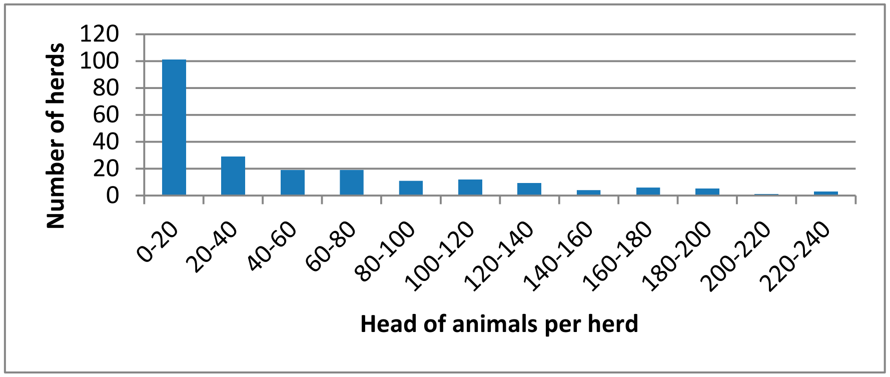


Figure 86: Colorado Swine(S) Population Distribution

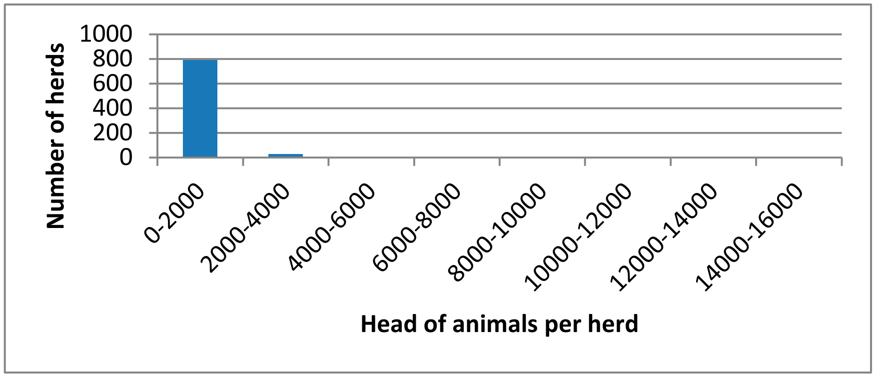


Figure 88: Colorado Sheep Population Distribution: Cut off after 16000 head (an additional 6 herds between 16000-76000 head)

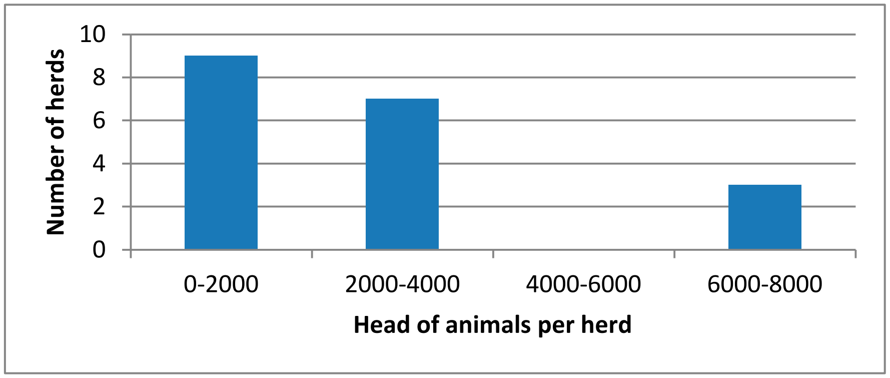


Figure 87: Colorado Swine(L) Population Distribution

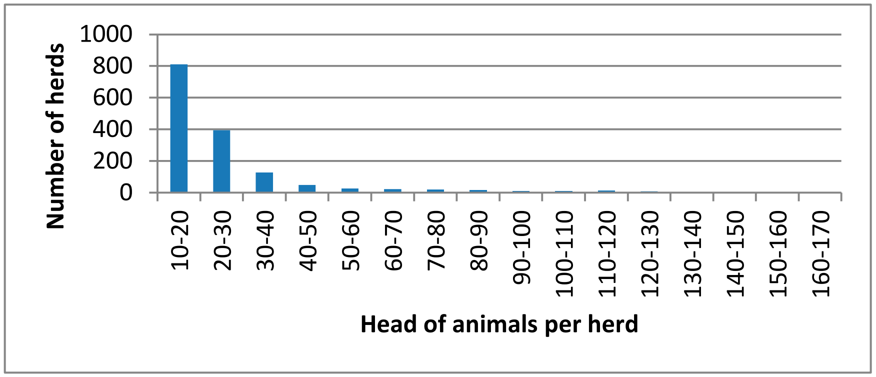


Figure 89: Colorado Goats Population Distribution

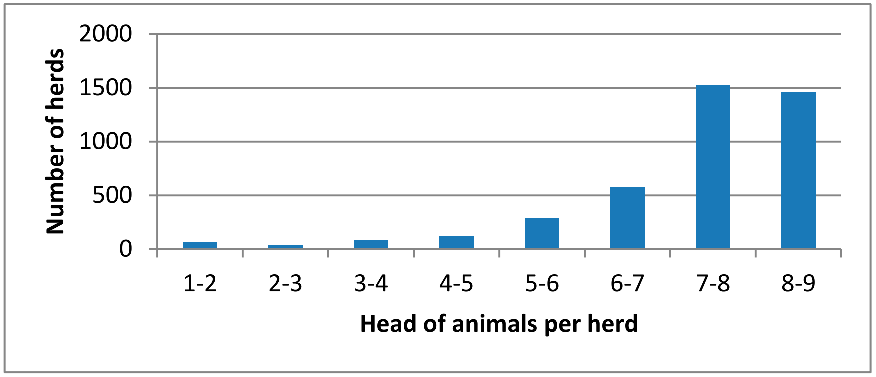


Figure 90: Colorado Beef (BY-SS) Population Distribution

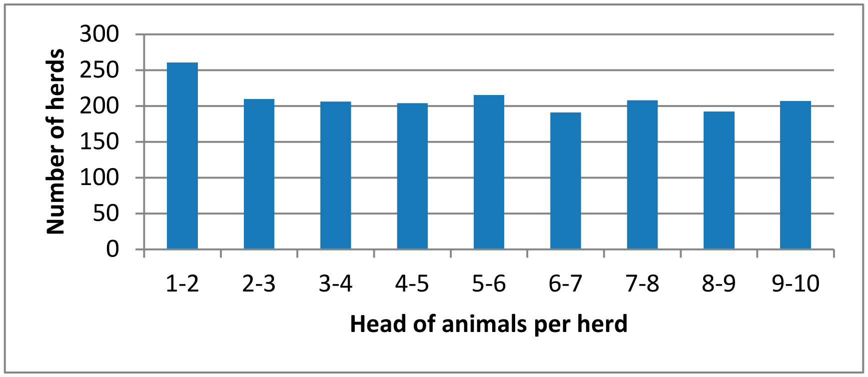


Figure 92: Colorado Small Ruminants (BY-SS) Population Distribution

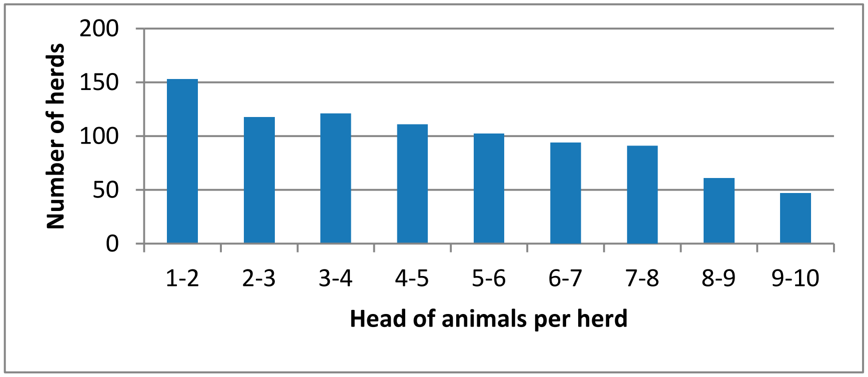


Figure 91: Colorado Swine(BY-SS) Population Distribution

All other parameters were the same as those input for Kansas. For the initial states, the initially latent, subclinical, and clinical animals were expressed by uniform and fixed functions. Initially latent animals were represented by a uniform function with a range of 1-5. The adequate exposures per time step parameter was specific for each production type but used universally for each state model, as described in Appendix Section A6.2.12.2 (Table 70).

Table 70: Adequate Exposures per Time Step for Each Production Type

Production Type	Adequate exposures per time step
Cow Calf	Beta(10.6,5.25,0,99)
Feedlot(S)	Beta(2.5,4.75,5,900)
Feedlot(L)	Beta(3,4.85,5,900)
Dairy	Lognormal(77.77996,46.339945)
Swine(S)	Weibull(5,200)
Swine(L)	Weibull(5,200)
Sheep	Beta(5,2,1,99)
Goats	Beta(5,2,1,99)
Beef (BY SS)	Beta(5,2,1,49)
Swine(BY SS)	Weibull(5,200)
SmRu(BY SS)	Beta(5,2,1,99)

The animal-level disease phase functions (subclinical, clinical, and immune) were species-specific and taken cumulatively from two expert documents, USDA 2011 and the Mardones paper on the parameterization of foot and mouth disease [Mardones, 2010] (Table 71). Herd-level parameters for each state were developed as described for Kansas in Appendix Section A6.2.12.

Table 71: Animal Level Disease State Parameters

Production Type	Latent Infectious Period	Subclinical Infectious Period	Clinical Infectious Period	Immune Period
Cow Calf	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Dairy	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Feedlot (S)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Feedlot (L)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Swine (S)	Gaussian (1.62, 1.91)	Pearson 5 (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Swine (L)	Gaussian (1.62, 1.91)	Pearson 5 (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Sheep	BetaPERT (0.00, 3.96, 13.98)	Gamma (2.40, 0.90)	Weibull (1.23, 2.12)	Gaussian (930.00, 90.00)
Goats	BetaPERT (0.00,	Gamma (2.40, 0.90)	Weibull (1.23,	Gaussian (930.00,

Table 71: Animal Level Disease State Parameters

Production Type	Latent Infectious Period	Subclinical Infectious Period	Clinical Infectious Period	Immune Period
	3.96, 13.98)		2.12)	90.00)
Beef (BY SS)	Weibull (1.78, 3.97)	Gamma (1.22, 1.67)	Weibull (1.46, 3.58)	Gaussian (1095.00, 180.00)
Swine (BY SS)	Gaussian (1.62, 1.91)	Pearson 5 (2.30, 3.05)	Weibull (1.87, 4.39)	Weibull (5.00, 985.00)
Small Ruminants (BY SS)	BetaPERT (0.00, 3.96, 13.98)	Gamma (2.40, 0.90)	Weibull (1.23, 2.12)	Gaussian (930.00, 90.00)

A6.3.2.2 Within-Herd Model Data and Herd-Level Parameter Development

Parameters were developed for each state using within-herd model output, as described in Appendix Section A6.2.12.2. The method is not described again here, but the resulting parameters for each state are provided.

Disease State Parameters

The disease progression parameters developed for all states in the modeled region are provided in Table 72-Table 77. Each distribution is plotted in Figures 93-146. Tables and figures are organized by state. There parameters were developed as described in Appendix Section A6.2.12.2.

Table 72: Colorado Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Gamma(2.2675,0.97392)	Uniform(0,2.8645)	Gamma(31.586,0.61731)	Gaussian (μ=1095,σ=180)
Dairy	LogLogistic(0,2.0694,2.4463)	Uniform(0,2.7429)	Gamma(55.268,0.44361)	Gaussian (μ=1095,σ=180)
Feedlot(L)	Lognorm(2.6109,1.9107)	Triang(0,0.76033,2.2062)	LogLogistic(0,60.399,3.2573)	Gaussian (μ=1095,σ=180)
Feedlot(S)	Gamma(2.1280,1.1132)	BetaGeneral(1.8379,3.3194,0,3.2609)	BetaGeneral(19.761,34.885, 0,56.441)	Gaussian (μ=1095,σ=180)
Swine(L)	Expon(1.9296)	Triang(0,0.86813,2.4318)	Lognorm(83.307,55.522)	Weibull (α=5,β=985)
Swine(S)	Expon(1.9578)	Pearson5(12.326,17.675)	LogLogistic(0,16.232,3.9069)	Weibull (α=5,β=985)
Goats	BetaGeneral(2.2184,15.208,0,25.153)	BetaGeneral(2.0030,4.8855,0,6.9521)	BetaGeneral(20.088,59.905, 0,58.859)	Gaussian (μ=930, σ=90)
Sheep	Gamma(2.6212,1.2319)	BetaGeneral(2.2344,3.2369,0,4.3884)	BetaGeneral(3.0735,1.4150, 0,41.251)	Gaussian (μ=930, σ=90)
Beef (BY SS)	Gamma(2.5959,0.85888)	Uniform(0,3.8515)	Gamma(16.160,0.81099)	Gaussian (μ=1095,σ=180)
Swine(BY SS)	Expon(2.2976)	LogLogistic(0,1.4942,3.0008)	Weibull(2.9977,10.855)	Weibull (α=5,β=985)
Small Ruminants (BY SS)	BetaGeneral(1.8504,6.5225,0,15.637)	Gamma(2.7256,0.84743)	Triang(0,11.655,18.365)	Gaussian (μ=930, σ=90)

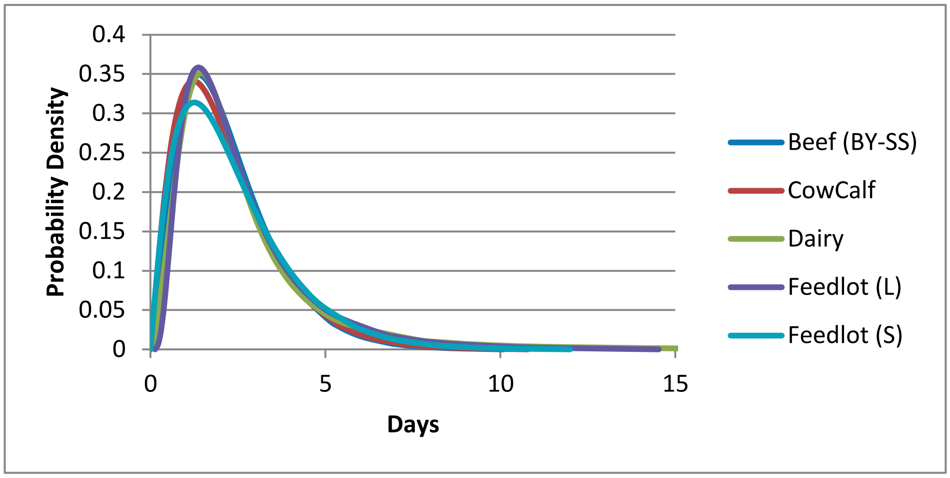


Figure 93: Colorado Cattle Latent Disease Phase

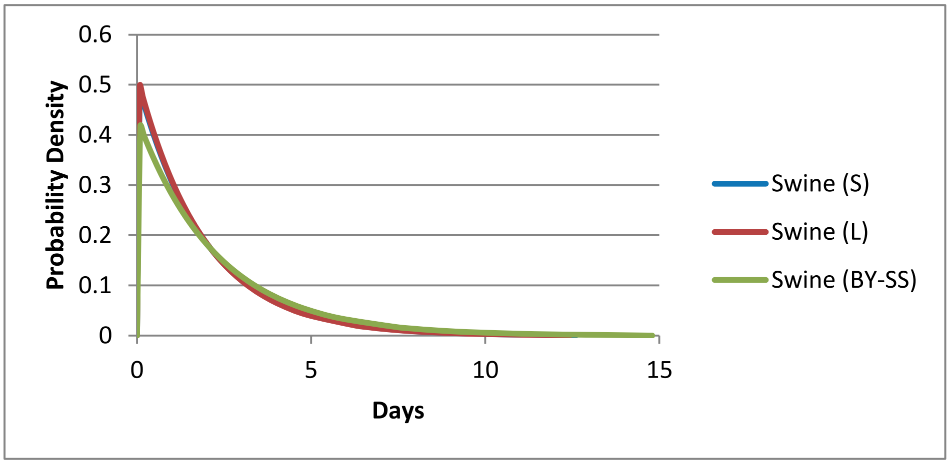


Figure 94: Colorado Swine Latent Disease Phase

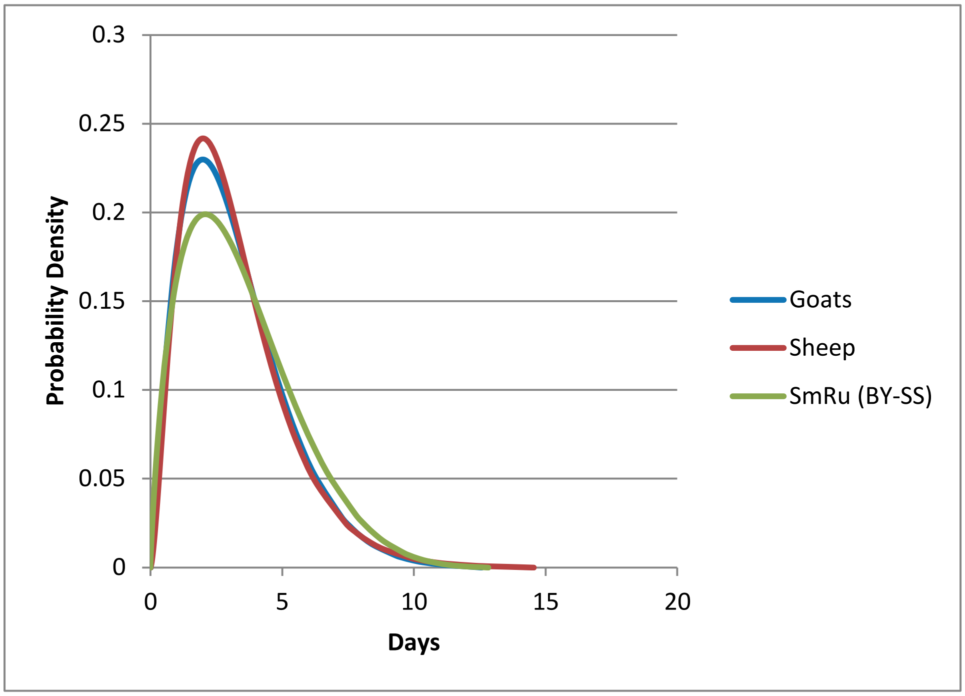


Figure 95: Colorado Small Ruminants Latent Disease Phase

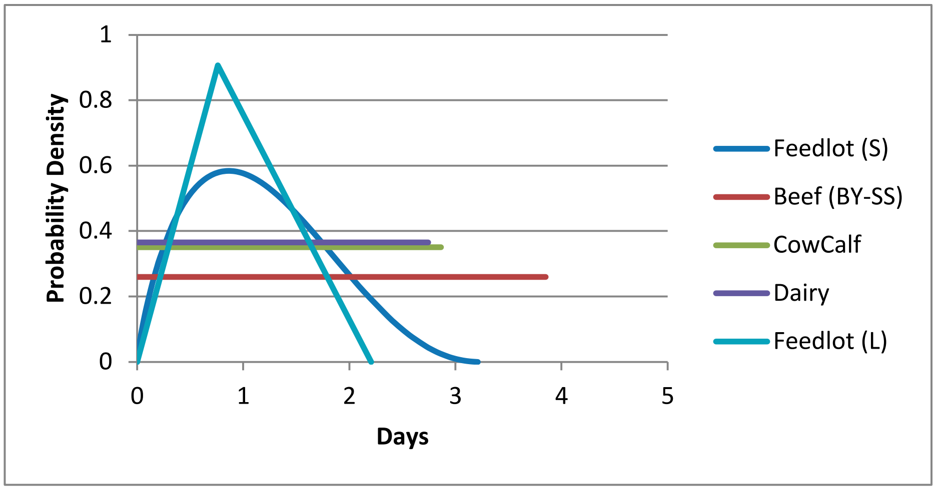


Figure 96: Colorado Cattle Subclinical Disease Phase

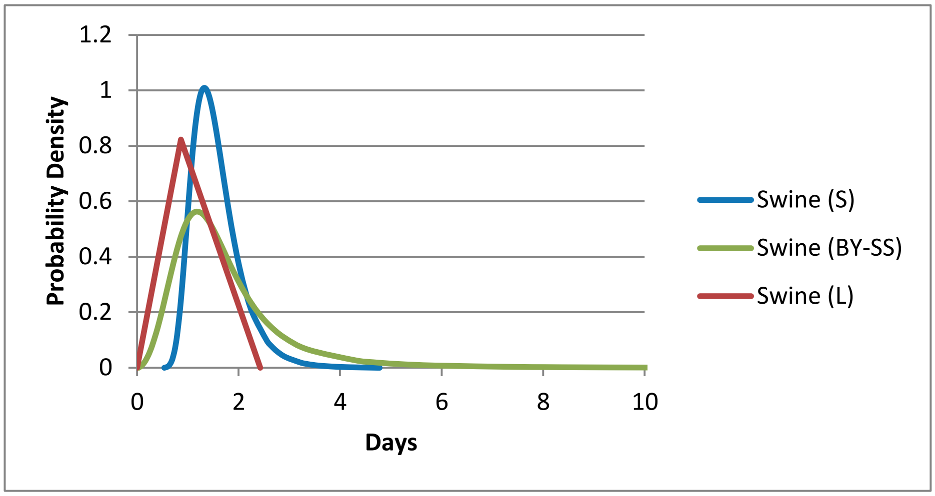


Figure 97: Colorado Swine Subclinical Disease Phase

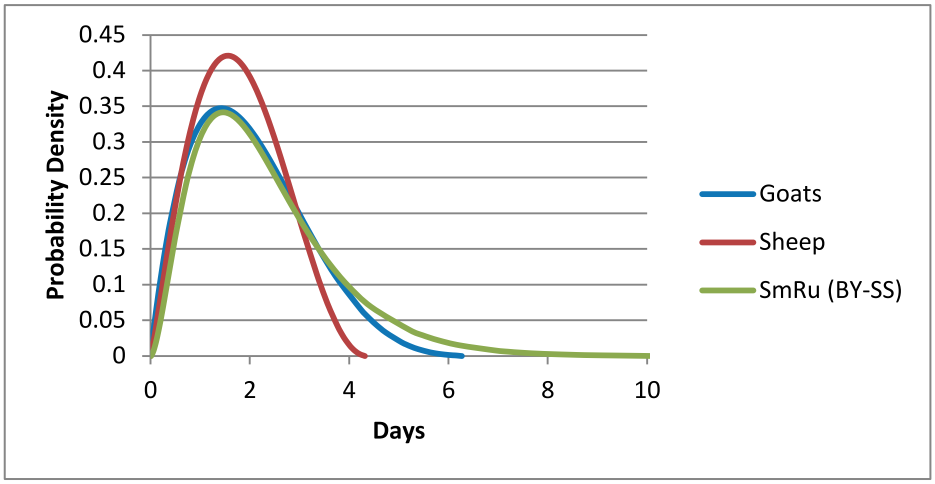


Figure 98: Colorado Small Ruminants Subclinical Disease Phase

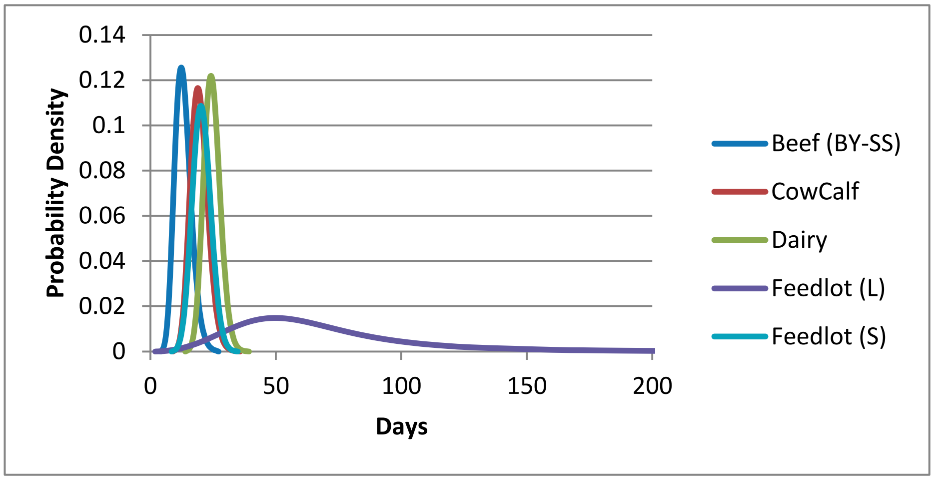


Figure 99: Colorado Cattle Clinical Disease Phase

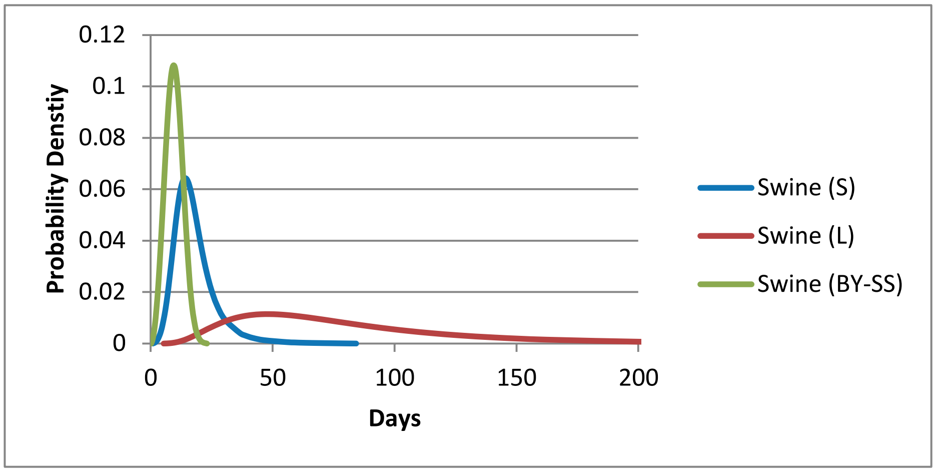


Figure 100: Colorado Swine Clinical Disease Phase

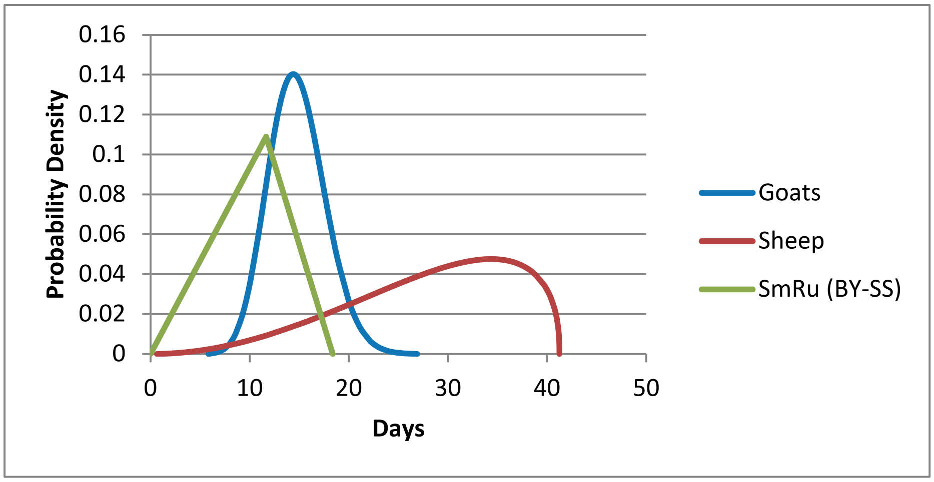


Figure 101: Colorado Small Ruminants Clinical Disease Phase

Table 73: Iowa Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Gamma(2.3512,0.9598)	Uniform(0,2.8462)	Pearson5(39.504,763.96)	Gaussian (μ=1095, σ=180)
Dairy	Gamma(1.9289,1.0864)	Uniform(0,2.8932)	Weibull(5.864,20.997)	Gaussian (μ=1095, σ=180)
Feedlot(L)	Loglogistic(0,2.0111, 2.4371)	Triang(0,0.77208,2.2571)	BetaGeneral(32.942,98.977,0,195.22)	Gaussian (μ=1095, σ=180)
Feedlot(S)	Gamma(2.0501,1.089)	Triang(0,0.73663,3.079)	Lognorm(20.858,3.7244)	Gaussian (μ=1095, σ=180)

Table 73: Iowa Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Swine(L)	Expon(1.9679)	Triang(0,0.89078,2.3103)	Loglogistic(0,68.276,2.7378)	Weibull (α = 5, β = 985)
Swine(S)	Expon(1.9939)	Pearson5(14.691,20.235)	Loglogistic(0,22.876,4.0452)	Weibull (α = 5, β = 985)
Goats	Gamma(2.5093,1.315)	BetaGeneral(2.2463,12.551,0,13.661)	Gamma(29.532,0.47347)	Gaussian (μ=930, σ=90)
Sheep	Gamma(2.4771,1.3008)	BetaGeneral(2.1418,4.7287,0,6.5278)	Gamma(30.669,0.45736)	Gaussian (μ=930, σ=90)
Beef (BY SS)	Gamma(2.2873,0.98803)	Uniform(0,3.8087)	Loglogistic(0,12.325,6.0183)	Gaussian (μ=1095, σ=180)
Swine(BY SS)	Expon(2.2456)	Loglogistic(0,1.4351,2.7976)	Loglogistic(0,10.403,4.6286)	Weibull (α = 5, β = 985)
Small Ruminants (BY SS)	BetaGeneral(2.7132,101.17,0,141.43)	Loglogistic(0,1.9784,2.748)	Triang(0,11.582,18.223)	Gaussian (μ=930, σ=90)

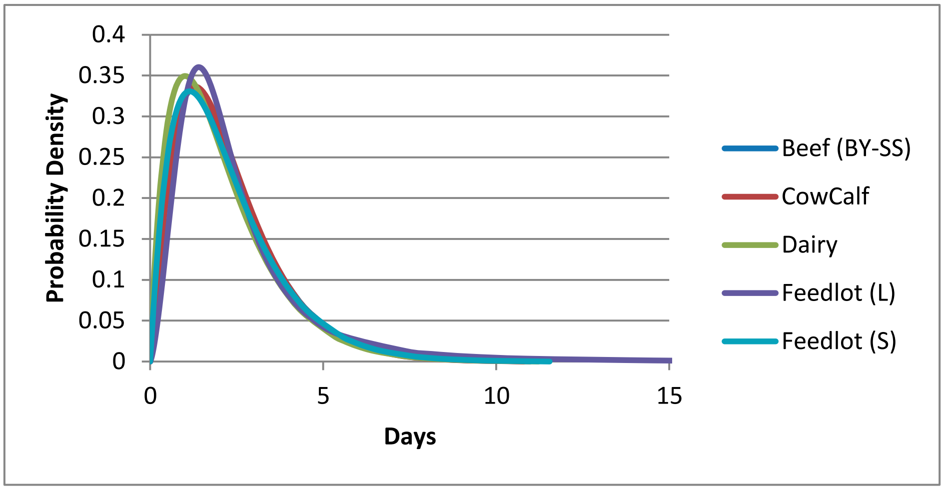


Figure 102: Iowa Cattle Latent Disease Phase

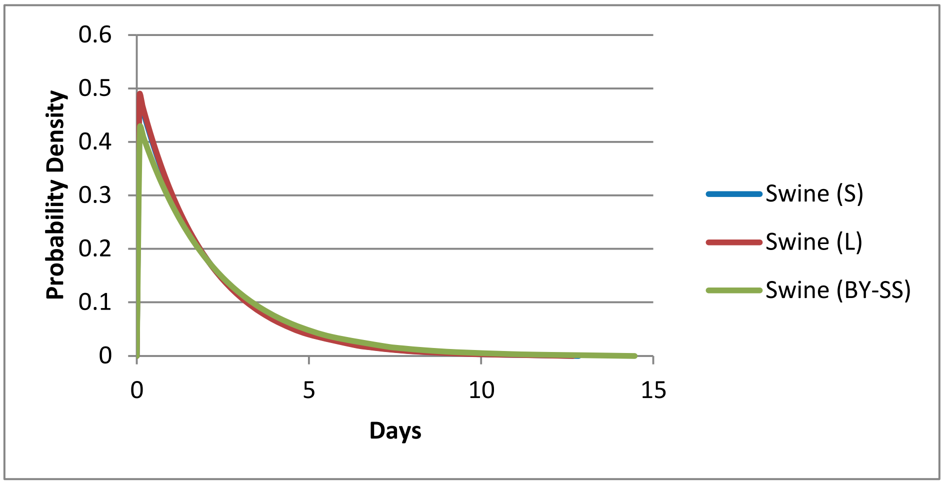


Figure 103: Iowa Swine Latent Disease Phase

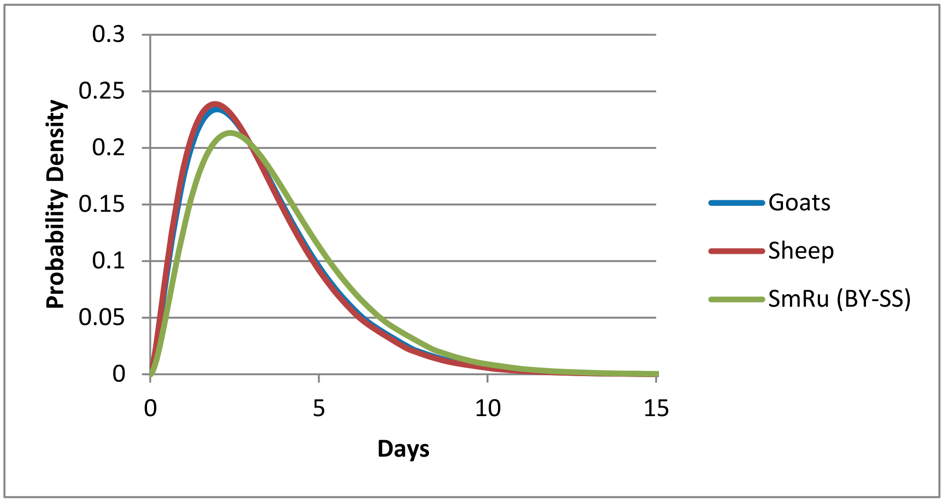


Figure 104: Iowa Small Ruminants Latent Disease Phase

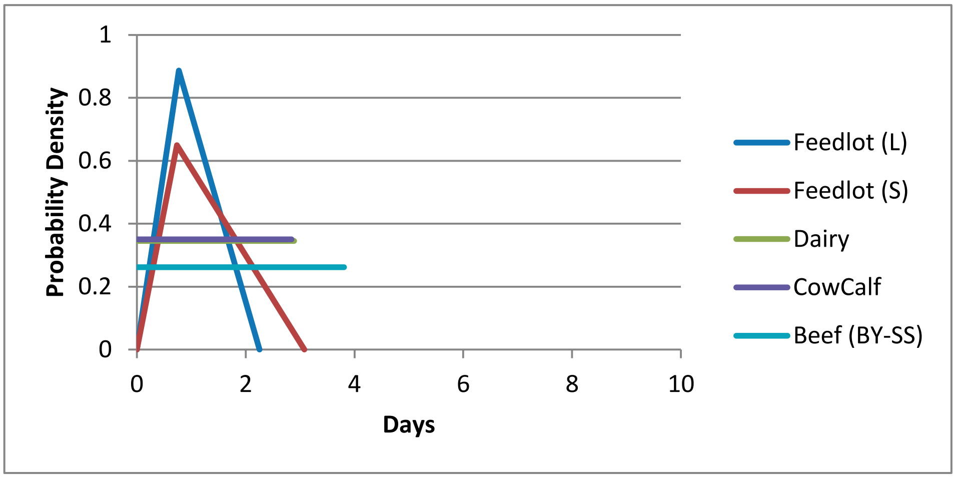


Figure 105: Iowa Cattle Subclinical Disease Phase

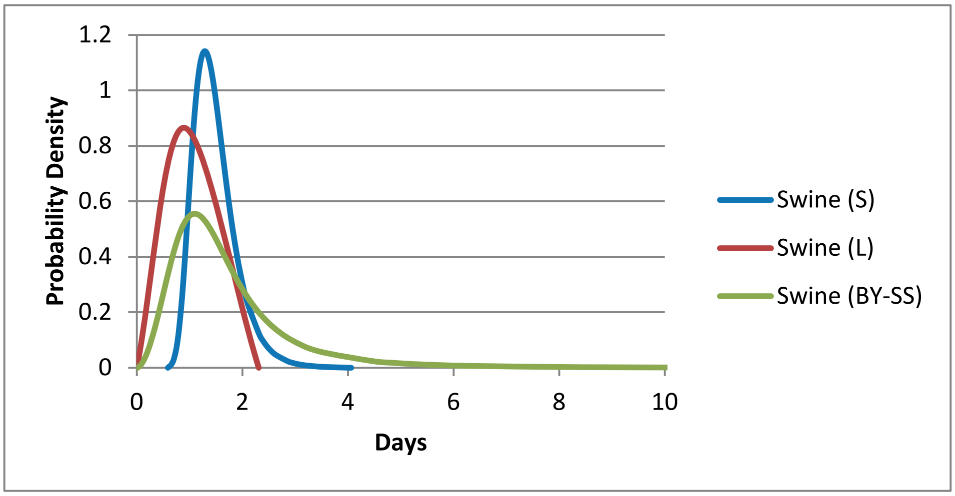


Figure 106: Iowa Swine Subclinical Disease Phase

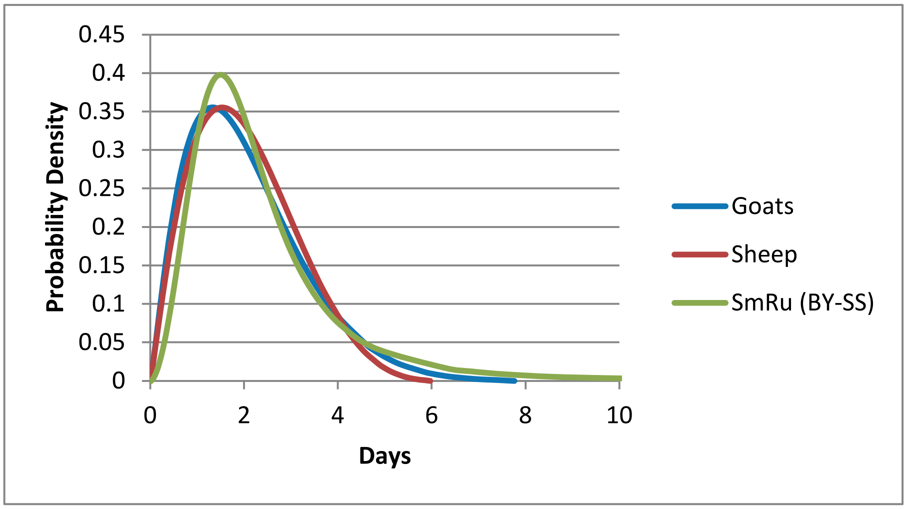


Figure 107: Iowa Small Ruminants Subclinical Disease Phase

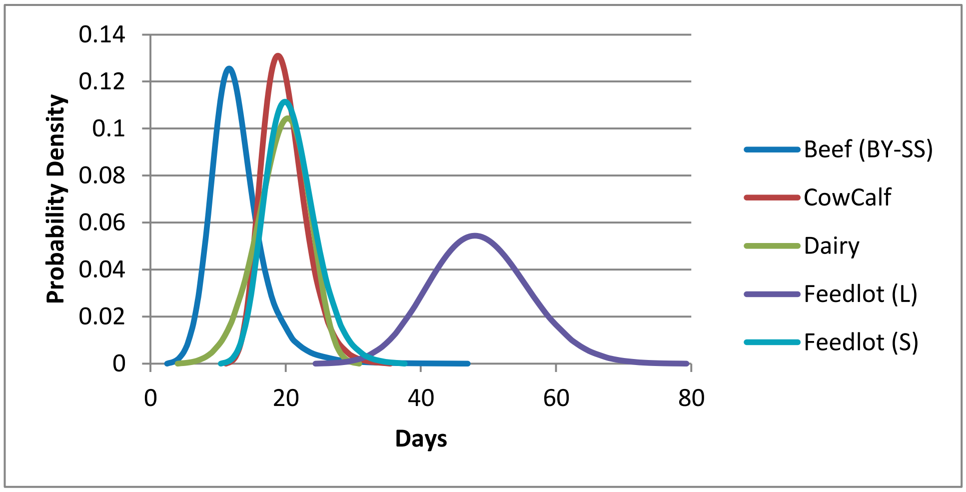


Figure 108: Iowa Cattle Clinical Disease Phase

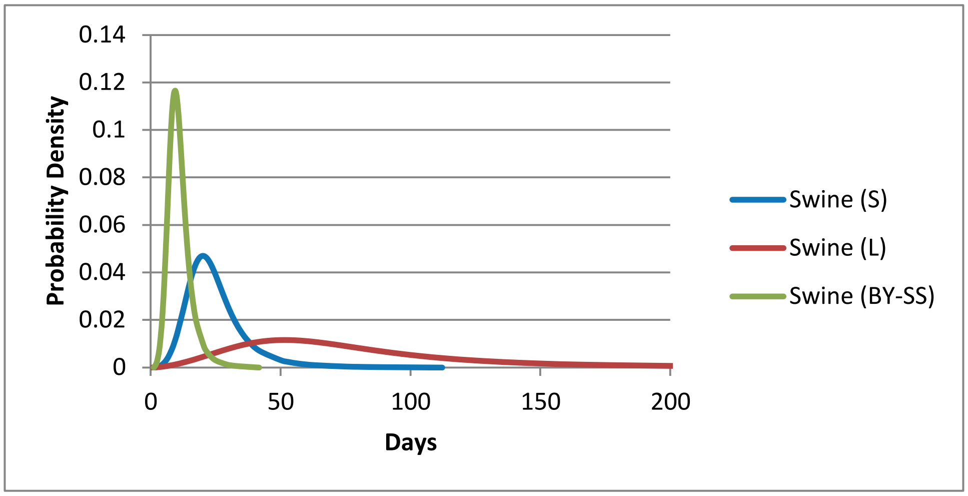


Figure 109: Iowa Swine Clinical Disease Phase

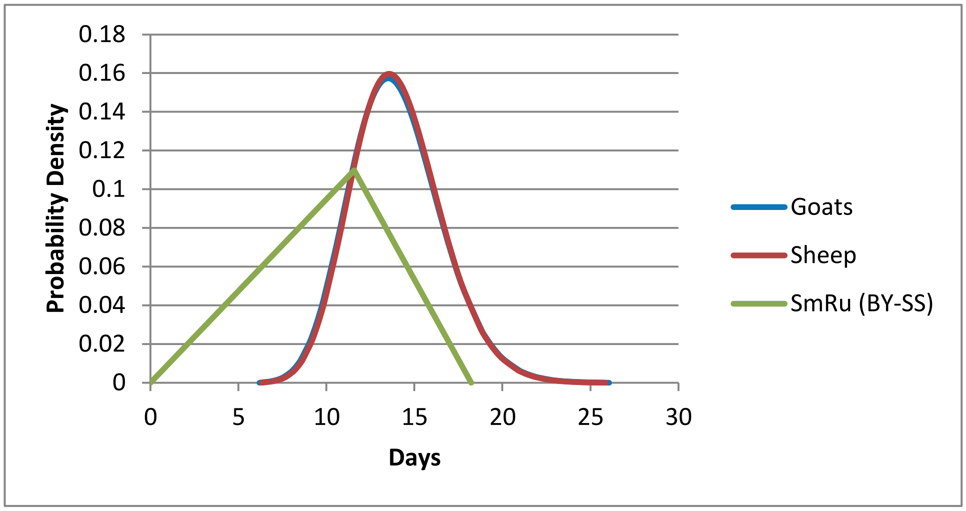


Figure 110: Iowa Small Ruminant Clinical Disease Phase

Table 74: Missouri Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Gamma(2.1799,1.0042)	Uniform(0,2.8686)	BetaGeneral(28.873, 106.44,0,89.273)	Gaussian (μ=1095, σ=180)
Dairy	Loglogistic(0,2.106,2.5835)	BetaGeneral(1.9449,2.9867,0,3.326)	Gamma(89.079,0.31886)	Gaussian (μ=1095, σ=180)
Feedlot(L)	Gamma(2.42,0.96656)	Weibull(2.2003,1.1242)	Lognorm(58.767,11.016)	Gaussian (μ=1095, σ=180)
Feedlot(S)	LogLogistic(0,2.0228, 2.5053)	Weibull(1.8902,1.5992)	BetaGeneral(13.384, 16.28,0,40.321)	Gaussian (μ=1095, σ=180)
Swine(L)	Expon(1.8508)	Triang(0,0.87695,2.3541)	Loglogistic(0,77.367,2.9114)	Weibull (α = 5, β = 985)

Table 74: Missouri Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Swine(S)	Expon(1.9586)	Weibull(2.4281,1.5064)	Loglogistic(0,21.016,3.6646)	Weibull (α = 5, β = 985)
Goats	Lognorm(3.5614,2.6385)	BetaGeneral(1.8794,3.3713,0,5.4576)	BetaGeneral(25.733,84.676,0,65.135)	Gaussian (μ=930, σ=90)
Sheep	BetaGeneral(2.515,38.391,0,54.724)	Weibull(1.9028,2.1887)	Weibull(5.117,17.113)	Gaussian (μ=930, σ=90)
Beef (BY SS)	Lognorm(2.8295,2.3988)	Uniform(0,3.8418)	Loglogistic(0,12.861,6.4404)	Gaussian (μ=1095, σ=180)
Swine(BY SS)	Expon(2.1871)	LogLogistic(0,1.4611,2.8712)	Loglogistic(0,10.2,4.4293)	Weibull (α = 5, β = 985)
Small Ruminants (BY SS)	Gamma(2.8473,1.1877)	Loglogistic(0,2.1101,2.5284)	BetaGeneral(3.1663,2.4272,0,18.46)	Gaussian (μ=930, σ=90)

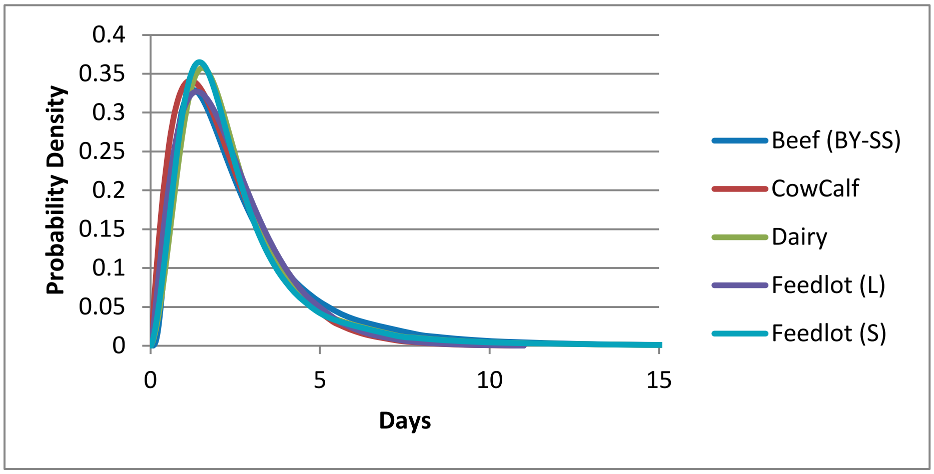


Figure 111: Missouri Cattle Latent Disease Phase

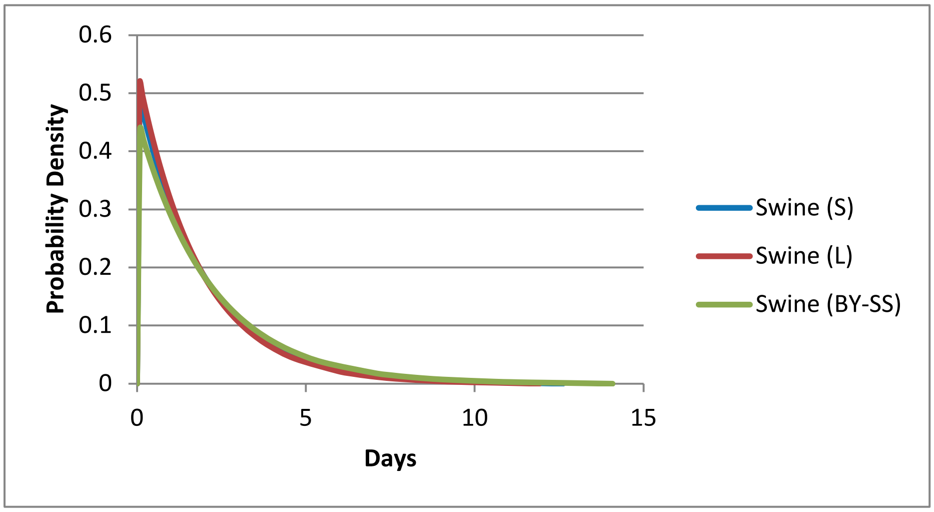


Figure 112: Missouri Swine Latent Disease Phase

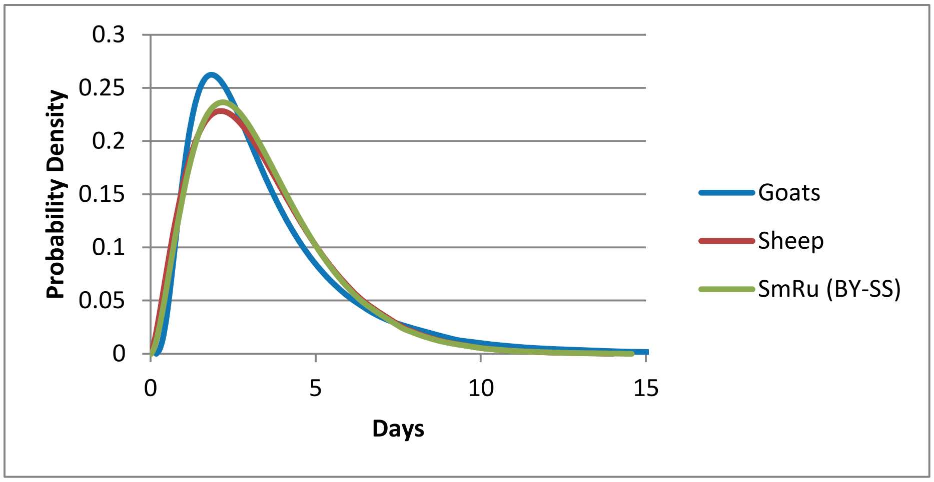


Figure 113: Missouri Small Ruminants Latent Disease Phase

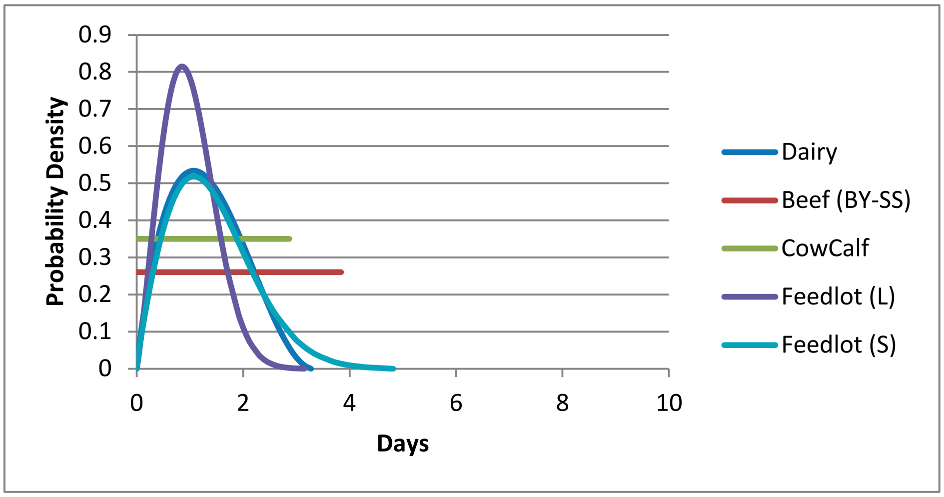


Figure 114: Missouri Cattle Subclinical Disease Phase

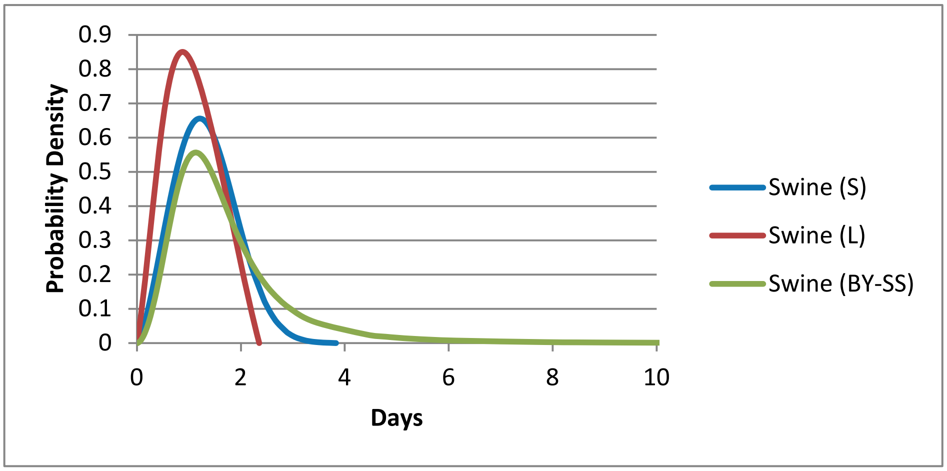


Figure 115: Missouri Swine Subclinical Disease Phase

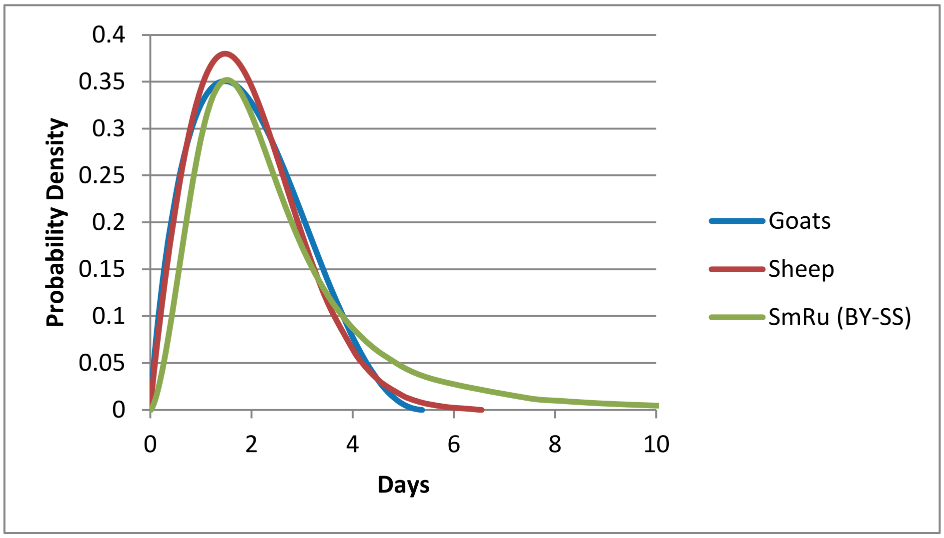


Figure 116: Missouri Small Ruminants Subclinical Disease Phase

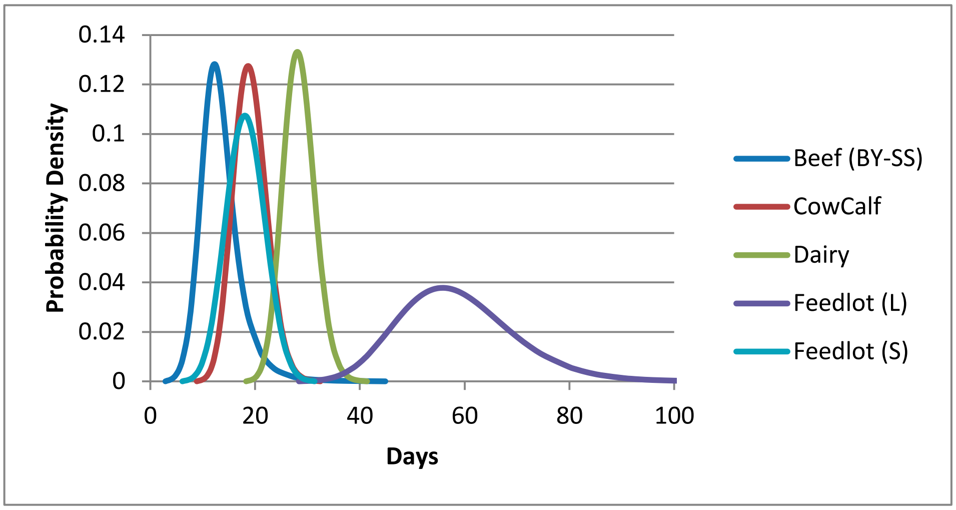


Figure 117: Missouri Cattle Clinical Disease Phase

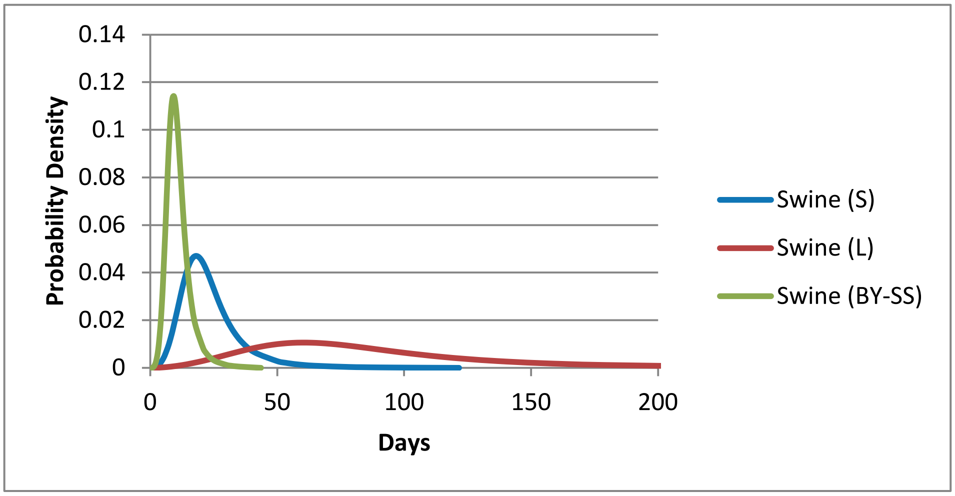


Figure 118: Missouri Swine Clinical Disease Phase

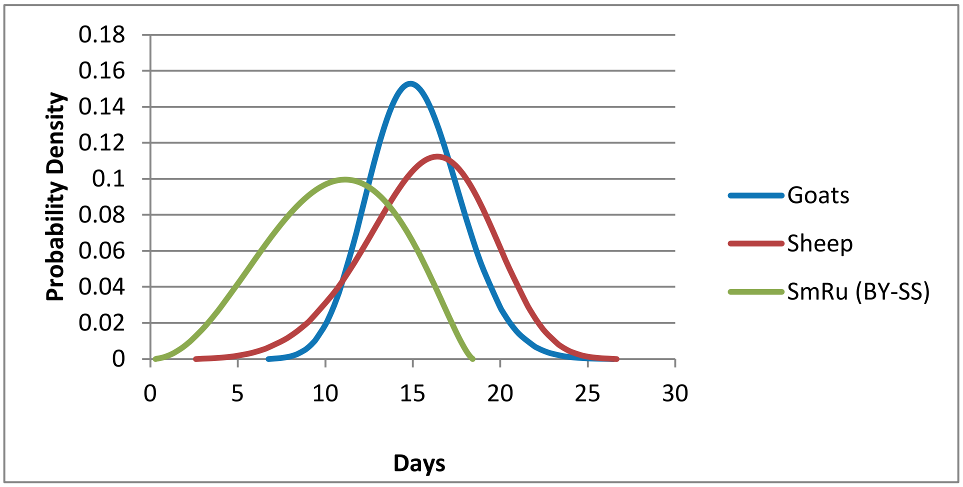


Figure 119: Missouri Small Ruminants Clinical Disease Phase

Table 75: Nebraska Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Gamma(2.1995,1.0560)	LogLogistic(0,1.4803,5.7879)	BetaGeneral(15.872,15.545,0,41.496)	Gaussian (μ=1095, σ=180)
Dairy	Lognorm(2.6205,1.9536)	Uniform(0,2.8998)	Weibull(5.3076,20.625)	Gaussian (μ=1095, σ=180)
Feedlot(L)	Gamma(2.1559,1.0004)	BetaGeneral(2.4098,2.9990,0,2.3441)	Pearson5(15.579,862.45)	Gaussian (μ=1095, σ=180)
Feedlot(S)	Gamma(2.3169,0.93117)	Triang(0,0.68070,3.0887)	BetaGeneral(26.078,45.809,0,56.361)	Gaussian (μ=1095, σ=180)
Swine(L)	Expon(2.0293)	Weibull(2.6836,1.3635)	Pearson5(2.2944,95.587)	Weibull (α = 5, β = 985)
Swine(S)	Expon(1.9562)	Weibull(2.5822,1.4501)	Pearson5(6.0295,128.50)	Weibull (α = 5, β = 985)
Goats	BetaGeneral(2.5811,68.836,0,90.757)	Weibull(1.9436,2.3284)	BetaGeneral(19.665,49.043,0,55.476)	Gaussian (μ=930, σ=90)
Sheep	Gamma(2.4881,1.3118)	BetaGeneral(2.0570,3.4744,0,5.3236)	BetaGeneral(19.889,42.916,0,53.577)	Gaussian (μ=930, σ=90)
Beef (BY SS)	LogLogistic(0,2.0468,2.5943)	Uniform(0,3.8227)	Gamma(17.558,0.75471)	Gaussian (μ=1095, σ=180)
Swine(BY SS)	Expon(1.7850)	Weibull(2.7179,1.3356)	BetaGeneral(3.6681,29.067,0,875.19)	Weibull (α = 5, β = 985)
Small Ruminants (BY SS)	Gamma(2.5721,1.3893)	Weibull(1.5929,2.2948)	Weibull(3.5028,11.971)	Gaussian (μ=930, σ=90)

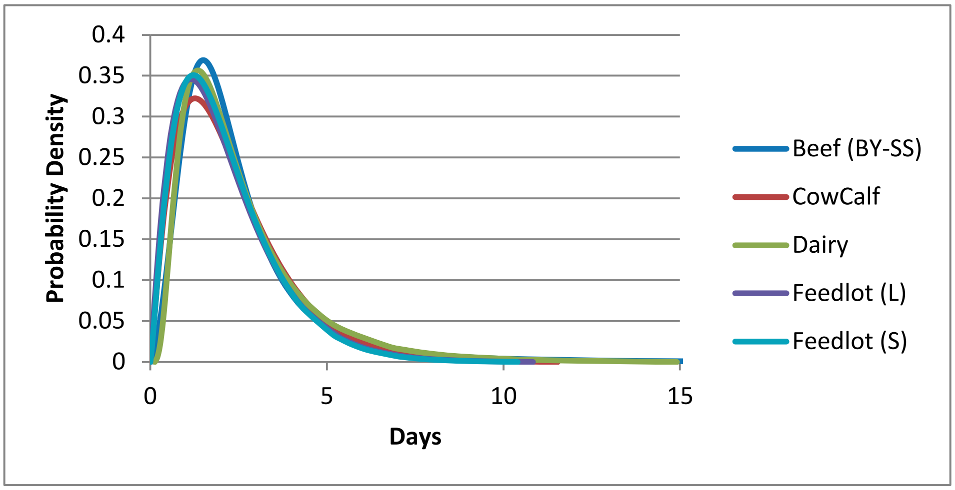


Figure 120: Nebraska Cattle Latent Disease Phase

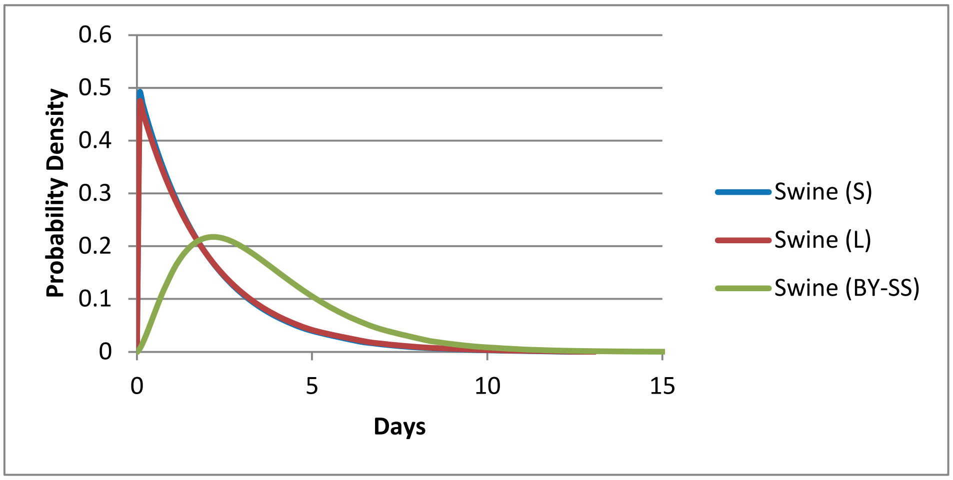


Figure 121: Nebraska Swine Latent Disease Phase

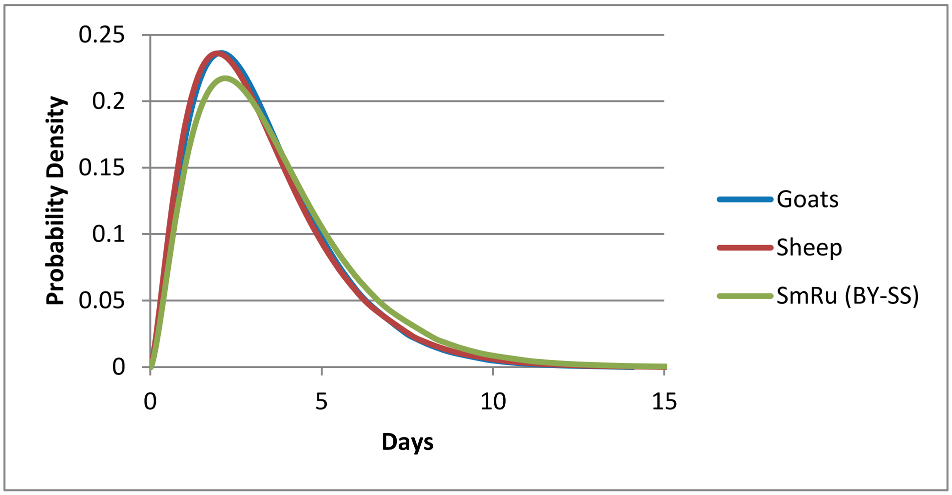


Figure 122: Nebraska Small Ruminants Latent Disease Phase

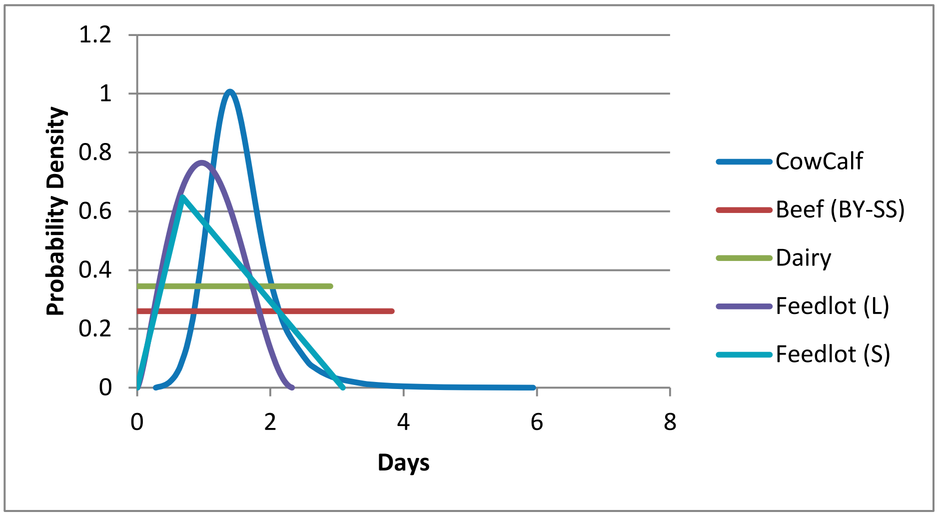


Figure 123: Nebraska Cattle Subclinical Disease Phase

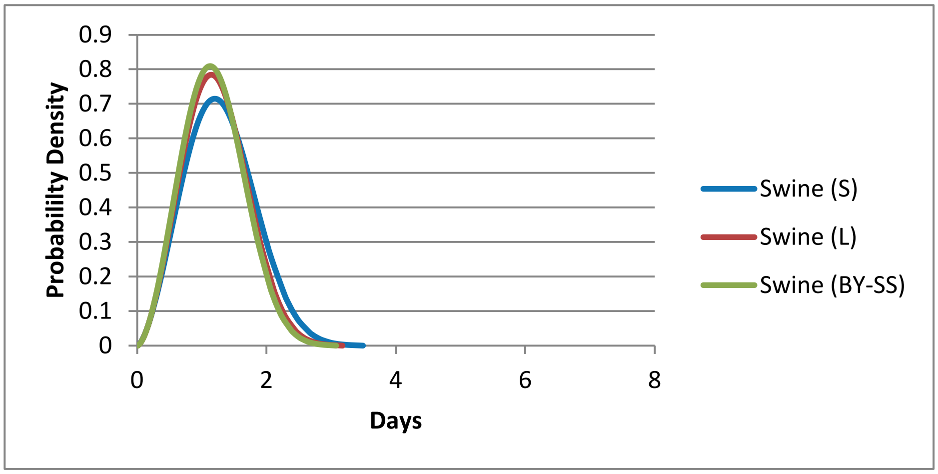


Figure 124: Nebraska Swine Subclinical Disease Phase

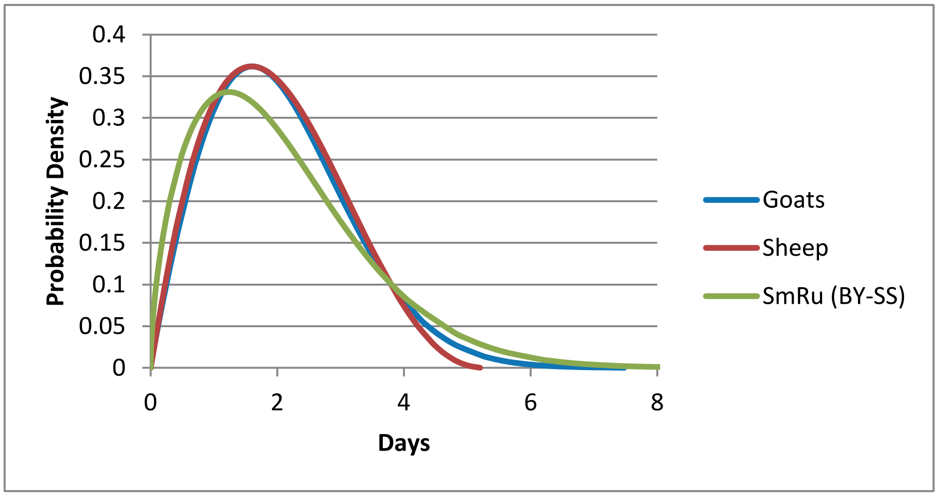


Figure 125: Nebraska Small Ruminants Subclinical Disease Phase

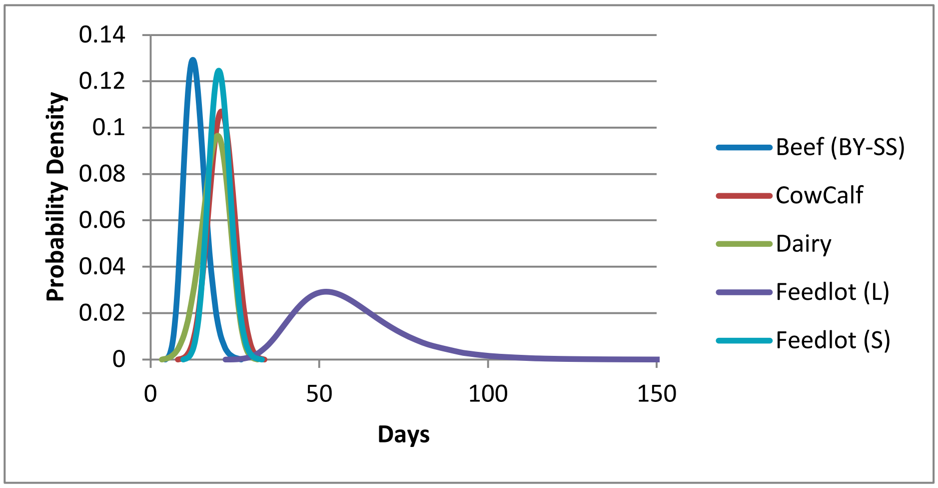


Figure 126: Nebraska Cattle Clinical Disease Phase

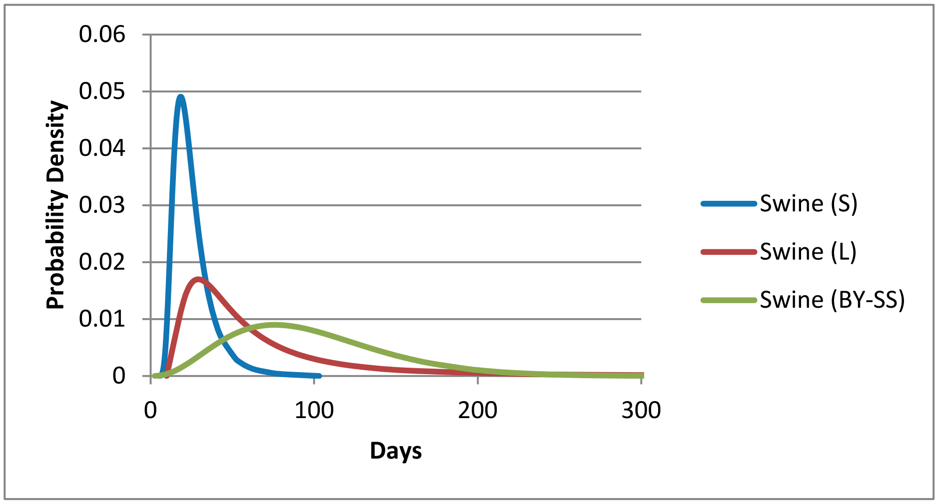


Figure 127: Nebraska Swine Clinical Disease Phase

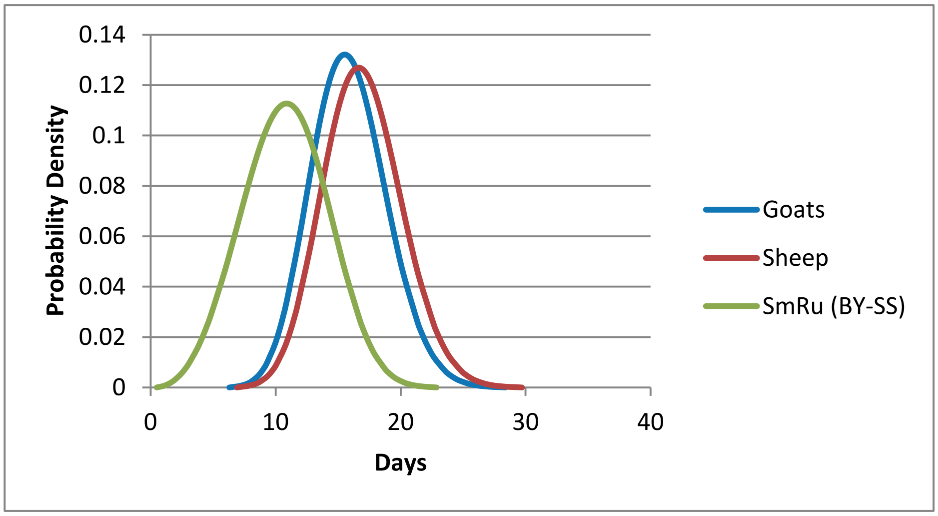


Figure 128: Nebraska Small Ruminants Clinical Disease Phase

Table 76: Oklahoma Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Gamma(2.5398,0.87577)	Weibull(1.8399,1.6702)	BetaGeneral(26.765,72.900,0,69.623)	Gaussian (μ=1095, σ=180)
Dairy	LogLogistic(0,1.9869,2.5457)	Uniform(0,2.8055)	BetaGeneral(23.645,18.825,0,39.941)	Gaussian (μ=1095, σ=180)
Feedlot(L)	Gamma(2.4233,0.96200)	Triang(0,0.78005,2.2174)	BetaGeneral(2.8552,1.0862,0,40.401)	Gaussian (μ=1095, σ=180)
Feedlot(S)	Gamma(2.5387,0.91399)	BetaGeneral(2.1733,5.1091,0,4.1301)	BetaGeneral(20.707,17.565,0,37.598)	Gaussian (μ=1095, σ=180)
Swine(L)	Expon(1.9192)	BetaGeneral(3.4712,3.3877,0,2.3868)	BetaGeneral(2.0502,0.87605,0,40.026)	Weibull (α = 5, β = 985)
Swine(S)	Expon(1.8581)	Triang(0,0.93115,3.0855)	LogLogistic(0,17.350,4.8583)	Weibull (α = 5, β = 985)
Goats	Lognorm(3.6835,2.8109)	BetaGeneral(1.9773,4.2449,0,6.0765)	Gamma(32.866,0.46922)	Gaussian (μ=930, σ=90)
Sheep	Lognorm(3.7846,2.8107)	BetaGeneral(2.1624,5.1393,0,6.5588)	Weibull(5.9403,17.416)	Gaussian (μ=930, σ=90)
Beef (BY SS)	Lognorm(2.8435,2.1860)	Gamma(1.9459,0.92251)	Weibull(3.6616,13.497)	Gaussian (μ=1095, σ=180)
Swine(BY SS)	Expon(2.1111)	Lognorm(1.7933,1.1857)	Weibull(3.2030,11.145)	Weibull (α = 5, β = 985)
Small Ruminants (BY SS)	BetaGeneral(1.9908,16.059,0,31.450)	Gamma(2.3047,0.98972)	Weibull(3.3182,12.106)	Gaussian (μ=930, σ=90)

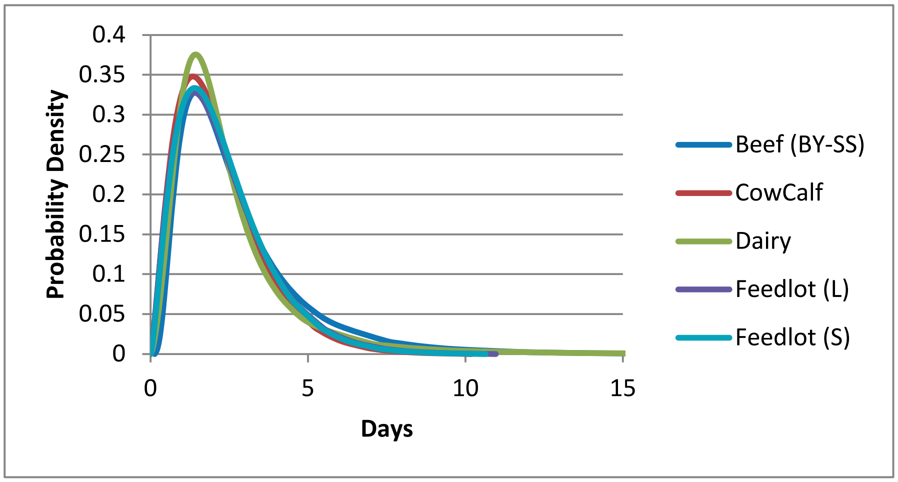


Figure 129: Oklahoma Cattle Latent Disease Phase

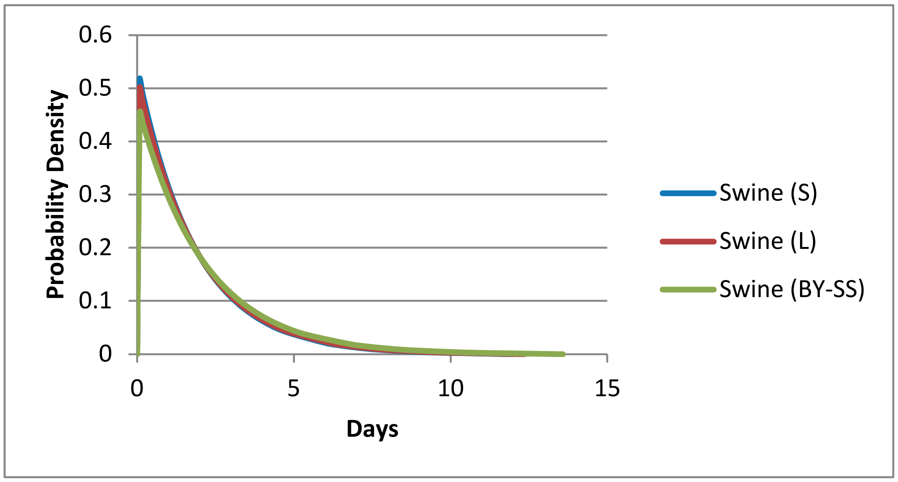


Figure 130: Oklahoma Swine Latent Disease Phase

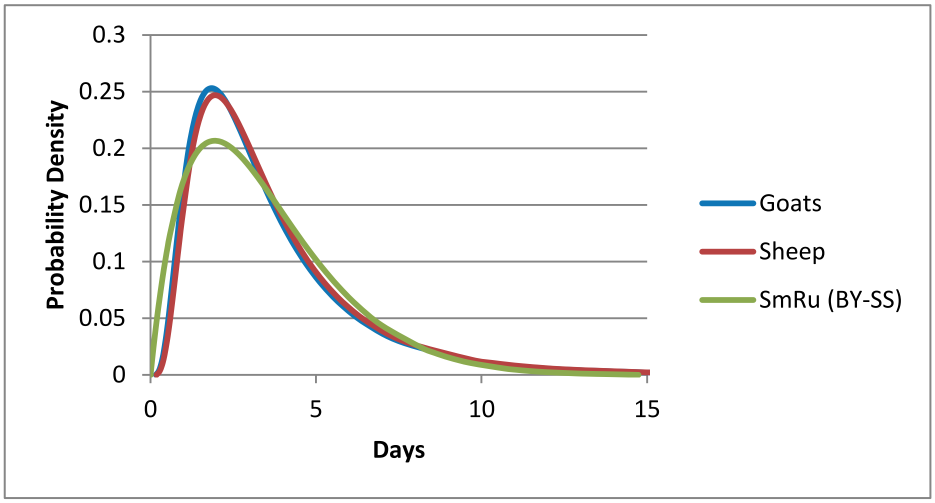


Figure 131: Oklahoma Small Ruminants Latent Disease Phase

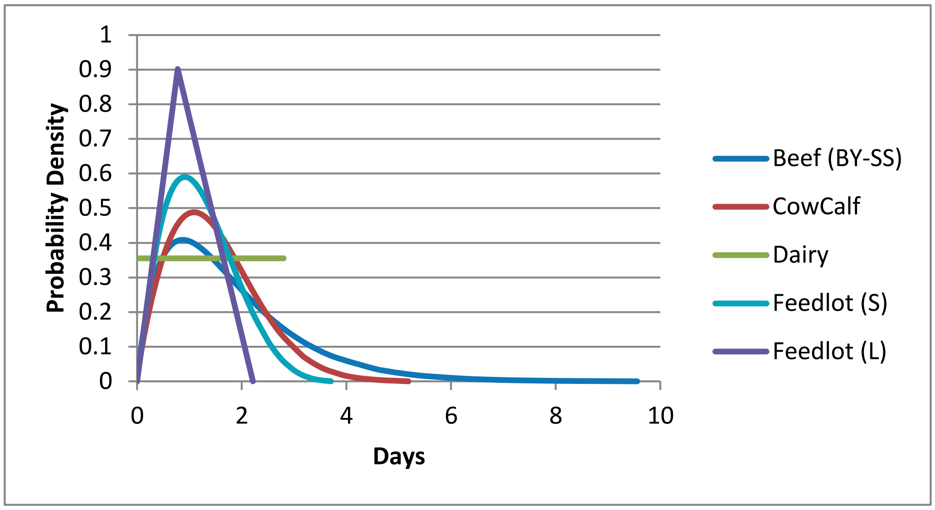


Figure 132: Oklahoma Cattle Subclinical Disease Phase

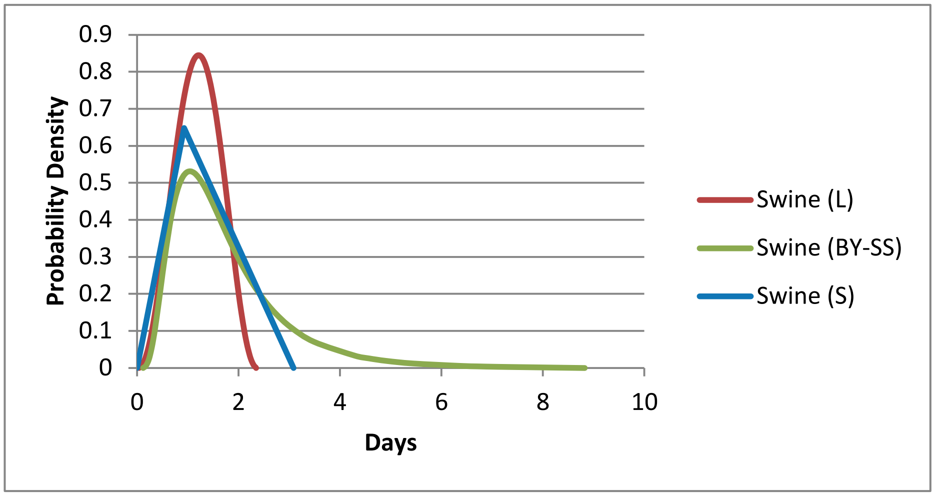


Figure 133: Oklahoma Swine Subclinical Disease Phase

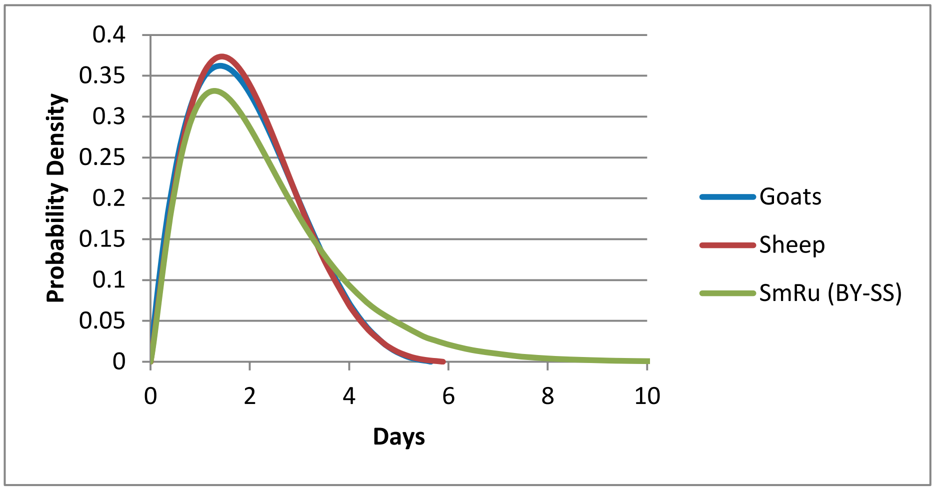


Figure 134: Oklahoma Small Ruminants Subclinical Disease Phase

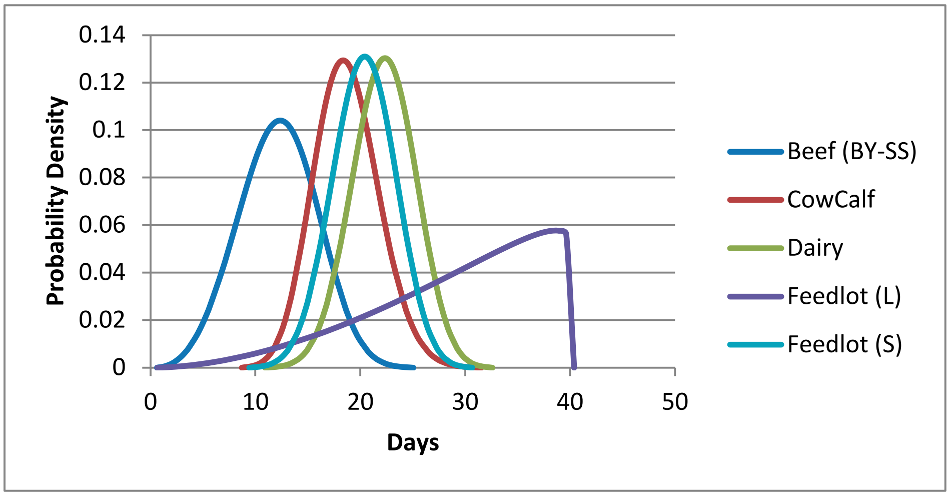


Figure 135: Oklahoma Cattle Clinical Disease Phase

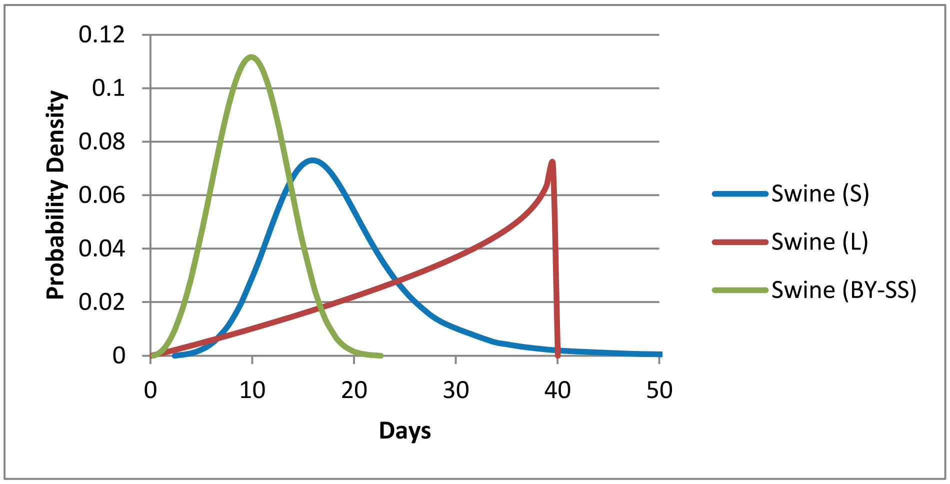


Figure 136: Oklahoma Swine Clinical Disease Phase

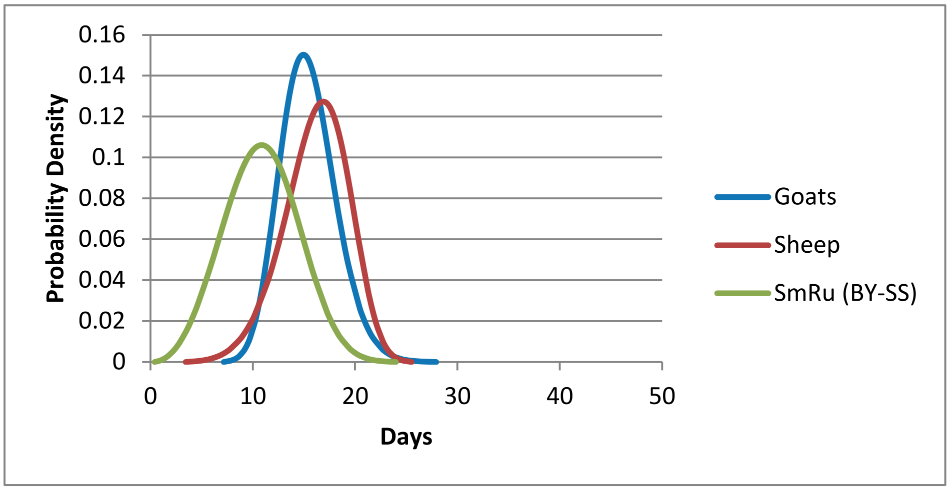


Figure 137: Oklahoma Small Ruminants Clinical Disease Phase

Table 77: Texas Herd Level Disease State Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Lognorm(2.6283,2.0389)	Uniform(0,2.8376)	BetaGeneral(19.113,47.371,0,64.297)	Gaussian (μ=1095, σ=180)
Dairy	Gamma(2.1918,1.0042)	BetaGeneral (1.9975,3.2620,0,3.2406)	Gamma(80.840,0.36359)	Gaussian (μ=1095, σ=180)
Feedlot(L)	Lognorm(2.5329,2.1119)	Triang(0,0.73728,2.2135)	Lognorm(160.83,154.28)	Gaussian (μ=1095, σ=180)
Feedlot(S)	LogLogistic(0,1.9800,2.4669)	Triang(0,0.72899,3.0325)	BetaGeneral(25.980,48.525,0,58.192)	Gaussian (μ=1095, σ=180)
Swine(L)	Expon(1.9040)	BetaGeneral (3.3240,3.5442,0,2.4330)	BetaGeneral(2.7626,2.1626,0,310.82)	Weibull (α = 5, β = 985)
Swine(S)	Expon(1.8945)	InvGauss(1.4871,19.4148)	Pearson5(9.4548,175.89)	Weibull (α = 5, β = 985)
Goats	Weibull(1.6135,3.5721)	BetaGeneral(2.1889,5.2599,0,6.4927)	Lognorm(16.206,3.2495)	Gaussian (μ=930, σ=90)
Sheep	BetaGeneral(2.6056,8382.8,0,10835)	BetaGeneral(2.0349,2.9855,0,4.7282)	Weibull(7.1501,19.249)	Gaussian (μ=930, σ=90)
Beef (BY SS)	Gamma(2.3223,0.96603)	Weibull(1.5925,1.9190)	Weibull(4.1299,13.617)	Gaussian (μ=1095, σ=180)
Swine(BY SS)	Expon(2.3030)	LogLogistic(0,1.5682,2.9261)	Weibull(3.0234,10.300)	Weibull (α = 5, β = 985)
Small Ruminants (BY SS)	Gamma(2.5609,1.3404)	Gamma(2.3688,0.94400)	Triang(0,11.819,18.357)	Gaussian (μ=930, σ=90)

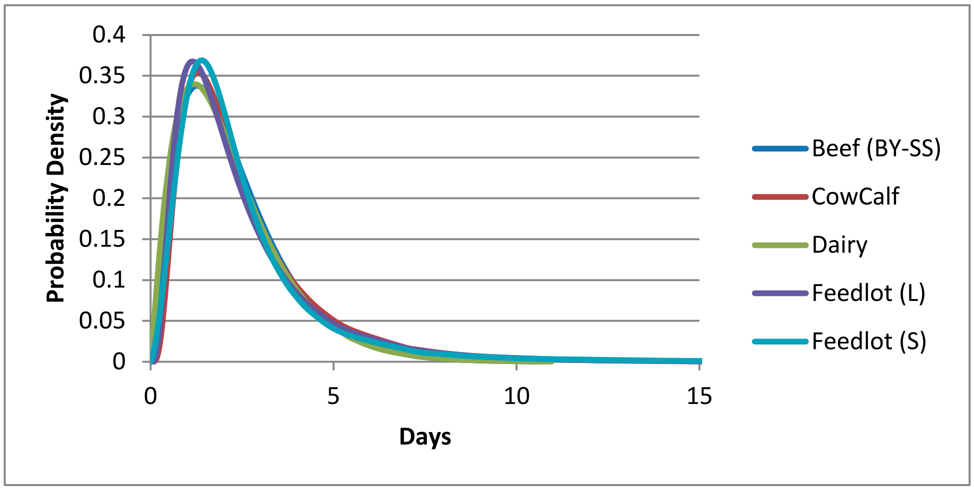


Figure 138: Texas Cattle Latent Disease Phase

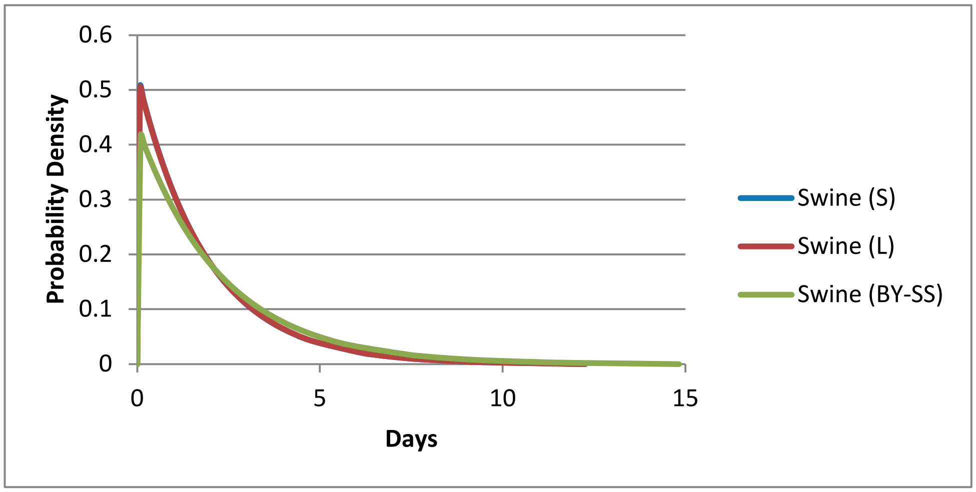


Figure 139: Texas Swine Latent Disease Phase

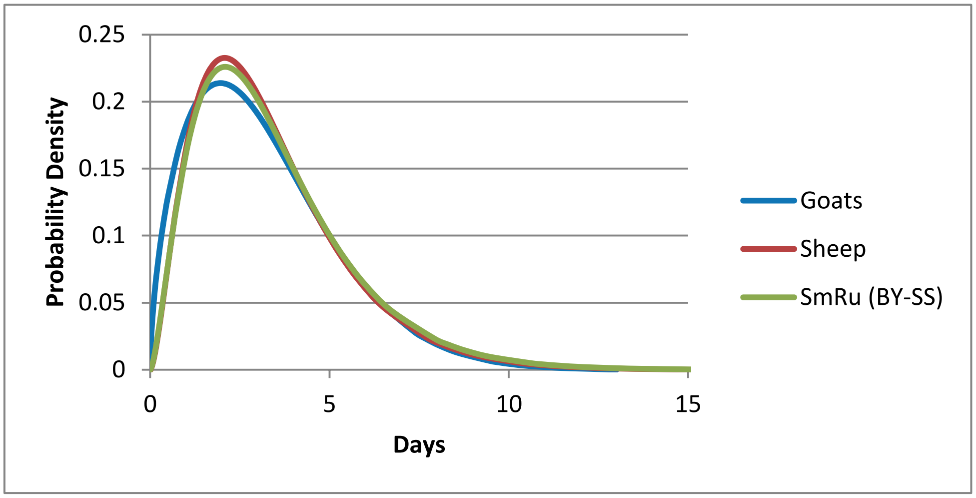


Figure 140: Texas Small Ruminants Latent Disease Phase

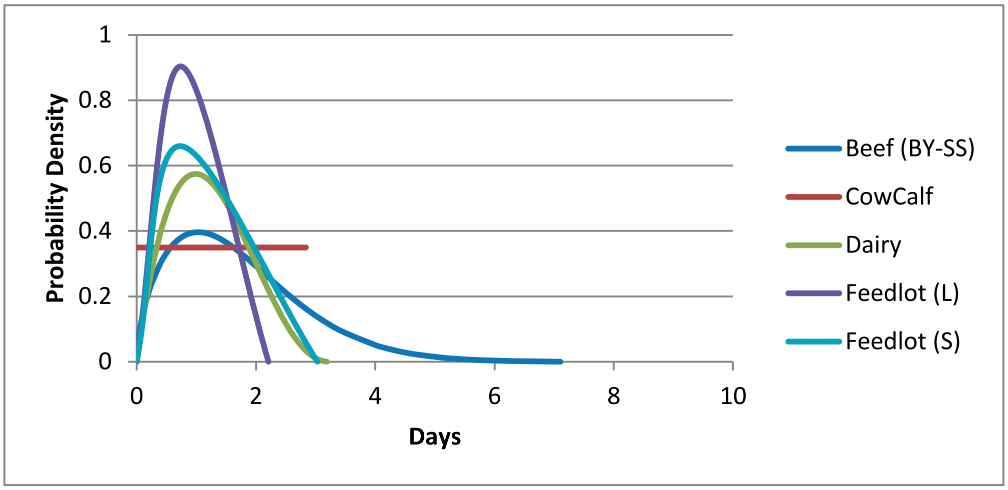


Figure 141: Texas Cattle Subclinical Disease Phase

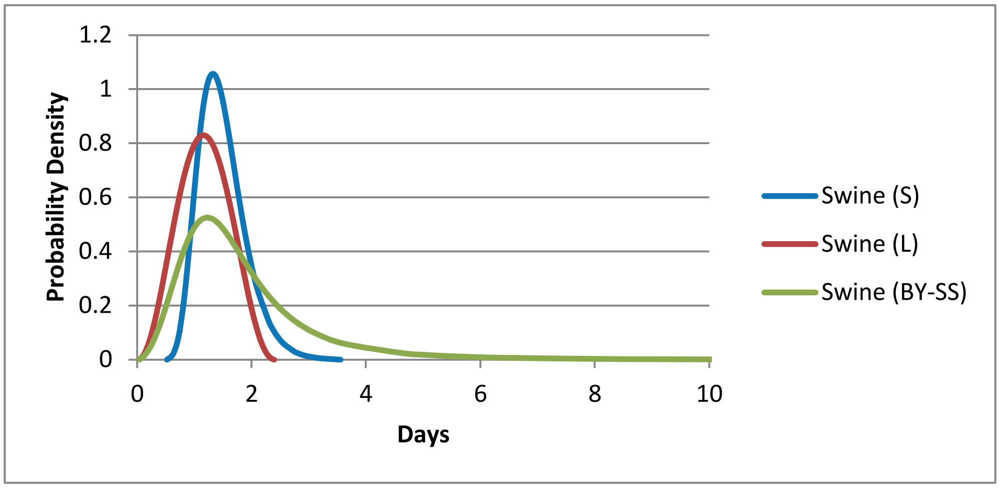


Figure 142: Texas Swine Subclinical Disease Phase

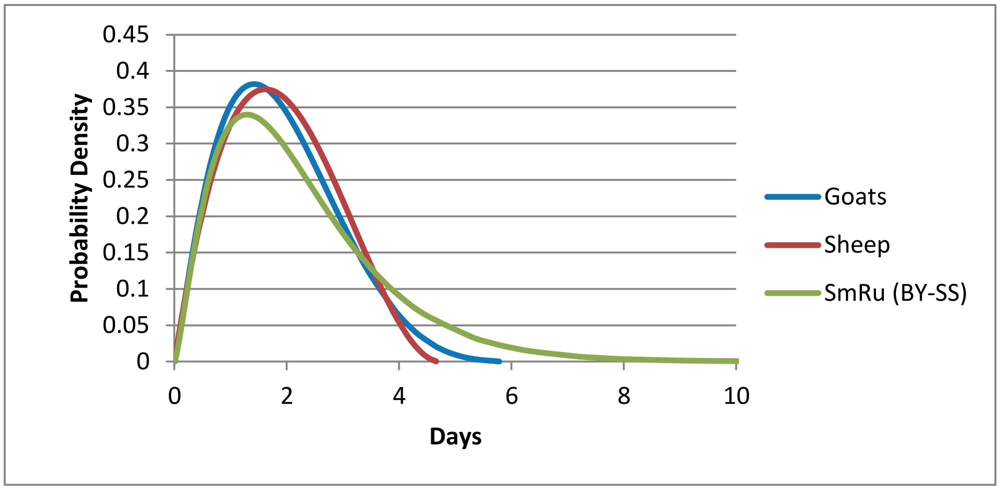


Figure 143: Texas Small Ruminants Subclinical Disease Phase

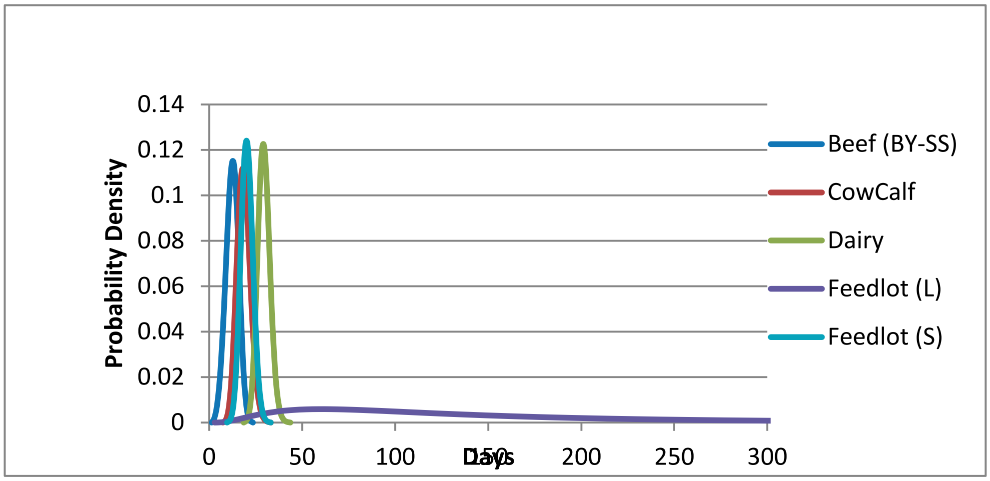


Figure 144: Texas Cattle Clinical Disease Phase

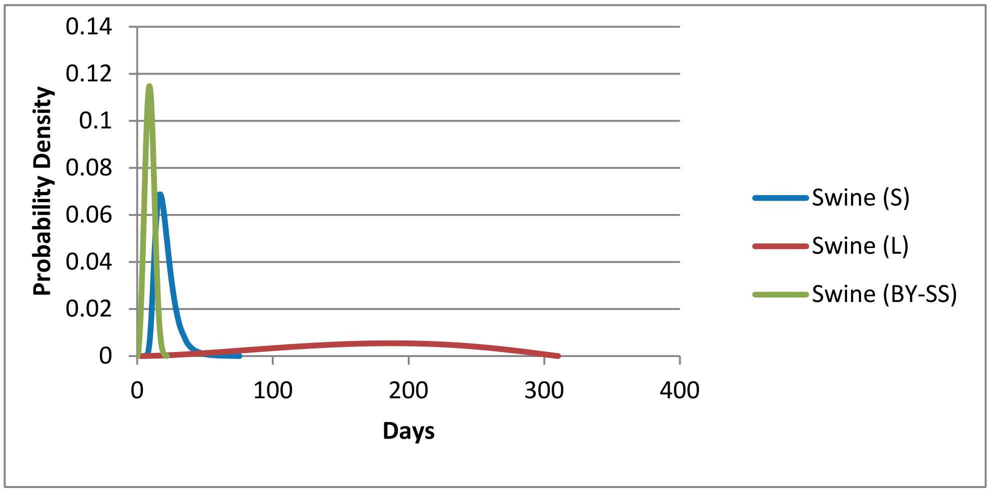


Figure 145: Texas Swine Clinical Disease Phase

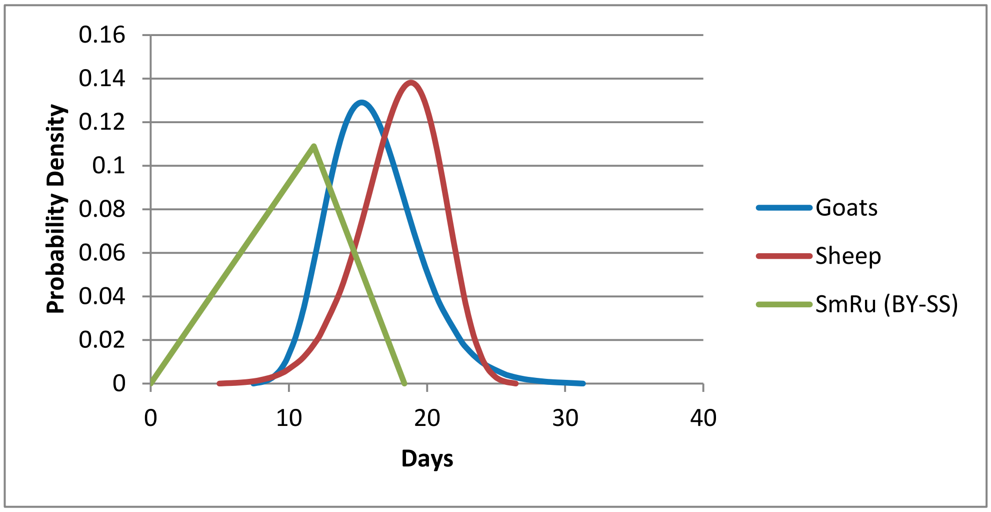


Figure 146: Texas Small Ruminants Clinical Disease Phase

Within-Unit Prevalence Curves

The production-type specific within-unit prevalence curves were developed from the within-unit prevalence data produced by the within-herd model as described above. These curves are provided in Figure 147 through Figure 164. The tables are also provided to enter these functions into NAADSM as piecewise functions (Table 78 through Table 83).

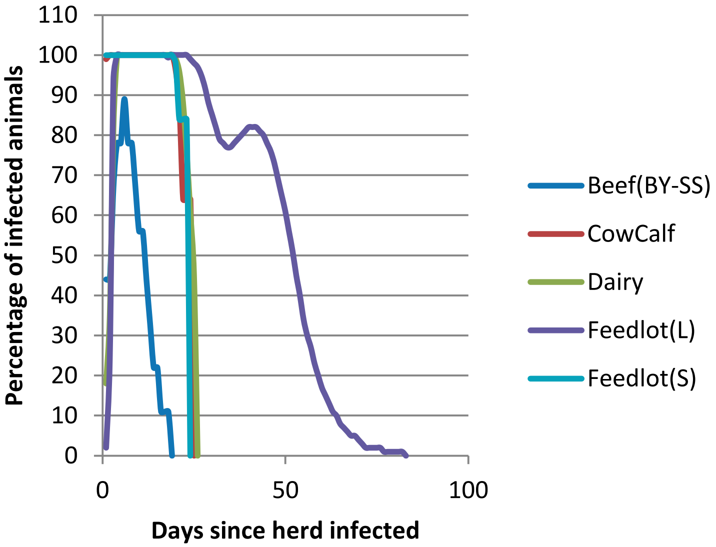


Figure 150: Missouri Cattle Within-Herd Prevalence

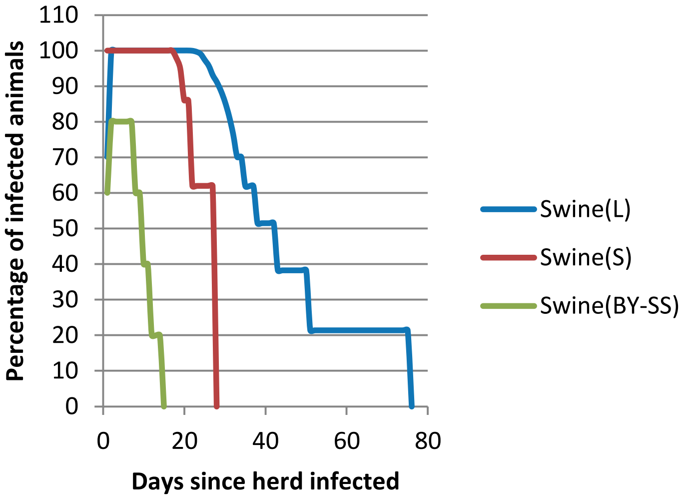


Figure 151: Missouri Swine Within-Herd Prevalence

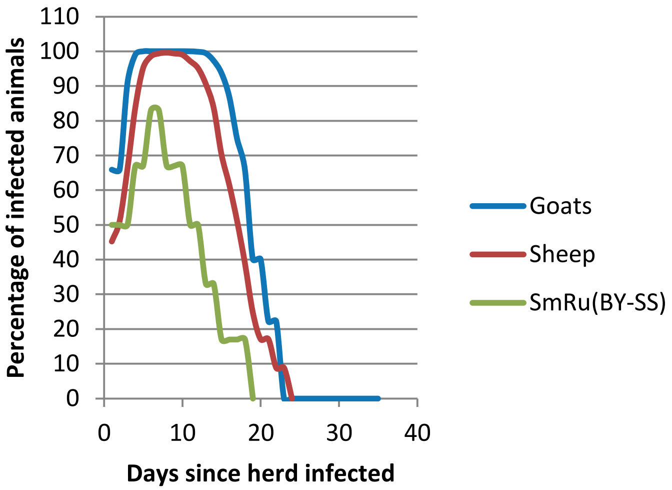


Figure 152: Missouri Small Ruminants Within-Herd Prevalence

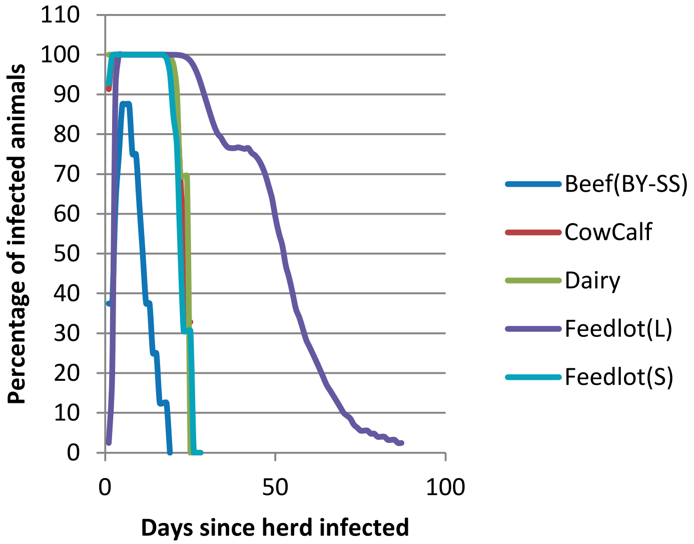


Figure 153: Nebraska Cattle Within-Herd Prevalence

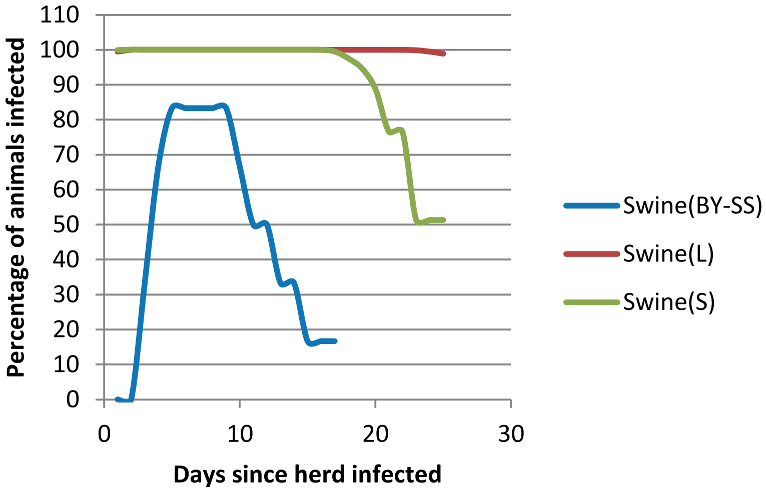


Figure 154: Nebraska Swine Within-Herd Prevalence

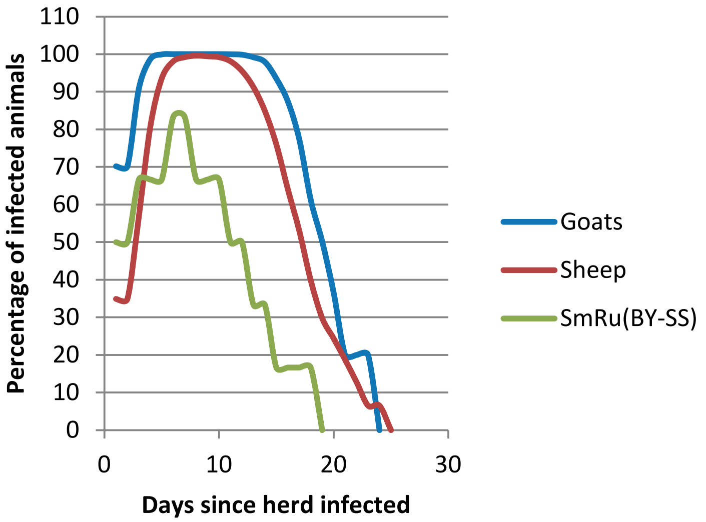
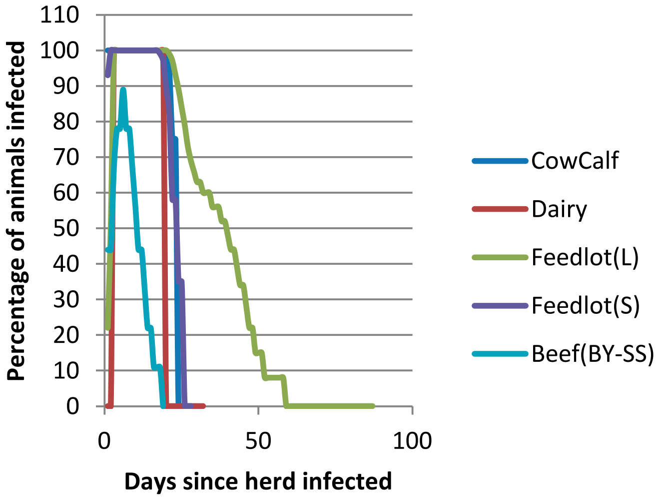


Figure 155: Nebraska Small Ruminants Within-Herd Prevalence



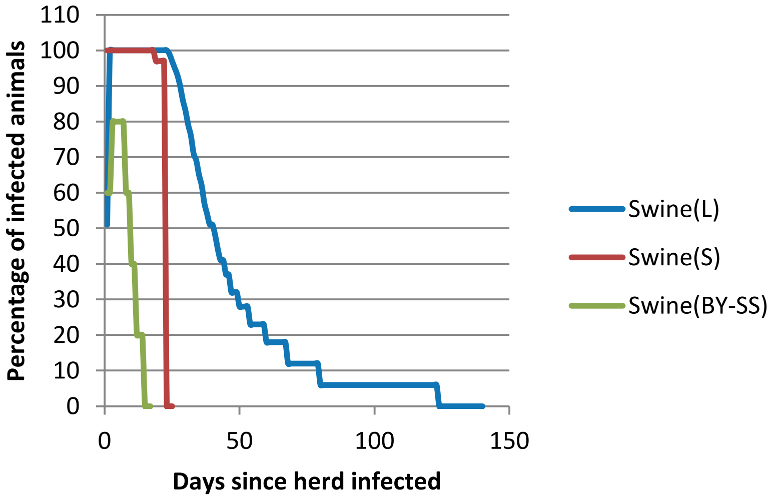


Figure 156: Oklahoma Cattle Within-Herd Prevalence

Figure 157: Oklahoma Swine Within-Herd Prevalence

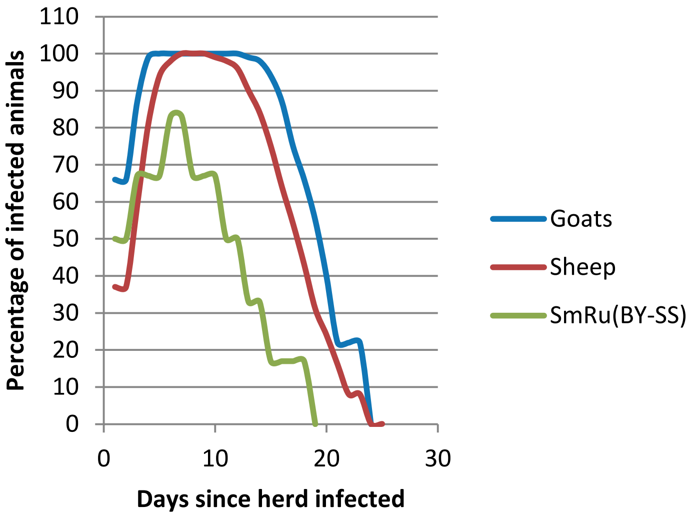


Figure 158: Oklahoma Small Ruminants Within-Herd Prevalence

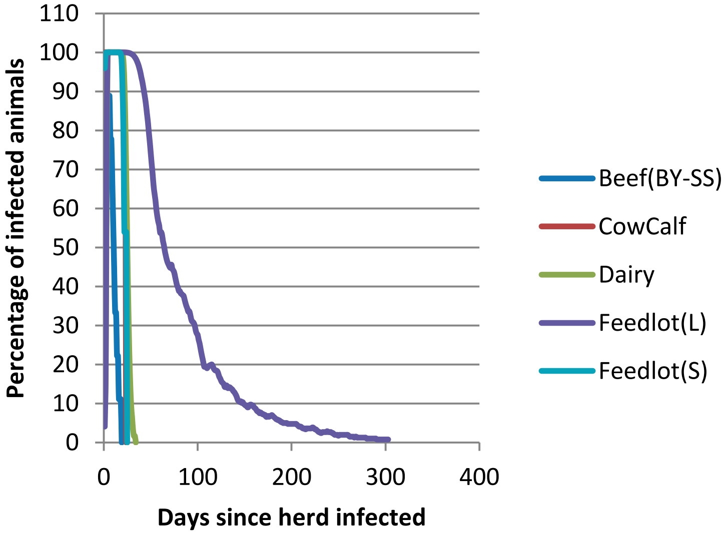


Figure 159: Texas Cattle Within-Herd Prevalence

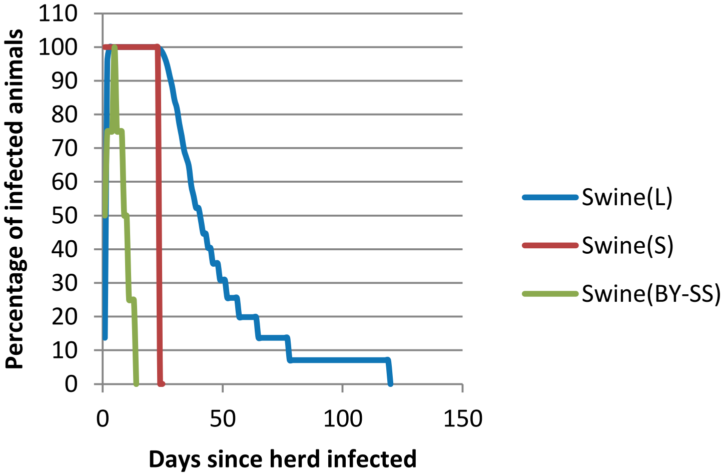


Figure 160: Texas Swine Within-Herd Prevalence

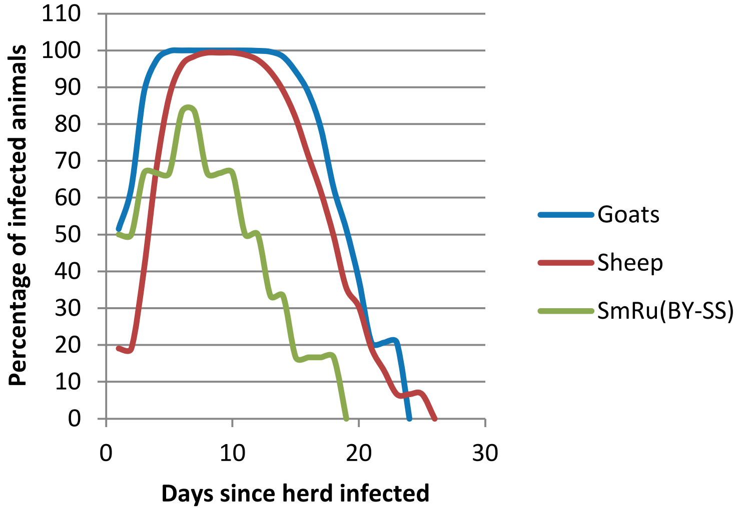
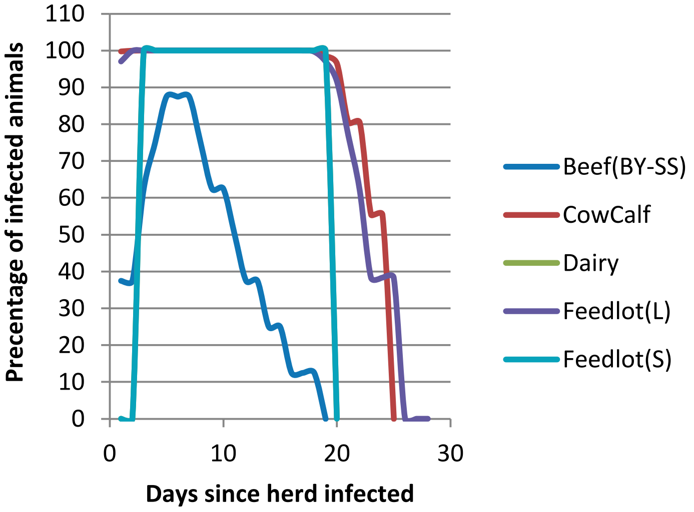


Figure 161: Texas Small Ruminants Within-Herd Prevalence



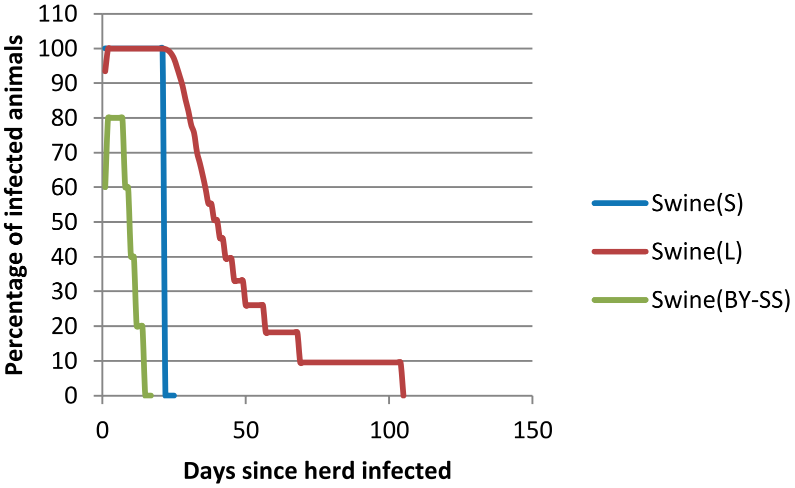


Figure 162: Colorado Cattle Within-Herd Prevalence

Figure 163: Colorado Swine Within-Herd Prevalence

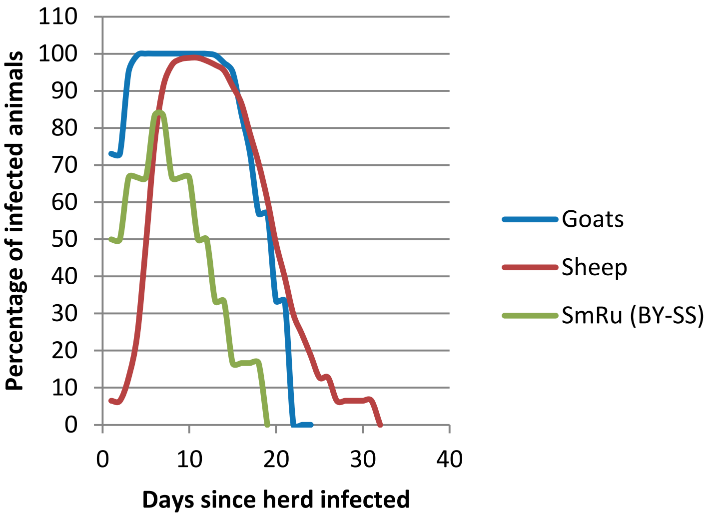


Figure 164: Colorado Small Ruminants Within-Herd Prevalence

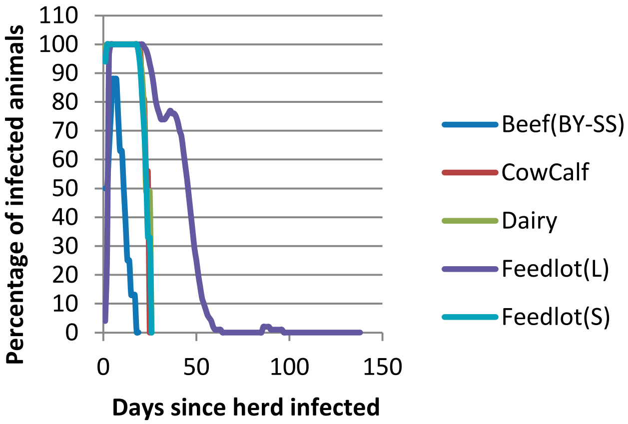


Figure 147: Iowa Cattle Within-Herd Prevalence

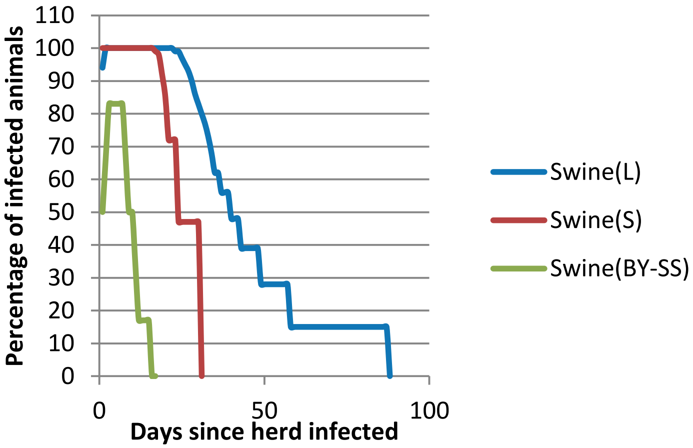


Figure 148: Iowa Swine Within-Herd Prevalence

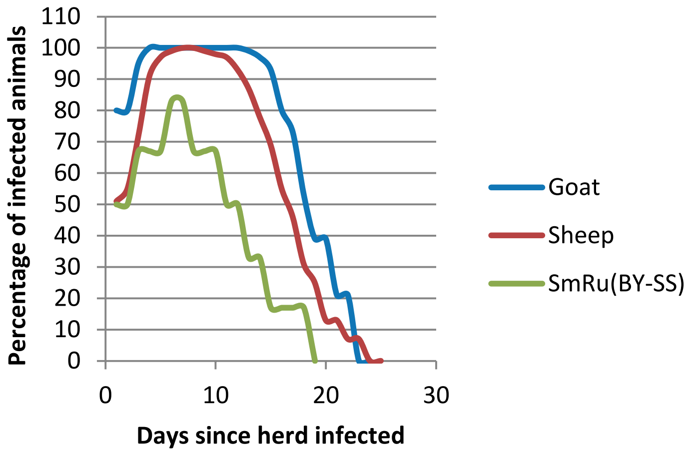


Figure 149: Iowa Small Ruminants Within-Herd Prevalence

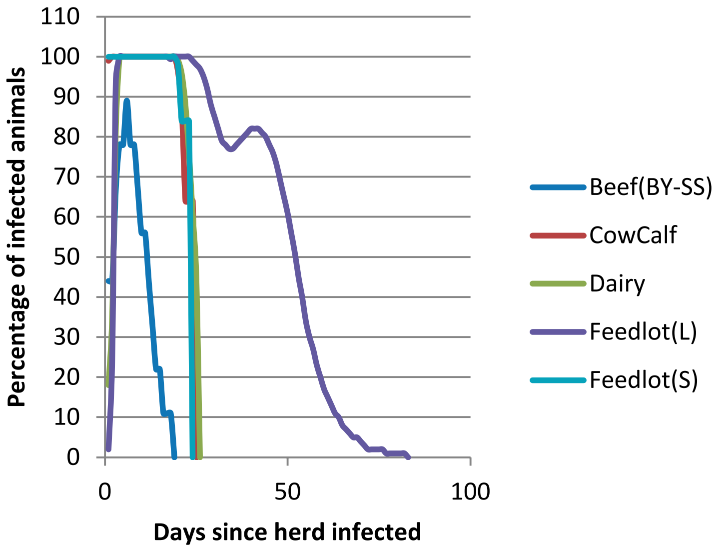


Figure 150: Missouri Cattle Within-Herd Prevalence

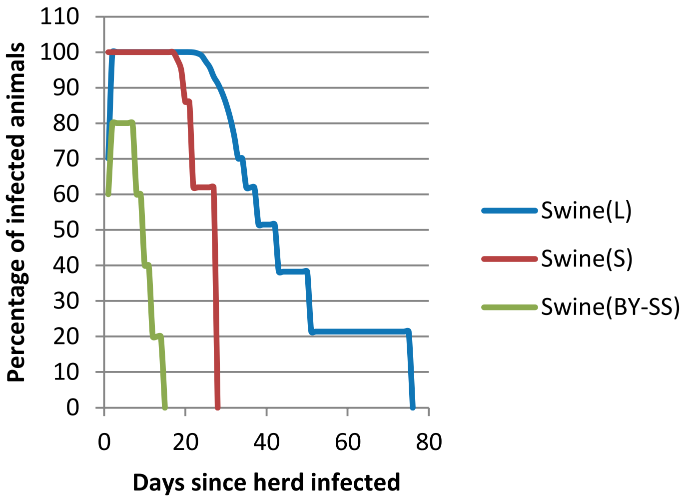


Figure 151: Missouri Swine Within-Herd Prevalence

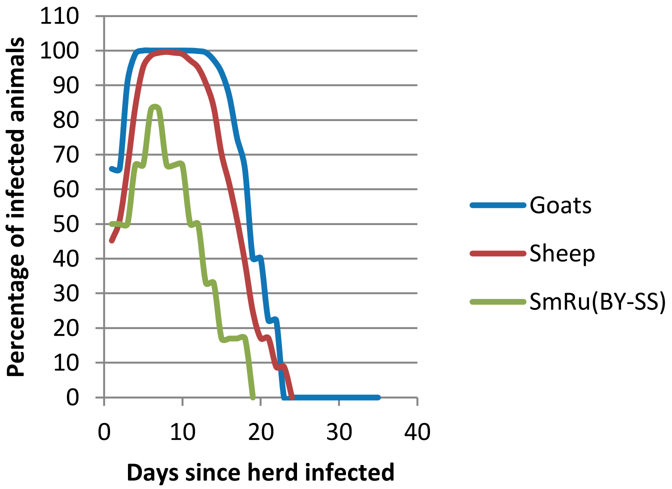


Figure 152: Missouri Small Ruminants Within-Herd Prevalence

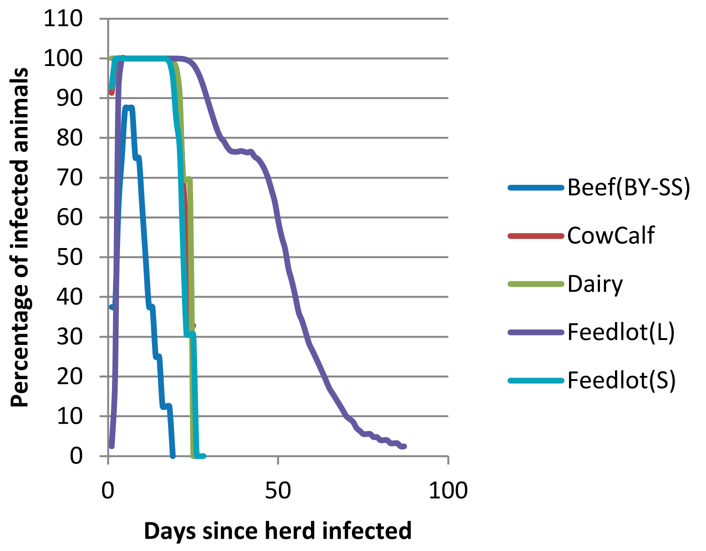


Figure 153: Nebraska Cattle Within-Herd Prevalence

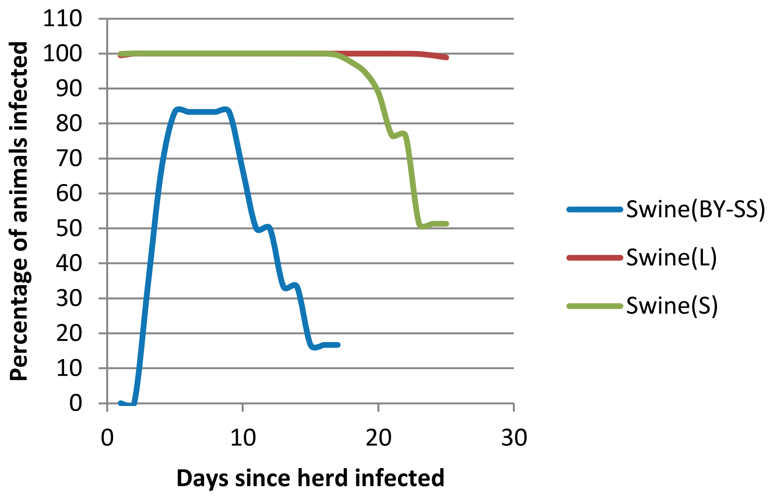


Figure 154: Nebraska Swine Within-Herd Prevalence

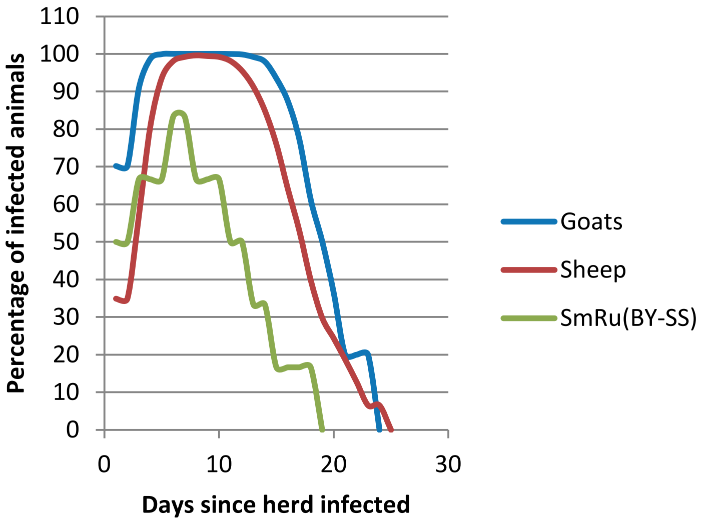


Figure 155: Nebraska Small Ruminants Within-Herd Prevalence

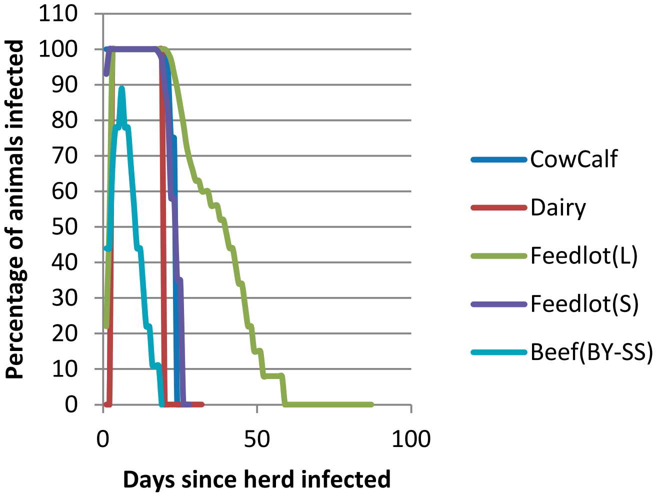


Figure 156: Oklahoma Cattle Within-Herd Prevalence

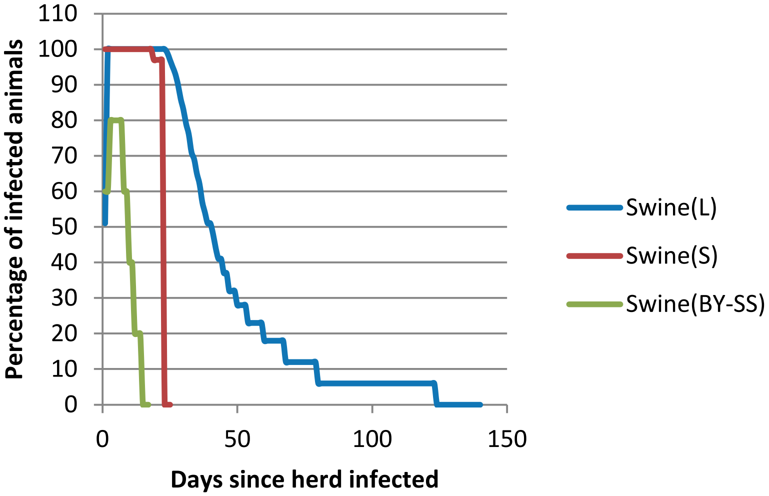


Figure 157: Oklahoma Swine Within-Herd Prevalence

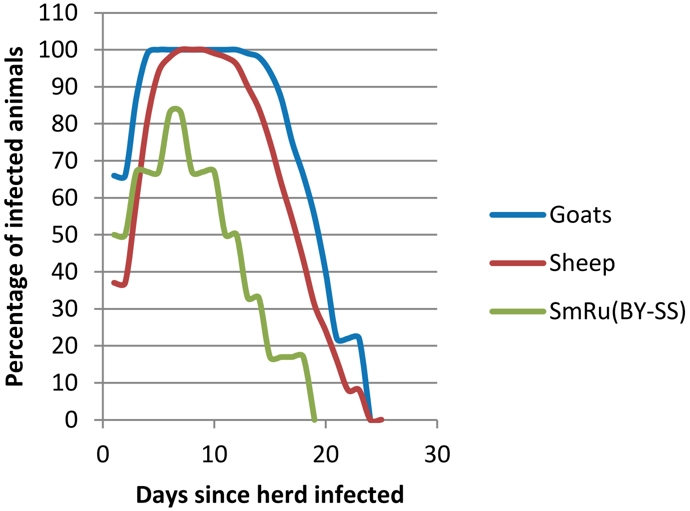


Figure 158: Oklahoma Small Ruminants Within-Herd Prevalence

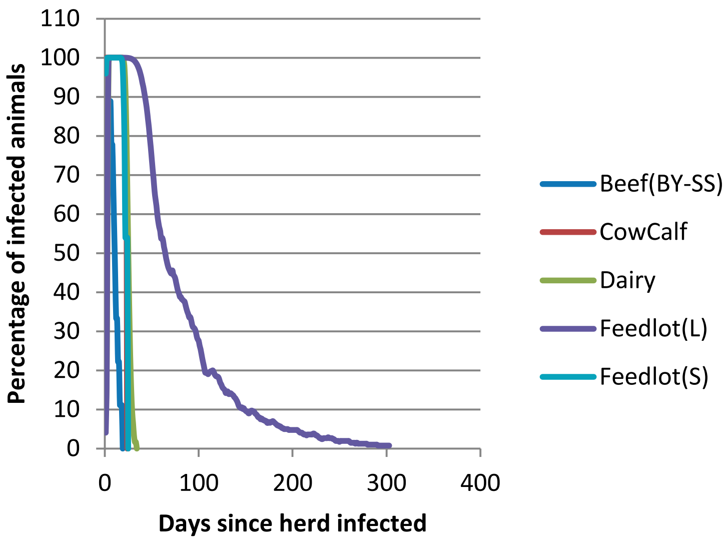


Figure 159: Texas Cattle Within-Herd Prevalence

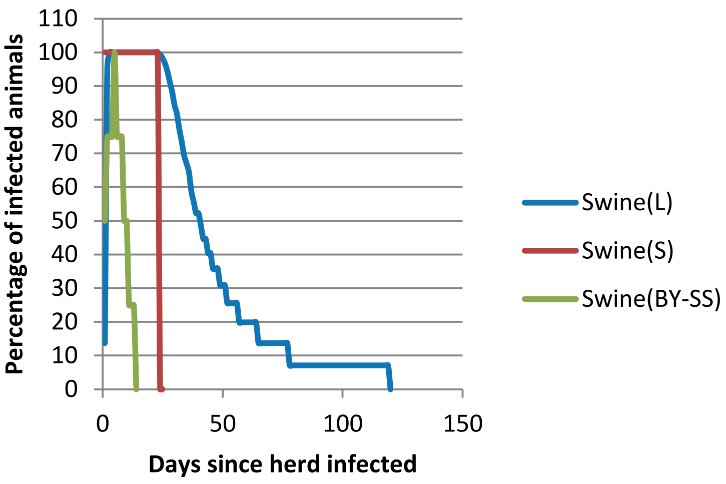


Figure 160: Texas Swine Within-Herd Prevalence

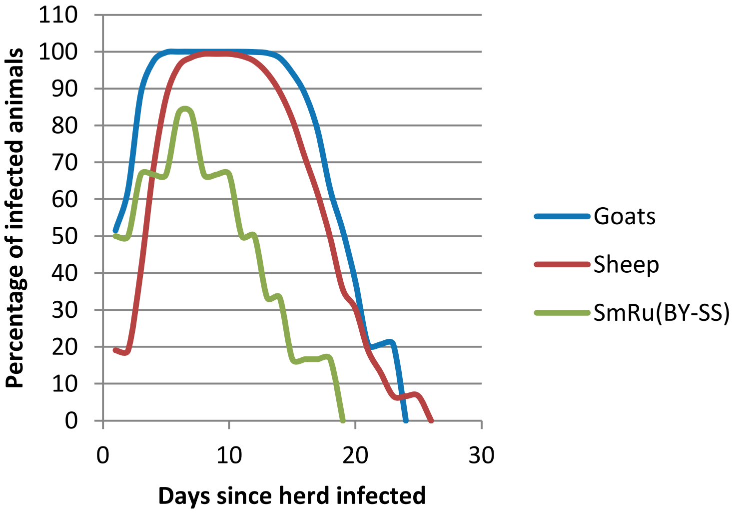


Figure 161: Texas Small Ruminants Within-Herd Prevalence

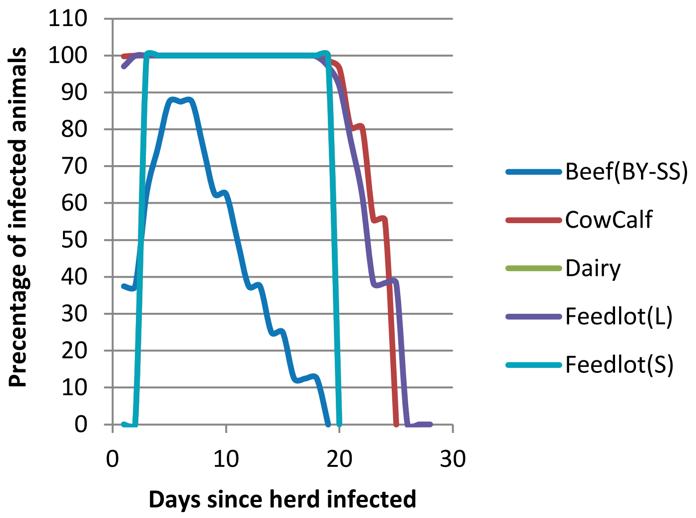


Figure 162: Colorado Cattle Within-Herd Prevalence

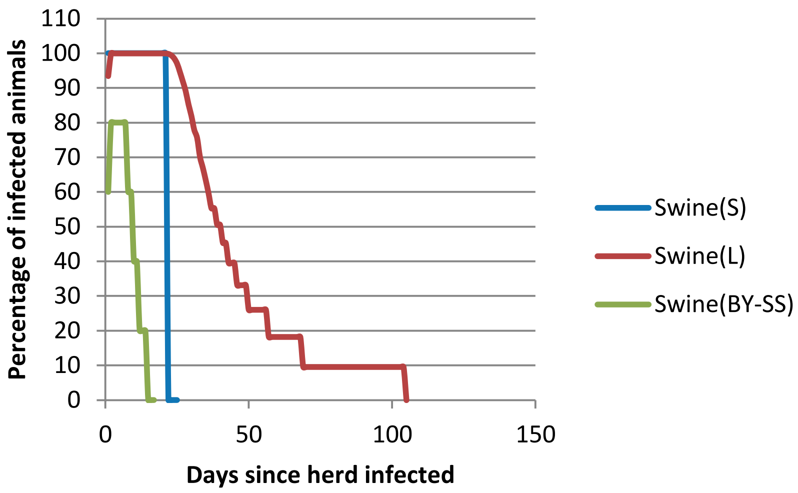


Figure 163: Colorado Swine Within-Herd Prevalence

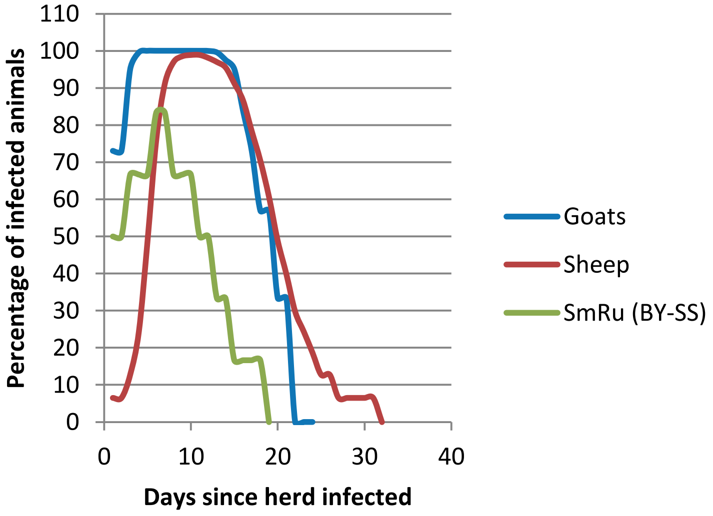


Figure 164: Colorado Small Ruminants Within-Herd Prevalence

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
1	100.00	93.00	22.00	0.00	100.00	51.00	37.00	66.00	44.00	50.00	50.00
2	100.00	100.00	52.00	0.00	100.00	100.00	37.00	66.00	44.00	50.00	50.00
3	100.00	100.00	100.00	100.00	100.00	100.00	59.00	87.00	67.00	67.00	67.00
4	100.00	100.00	100.00	100.00	100.00	100.00	81.00	99.00	78.00	67.00	67.00
5	100.00	100.00	100.00	100.00	100.00	100.00	94.00	100.00	78.00	67.00	67.00
6	100.00	100.00	100.00	100.00	100.00	100.00	98.00	100.00	89.00	83.00	83.00
7	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.00	83.00	83.00
8	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.00	67.00	67.00
9	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	67.00	67.00	67.00
10	100.00	100.00	100.00	100.00	100.00	100.00	99.00	100.00	56.00	67.00	67.00
11	100.00	100.00	100.00	100.00	100.00	100.00	98.00	100.00	44.00	50.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	96.00	100.00	44.00	50.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	90.00	99.00	33.00	33.00	33.00
14	100.00	100.00	100.00	100.00	100.00	100.00	84.00	98.00	22.00	33.00	33.00
15	100.00	100.00	100.00	100.00	100.00	100.00	75.00	94.00	22.00	17.00	17.00
16	100.00	100.00	100.00	100.00	100.00	100.00	64.00	87.00	11.00	17.00	17.00
17	100.00	100.00	100.00	100.00	100.00	100.00	54.00	75.00	11.00	17.00	17.00
18	100.00	99.00	100.00	100.00	100.00	100.00	43.00	66.00	11.00	17.00	17.00
19	100.00	97.00	100.00	100.00	97.00	100.00	31.00	55.00	0.00	0.00	0.00
20	99.00	89.00	100.00	0.00	97.00	100.00	24.00	40.00			
21	94.00	82.00	99.00	0.00	97.00	100.00	16.00	22.00			
22	75.00	58.00	97.00	0.00	97.00	100.00	8.00	22.00			
23	75.00	58.00	93.00	0.00	0.00	100.00	8.00	22.00			

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
24	0.00	35.00	89.00	0.00	0.00	99.00	0.00	0.00			
25	0.00	35.00	84.00	0.00	0.00	97.00	0.00				
26		0.00	79.00	0.00		95.00					
27		0.00	73.00	0.00		93.00					
28		0.00	69.00	0.00		90.00					
29			66.00	0.00		86.00					
30			63.00	0.00		83.00					
31			63.00	0.00		79.00					
32			60.00	0.00		76.00					
33			60.00			71.00					
34			60.00			69.00					
35			56.00			65.00					
36			56.00			62.00					
37			56.00			57.00					
38			52.00			54.00					
39			52.00			51.00					
40			48.00			51.00					
41			44.00			48.00					
42			44.00			44.00					
43			39.00			41.00					
44			34.00			41.00					
45			34.00			37.00					
46			28.00			37.00					
47			22.00			32.00					

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
48			22.00			32.00					
49			15.00			32.00					
50			15.00			28.00					
51			15.00			28.00					
52			8.00			28.00					
53			8.00			28.00					
54			8.00			23.00					
55			8.00			23.00					
56			8.00			23.00					
57			8.00			23.00					
58			8.00			23.00					
59			0.00			23.00					
60			0.00			18.00					
61			0.00			18.00					
62			0.00			18.00					
63			0.00			18.00					
64			0.00			18.00					
65			0.00			18.00					
66			0.00			18.00					
67			0.00			18.00					
68			0.00			12.00					
69			0.00			12.00					
70			0.00			12.00					
71			0.00			12.00					

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
72			0.00			12.00					
73			0.00			12.00					
74			0.00			12.00					
75			0.00			12.00					
76			0.00			12.00					
77			0.00			12.00					
78			0.00			12.00					
79			0.00			12.00					
80			0.00			6.00					
81			0.00			6.00					
82			0.00			6.00					
83			0.00			6.00					
84			0.00			6.00					
85			0.00			6.00					
86			0.00			6.00					
87			0.00			6.00					
88						6.00					
89						6.00					
90						6.00					
91						6.00					
92						6.00					
93						6.00					
94						6.00					
95						6.00					

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
96						6.00					
97						6.00					
98						6.00					
99						6.00					
100						6.00					
101						6.00					
102						6.00					
103						6.00					
104						6.00					
105						6.00					
106						6.00					
107						6.00					
108						6.00					
109						6.00					
110						6.00					
111						6.00					
112						6.00					
113						6.00					
114						6.00					
115						6.00					
116						6.00					
117						6.00					
118						6.00					
119						6.00					

Table 78: Oklahoma Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
120						6.00					
121						6.00					
122						6.00					
123						6.00					
124						0.00					
125						0.00					
126						0.00					
127						0.00					
128						0.00					
129						0.00					
130						0.00					
131						0.00					
132						0.00					
133						0.00					
134						0.00					
135						0.00					
136						0.00					
137						0.00					
138						0.00					
139						0.00					
140						0.00					

Table 79: Colorado Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
1	99.76	0.00	97.01	0.00	100.00	93.46	6.52	73.04	37.50	60.00	50.00
2	99.97	0.00	99.89	0.00	100.00	100.00	6.52	73.04	37.50	80.00	50.00
3	100.00	100.00	100.00	100.00	100.00	100.00	12.75	95.02	62.50	80.00	66.67
4	100.00	100.00	100.00	100.00	100.00	100.00	24.37	99.55	75.00	80.00	66.67
5	100.00	100.00	100.00	100.00	100.00	100.00	48.81	99.99	87.50	80.00	66.67
6	100.00	100.00	100.00	100.00	100.00	100.00	75.93	100.00	87.50	80.00	83.33
7	100.00	100.00	100.00	100.00	100.00	100.00	91.24	100.00	87.50	80.00	83.33
8	100.00	100.00	100.00	100.00	100.00	100.00	97.00	100.00	75.00	60.00	66.67
9	100.00	100.00	100.00	100.00	100.00	100.00	98.55	100.00	62.50	60.00	66.67
10	100.00	100.00	100.00	100.00	100.00	100.00	98.91	100.00	62.50	40.00	66.67
11	100.00	100.00	100.00	100.00	100.00	100.00	98.91	99.99	50.00	40.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	98.12	99.96	37.50	20.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	97.00	99.55	37.50	20.00	33.33
14	100.00	100.00	100.00	100.00	100.00	100.00	95.52	97.51	25.00	20.00	33.33
15	100.00	100.00	100.00	100.00	100.00	100.00	91.24	95.02	25.00	0.00	16.67
16	100.00	100.00	100.00	100.00	100.00	100.00	86.67	83.82	12.50	0.00	16.67
17	100.00	100.00	99.96	100.00	100.00	100.00	78.42	73.04	12.50	0.00	16.67
18	99.91	100.00	99.65	100.00	100.00	100.00	70.39	56.86	12.50		16.67
19	98.53	100.00	97.01	100.00	100.00	100.00	60.58	56.86	0.00		0.00
20	96.44	0.00	91.59	0.00	100.00	100.00	48.81	33.33			
21	80.45		76.95		100.00	99.98	39.80	33.33			
22	80.45		62.18		0.00	99.86	29.78	0.00			
23	55.41		38.32			99.43	24.37				
24	55.41		38.32			98.58	18.70				
26	0.00		38.32			97.10	12.75				

Table 79: Colorado Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
27			0.00			94.66	12.75				
28						91.99	6.52				
29						89.15	6.52				
30						85.29	6.52				
31						82.00	6.52				
32						77.96	6.52				
33						75.62	0.00				
34						70.16					
35						67.00					
36						63.49					
37						59.62					
38						55.33					
39						55.33					
40						50.59					
41						50.59					
42						45.35					
43						45.35					
44						39.56					
45						39.56					
46						39.56					
47						33.15					
48						33.15					
49						33.15					
50						33.15					
51						26.06					
52						26.06					
53						26.06					

Table 79: Colorado Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
54						26.06					
55						26.06					
56						26.06					
57						26.06					
58						18.23					
59						18.23					
60						18.23					
61						18.23					
62						18.23					
63						18.23					
64						18.23					
65						18.23					
66						18.23					
67						18.23					
68						18.23					
69						18.23					
70						9.57					
71						9.57					
72						9.57					
73						9.57					
74						9.57					
75						9.57					
76						9.57					
77						9.57					
78						9.57					
79						9.57					
80						9.57					

Table 79: Colorado Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
81						9.57					
82						9.57					
83						9.57					
84						9.57					
85						9.57					
86						9.57					
87						9.57					
88						9.57					
89						9.57					
90						9.57					
91						9.57					
92						9.57					
93						9.57					
94						9.57					
95						9.57					
96						9.57					
97						9.57					
98						9.57					
99						9.57					
100						9.57					
101						9.57					
102						9.57					
103						9.57					
104						9.57					
105						9.57					
106						0.00					

Table 80: Iowa Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
1	99.00	94.00	4.00	99.00	100.00	94.00	51.00	80.00	50.00	50.00	50.00
2	100.00	100.00	28.00	100.00	100.00	100.00	55.00	80.00	50.00	67.00	50.00
3	100.00	100.00	96.00	100.00	100.00	100.00	72.00	95.00	63.00	83.00	67.00
4	100.00	100.00	100.00	100.00	100.00	100.00	91.00	100.00	75.00	83.00	67.00
5	100.00	100.00	100.00	100.00	100.00	100.00	97.00	100.00	88.00	83.00	67.00
6	100.00	100.00	100.00	100.00	100.00	100.00	99.00	100.00	88.00	83.00	83.00
7	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.00	83.00	83.00
8	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	75.00	67.00	67.00
9	100.00	100.00	100.00	100.00	100.00	100.00	99.00	100.00	63.00	50.00	67.00
10	100.00	100.00	100.00	100.00	100.00	100.00	98.00	100.00	63.00	50.00	67.00
11	100.00	100.00	100.00	100.00	100.00	100.00	97.00	100.00	50.00	33.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	93.00	100.00	38.00	17.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	87.00	99.00	25.00	17.00	33.00
14	100.00	100.00	100.00	100.00	100.00	100.00	78.00	97.00	25.00	17.00	33.00
15	100.00	100.00	100.00	100.00	100.00	100.00	69.00	93.00	13.00	17.00	17.00
16	100.00	100.00	100.00	100.00	100.00	100.00	55.00	80.00	13.00	0.00	17.00
17	100.00	100.00	100.00	100.00	99.00	100.00	46.00	73.00	13.00	0.00	17.00
18	100.00	100.00	100.00	100.00	98.00	100.00	31.00	53.00	0.00		17.00
19	99.00	97.00	100.00	99.00	92.00	100.00	25.00	39.00	0.00		0.00
20	97.00	91.00	100.00	94.00	85.00	100.00	13.00	39.00			
21	81.00	80.00	100.00	88.00	72.00	100.00	13.00	21.00			
22	81.00	70.00	99.00	75.00	72.00	100.00	7.00	21.00			
23	56.00	55.00	98.00	49.00	72.00	99.00	7.00	0.00			
24	56.00	33.00	96.00	49.00	47.00	99.00	0.00	0.00			

Table 80: Iowa Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
25	0.00	33.00	93.00	49.00	47.00	97.00	0.00				
26		0.00	90.00	0.00	47.00	95.00					
27			86.00		47.00	93.00					
28			81.00		47.00	90.00					
29			78.00		47.00	86.00					
30			76.00		47.00	83.00					
31			74.00		0.00	80.00					
32			74.00			77.00					
33			74.00			73.00					
34			75.00			68.00					
35			76.00			62.00					
36			77.00			62.00					
37			76.00			56.00					
38			76.00			56.00					
39			75.00			56.00					
40			73.00			48.00					
41			70.00			48.00					
42			68.00			48.00					
43			63.00			39.00					
44			58.00			39.00					
45			53.00			39.00					
46			47.00			39.00					
47			41.00			39.00					
48			35.00			39.00					
49			29.00			28.00					

Table 80: Iowa Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
50			25.00			28.00					
51			20.00			28.00					
52			16.00			28.00					
53			12.00			28.00					
54			10.00			28.00					
55			8.00			28.00					
56			6.00			28.00					
57			5.00			28.00					
58			4.00			15.00					
59			2.00			15.00					
60			1.00			15.00					
61			1.00			15.00					
62			1.00			15.00					
63			1.00			15.00					
64			0.00			15.00					
65			0.00			15.00					
66			0.00			15.00					
67			0.00			15.00					
68			0.00			15.00					
69			0.00			15.00					
70			0.00			15.00					
71			0.00			15.00					
72			0.00			15.00					
73			0.00			15.00					
74			0.00			15.00					

Table 80: Iowa Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
75			0.00			15.00					
76			0.00			15.00					
77			0.00			15.00					
78			0.00			15.00					
79			0.00			15.00					
80			0.00			15.00					
81			0.00			15.00					
82			0.00			15.00					
83			0.00			15.00					
84			0.00			15.00					
85			0.00			15.00					
86			2.00			15.00					
87			2.00			15.00					
88			2.00			0.00					
89			2.00								
90			1.00								
91			1.00								
92			1.00								
93			1.00								
94			1.00								
95			1.00								
96			1.00								
97			0.00								

Table 81: Missouri Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu(BY SS)
1	99.00	100.00	2.00	18.02	100.00	70.09	45.25	65.90	44.00	60.00	50.00
2	100.00	100.00	24.00	35.07	100.00	100.00	51.12	65.90	44.00	80.00	50.00
3	100.00	100.00	94.00	82.11	100.00	100.00	66.18	90.83	67.00	80.00	50.00
4	100.00	100.00	100.00	99.62	100.00	100.00	83.81	98.99	78.00	80.00	67.00
5	100.00	100.00	100.00	100.00	100.00	100.00	95.22	99.97	78.00	80.00	67.00
6	100.00	100.00	100.00	100.00	100.00	100.00	98.60	100.00	89.00	80.00	83.00
7	100.00	100.00	100.00	100.00	100.00	100.00	99.42	100.00	78.00	80.00	83.00
8	100.00	100.00	100.00	100.00	100.00	100.00	99.67	100.00	78.00	60.00	67.00
9	100.00	100.00	100.00	100.00	100.00	100.00	99.42	100.00	67.00	60.00	67.00
10	100.00	100.00	100.00	100.00	100.00	100.00	99.06	100.00	56.00	40.00	67.00
11	100.00	100.00	100.00	100.00	100.00	100.00	97.24	99.97	56.00	40.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	95.22	99.84	44.00	20.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	90.64	99.42	33.00	20.00	33.00
14	100.00	100.00	100.00	100.00	100.00	100.00	83.81	97.29	22.00	20.00	33.00
15	100.00	100.00	100.00	100.00	100.00	100.00	70.40	93.73	22.00	0.00	17.00
16	100.00	100.00	100.00	100.00	100.00	100.00	61.56	86.91	11.00		17.00
17	100.00	100.00	100.00	100.00	100.00	100.00	51.12	74.79	11.00		17.00
18	100.00	100.00	100.00	99.99	98.00	100.00	38.94	65.90	11.00		17.00
19	100.00	100.00	100.00	99.87	95.00	100.00	24.88	40.17	0.00		0.00
20	96.00	98.00	100.00	99.04	86.00	100.00	17.11	40.17			
21	87.00	84.00	100.00	95.75	86.00	99.99	17.11	22.22			
22	64.00	84.00	100.00	88.19	62.00	99.91	8.82	22.22			
23	64.00	84.00	100.00	75.63	62.00	99.63	8.82	0.00			
24	64.00	0.00	99.00	60.77	62.00	99.00	0.00	0.00			
25	0.00		98.00	45.07	62.00	97.36		0.00			

Table 81: Missouri Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu(BY SS)
26			97.00	0.00	62.00	95.70		0.00			
27			95.00		62.00	93.01		0.00			
28			92.00		0.00	91.09		0.00			
29			88.00			88.64		0.00			
30			85.00			85.53		0.00			
31			82.00			81.56		0.00			
32			79.00			76.52		0.00			
33			78.00			70.09		0.00			
34			77.00			70.09		0.00			
35			77.00			61.91		0.00			
36			78.00			61.91					
37			79.00			61.91					
38			80.00			51.50					
39			81.00			51.50					
40			82.00			51.50					
41			82.00			51.50					
42			82.00			51.50					
43			81.00			38.26					
44			80.00			38.26					
45			78.00			38.26					
46			76.00			38.26					
47			73.00			38.26					
48			69.00			38.26					
49			65.00			38.26					
50			61.00			38.26					

Table 81: Missouri Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu(BY SS)
51			56.00			21.42					
52			51.00			21.42					
53			45.00			21.42					
54			40.00			21.42					
55			34.00			21.42					
56			30.00			21.42					
57			27.00			21.42					
58			23.00			21.42					
59			20.00			21.42					
60			17.00			21.42					
61			15.00			21.42					
62			13.00			21.42					
63			11.00			21.42					
64			10.00			21.42					
65			8.00			21.42					
66			7.00			21.42					
67			6.00			21.42					
68			5.00			21.42					
69			5.00			21.42					
70			4.00			21.42					
71			3.00			21.42					
72			2.00			21.42					
73			2.00			21.42					
74			2.00			21.42					
75			2.00			21.42					

Table 81: Missouri Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu(BY SS)
76			2.00			0.00					
77			1.00								
78			1.00								
79			1.00								
80			1.00								
81			1.00								
82			1.00								
83			0.00								

Table 82: Nebraska Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
1	91.33	92.78	2.40	99.99	99.89	99.50	34.91	70.17	37.50	0.00	50.00
2	98.44	99.71	19.67	100.00	100.00	100.00	34.91	70.17	37.50	0.00	50.00
3	100.00	100.00	92.16	100.00	100.00	100.00	56.88	90.86	62.50	33.33	66.67
4	100.00	100.00	100.00	100.00	100.00	100.00	80.73	98.65	75.00	66.67	66.67
5	100.00	100.00	100.00	100.00	100.00	100.00	93.62	99.92	87.50	83.33	66.67
6	100.00	100.00	100.00	100.00	100.00	100.00	98.12	100.00	87.50	83.33	83.33
7	100.00	100.00	100.00	100.00	100.00	100.00	99.21	100.00	87.50	83.33	83.33
8	100.00	100.00	100.00	100.00	100.00	100.00	99.63	100.00	75.00	83.33	66.67
9	100.00	100.00	100.00	100.00	100.00	100.00	99.45	100.00	75.00	83.33	66.67
10	100.00	100.00	100.00	100.00	100.00	100.00	99.21	100.00	62.50	66.67	66.67

Table 82: Nebraska Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
11	100.00	100.00	100.00	100.00	100.00	100.00	98.12	99.96	50.00	50.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	95.52	99.84	37.50	50.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	91.24	99.16	37.50	33.33	33.33
14	100.00	100.00	100.00	100.00	100.00	100.00	84.85	97.92	25.00	33.33	33.33
15	100.00	100.00	100.00	100.00	100.00	100.00	75.93	93.47	25.00	16.67	16.67
16	100.00	99.99	100.00	100.00	99.95	100.00	64.06	87.43	12.50	16.67	16.67
17	99.99	99.88	100.00	100.00	99.47	100.00	52.96	77.33	12.50	16.67	16.67
18	99.84	99.01	100.00	99.96	97.50	100.00	39.80	61.23	12.50		16.67
19	99.00	95.11	100.00	99.33	94.67	100.00	29.78	50.15	0.00		0.00
20	94.32	84.43	99.99	97.49	88.75	100.00	24.37	36.55			
21	86.84	77.26	99.96	91.06	76.48	100.00	18.70	20.00			
22	70.01	51.99	99.88	69.49	76.48	99.98	12.75	20.00			
23	55.02	30.60	99.67	69.49	51.28	99.89	6.52	20.00			
24	32.80	30.60	99.22	69.49	51.28	99.50	6.52	0.00			
25	32.80	30.60	98.43	0.00	51.28	98.92	0.00				
26		0.00	97.12								
27		0.00	95.25								
28		0.00	92.87								
29			90.11								
30			87.33								
31			84.60								
32			82.07								
33			80.16								
34			79.13								
35			77.68								

Table 82: Nebraska Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
36			76.73								
37			76.53								
38			76.53								
39			76.73								
40			76.53								
41			76.33								
42			76.53								
43			75.32								
44			74.69								
45			73.61								
46			72.02								
47			69.84								
48			66.95								
49			63.79								
50			59.00								
51			55.10								
52			52.04								
53			47.06								
54			43.93								
55			40.13								
56			36.08								
57			33.95								
58			31.20								
59			28.33								
60			26.56								

Table 82: Nebraska Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
61			24.74								
62			22.88								
63			20.97								
64			19.02								
65			17.02								
66			15.66								
67			14.28								
68			12.87								
69			11.45								
70			10.00								
71			9.26								
72			8.53								
73			7.03								
74			6.27								
75			5.51								
76			5.51								
77			5.51								
78			4.74								
79			4.74								
80			3.97								
81			3.97								
82			3.97								
83			3.19								
84			3.19								
85			3.19								

Table 82: Nebraska Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
86			2.40								
87			2.40								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
1	99.98	95.92	4.02	9.61	100.00	13.74	19.10	51.53	44.44	50.00	50.00
2	100.00	99.88	17.60	18.32	100.00	95.57	19.10	62.72	44.44	75.00	50.00
3	100.00	100.00	77.80	65.24	100.00	100.00	40.55	88.58	66.67	75.00	66.67
4	100.00	100.00	99.80	98.49	100.00	100.00	68.32	97.39	77.78	75.00	66.67
5	100.00	100.00	100.00	100.00	100.00	100.00	87.52	99.81	88.89	100.00	66.67
6	100.00	100.00	100.00	100.00	100.00	100.00	96.05	99.99	88.89	75.00	83.33
7	100.00	100.00	100.00	100.00	100.00	100.00	98.45	100.00	77.78	75.00	83.33
8	100.00	100.00	100.00	100.00	100.00	100.00	99.41	100.00	77.78	75.00	66.67
9	100.00	100.00	100.00	100.00	100.00	100.00	99.41	100.00	66.67	50.00	66.67
10	100.00	100.00	100.00	100.00	100.00	100.00	99.41	100.00	55.56	50.00	66.67
11	100.00	100.00	100.00	100.00	100.00	100.00	98.84	99.99	44.44	25.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	97.43	99.90	33.33	25.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	94.25	99.64	33.33	25.00	33.33
14	100.00	100.00	100.00	100.00	100.00	100.00	89.15	98.31	22.22	0.00	33.33
15	100.00	100.00	100.00	100.00	100.00	100.00	81.68	94.29	22.22		16.67
16	100.00	100.00	100.00	100.00	100.00	100.00	71.39	88.58	11.11		16.67

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
17	100.00	99.98	100.00	100.00	100.00	100.00	61.55	78.75	11.11		16.67
18	99.98	99.69	100.00	100.00	100.00	100.00	49.68	62.72	11.11		16.67
19	99.88	98.24	100.00	99.93	100.00	100.00	35.60	51.53	0.00		0.00
20	95.85	90.69	99.99	99.41	100.00	100.00	30.37	37.68			
21	95.85	79.12	99.99	97.12	100.00	100.00	19.10	20.69			
22	78.85	53.95	99.98	91.00	100.00	99.97	13.03	20.69			
23	78.85	53.95	99.97	80.07	100.00	99.82	6.67	20.69			
24	0.00	53.95	99.95	65.24	0.00	99.32	6.67	0.00			
25	0.00	0.00	99.93	49.27	0.00	98.32	6.67				
26			99.89	35.58		96.71	0.00				
27			99.83	23.67		94.46					
28			99.75	15.51		91.34					
29			99.64	9.61		88.34					
30			99.49	6.51		84.30					
31			99.30	3.31		81.79					
32			99.07	1.67		77.25					
33			98.74	1.67		73.61					
34			98.37	0.00		69.39					
35			97.90			67.04					
36			97.31			64.50					
37			96.64			58.83					
38			95.77			55.67					
39			94.82			52.26					
40			93.60			52.26					
41			92.51			48.59					

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
42			91.13			44.65					
43			89.68			44.65					
44			88.19			40.40					
45			86.38			40.40					
46			84.23			35.82					
47			82.07			35.82					
48			79.41			35.82					
49			76.95			30.89					
50			74.14			30.89					
51			71.36			30.89					
52			68.83			25.59					
53			65.83			25.59					
54			63.83			25.59					
55			62.09			25.59					
56			59.68			25.59					
57			57.95			19.88					
58			56.58			19.88					
59			55.61			19.88					
60			53.71			19.88					
61			53.94			19.88					
62			53.25			19.88					
63			51.61			19.88					
64			50.53			19.88					
65			49.05			13.74					
66			47.91			13.74					

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
67			46.88			13.74					
68			46.09			13.74					
69			45.56			13.74					
70			45.03			13.74					
71			44.76			13.74					
72			45.56			13.74					
73			44.49			13.74					
74			44.08			13.74					
75			43.53			13.74					
76			42.41			13.74					
77			41.27			13.74					
78			40.26			7.12					
79			39.67			7.12					
80			38.78			7.12					
81			38.78			7.12					
82			38.18			7.12					
83			38.03			7.12					
84			37.72			7.12					
85			37.57			7.12					
86			36.65			7.12					
87			35.71			7.12					
88			34.92			7.12					
89			34.29			7.12					
90			33.48			7.12					
91			33.64			7.12					

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
92			32.83			7.12					
93			31.67			7.12					
94			31.00			7.12					
95			30.83			7.12					
96			30.50			7.12					
97			29.82			7.12					
98			28.61			7.12					
99			27.91			7.12					
100			27.56			7.12					
101			26.32			7.12					
102			25.41			7.12					
103			24.13			7.12					
104			22.83			7.12					
105			21.70			7.12					
106			20.55			7.12					
107			19.38			7.12					
108			19.38			7.12					
109			19.38			7.12					
110			18.99			7.12					
111			19.38			7.12					
112			19.58			7.12					
113			19.77			7.12					
114			19.77			7.12					
115			19.97			7.12					
116			19.58			7.12					

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
117			18.99			7.12					
118			18.60			7.12					
119			18.40			7.12					
120			18.40			0.00					
121			18.20								
122			17.60								
123			16.80								
124			16.40								
125			15.78								
126			15.38								
127			15.17								
128			14.76								
129			14.14								
130			14.55								
131			14.55								
132			13.93								
133			13.93								
134			14.14								
135			13.93								
136			13.72								
137			13.51								
138			13.09								
139			12.88								
140			12.46								
141			12.03								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
142			11.39								
143			10.74								
144			10.53								
145			10.31								
146			10.53								
147			10.09								
148			10.31								
149			9.87								
150			9.66								
151			9.44								
152			9.44								
153			9.00								
154			9.00								
155			9.44								
156			9.66								
157			9.66								
158			9.44								
159			9.44								
160			9.00								
161			8.78								
162			8.56								
163			8.11								
164			7.89								
165			7.89								
166			7.44								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
167			7.67								
168			7.44								
169			7.22								
170			7.22								
171			6.99								
172			6.99								
173			6.54								
174			6.54								
175			6.77								
176			6.54								
177			6.77								
178			6.77								
179			6.99								
180			6.77								
181			6.54								
182			6.32								
183			6.09								
184			5.86								
185			5.86								
186			5.63								
187			5.63								
188			5.41								
189			5.18								
190			5.18								
191			4.95								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
192			4.95								
193			4.95								
194			4.95								
195			4.95								
196			4.72								
197			4.72								
198			4.72								
199			4.72								
200			4.72								
201			4.72								
202			4.72								
203			4.72								
204			4.72								
205			4.72								
206			4.49								
207			4.26								
208			4.02								
209			4.02								
210			4.02								
211			3.79								
212			3.56								
213			3.56								
214			3.56								
215			3.33								
216			3.56								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
217			3.56								
218			3.56								
219			3.56								
220			3.56								
221			3.56								
222			3.79								
223			3.79								
224			3.56								
225			3.33								
226			3.33								
227			3.09								
228			2.86								
229			2.62								
230			2.62								
231			2.39								
232			2.39								
233			2.62								
234			2.62								
235			2.62								
236			2.62								
237			2.62								
238			2.86								
239			2.62								
240			2.62								
241			2.62								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
242			2.62								
243			2.39								
244			2.39								
245			2.15								
246			1.91								
247			1.91								
248			1.91								
249			1.91								
250			1.68								
251			1.91								
252			1.91								
253			1.91								
254			1.91								
255			1.91								
256			1.91								
257			1.91								
258			1.91								
259			1.91								
260			1.91								
261			1.68								
262			1.44								
263			1.44								
264			1.44								
265			1.44								
266			1.44								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
267			1.20								
268			1.44								
269			1.44								
270			1.20								
271			1.20								
272			1.20								
273			1.20								
274			1.20								
275			1.20								
276			1.20								
277			1.20								
278			1.20								
279			1.20								
280			0.96								
281			0.96								
282			0.96								
283			0.96								
284			0.96								
285			0.96								
286			0.96								
287			0.96								
288			0.96								
289			0.96								
290			0.96								
291			0.72								

Table 83: Texas Within Unit Prevalence

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	SmRu (BY SS)
292			0.72								
293			0.72								
294			0.72								
295			0.72								
296			0.72								
297			0.72								
298			0.72								
299			0.72								
300			0.72								
301			0.72								
302			0.72								
303			0.72								

Detection Functions

State specific observation functions for each production type are shown in Figure 165 to Figure 182, and in Table 84 through Table 89. State specific reporting functions are shown in Table 90 through Table 95. Development of these functions was described in Appendix Section A6.2.12.

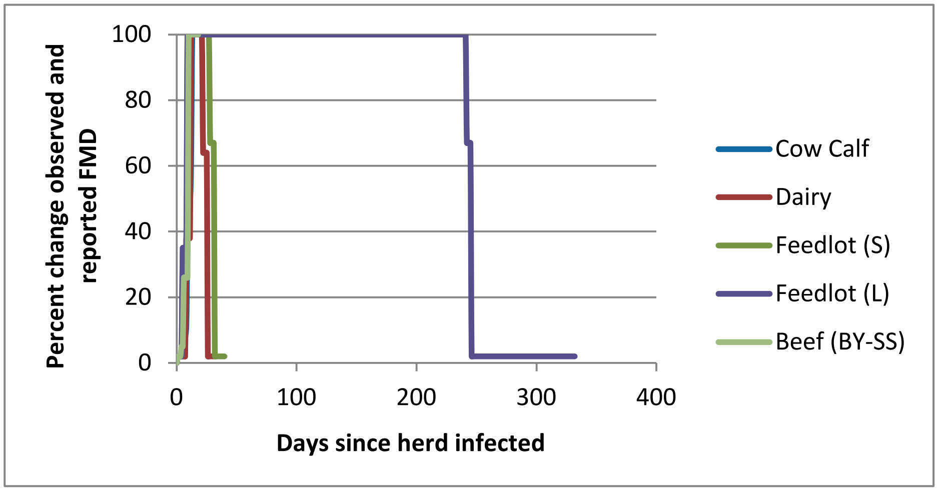


Figure 165: Oklahoma Cattle Production Type “obs and rep fxs” (NAADSM observation functions)

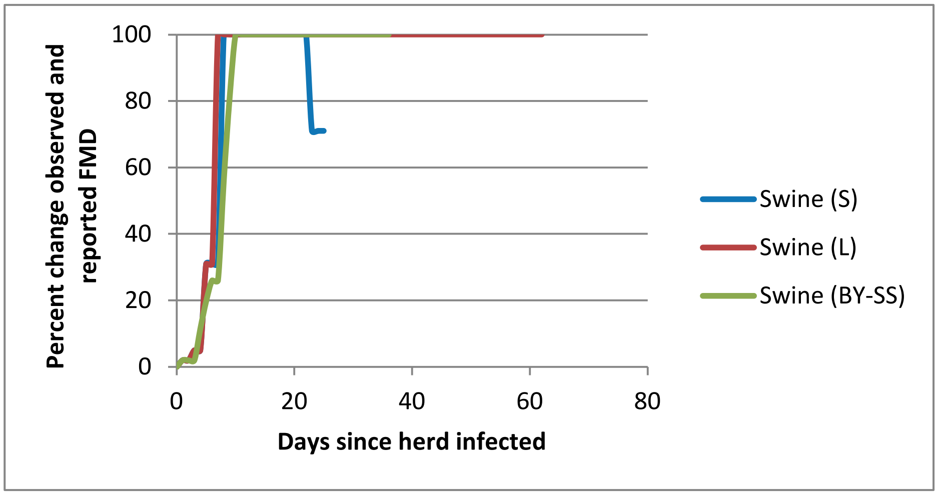


Figure 166: Oklahoma Swine Production Type “obs and rep fxs” (NAADSM observation functions)

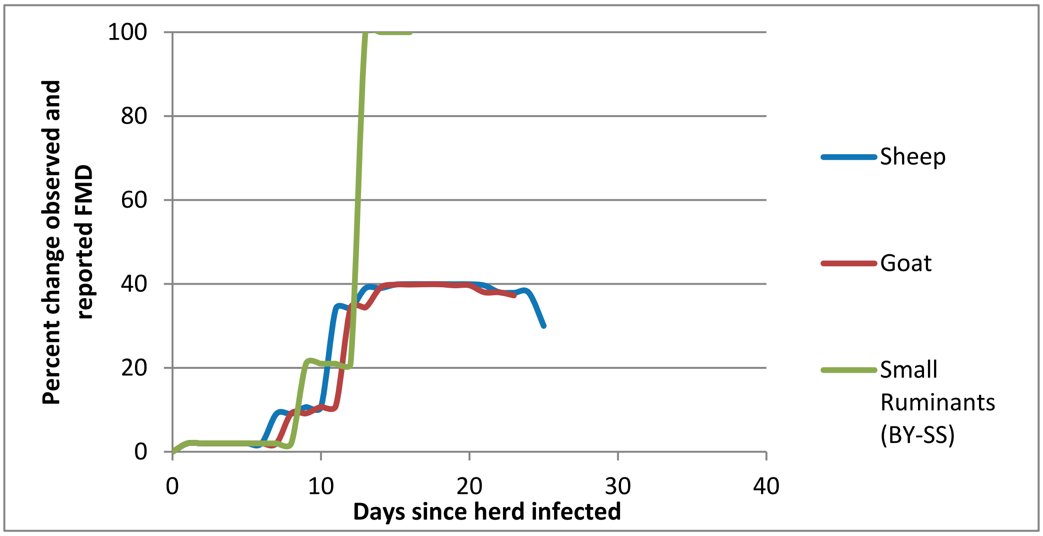


Figure 167: Oklahoma Small Ruminants Production Type "obs and rep fxs" (NAADSM observation functions)

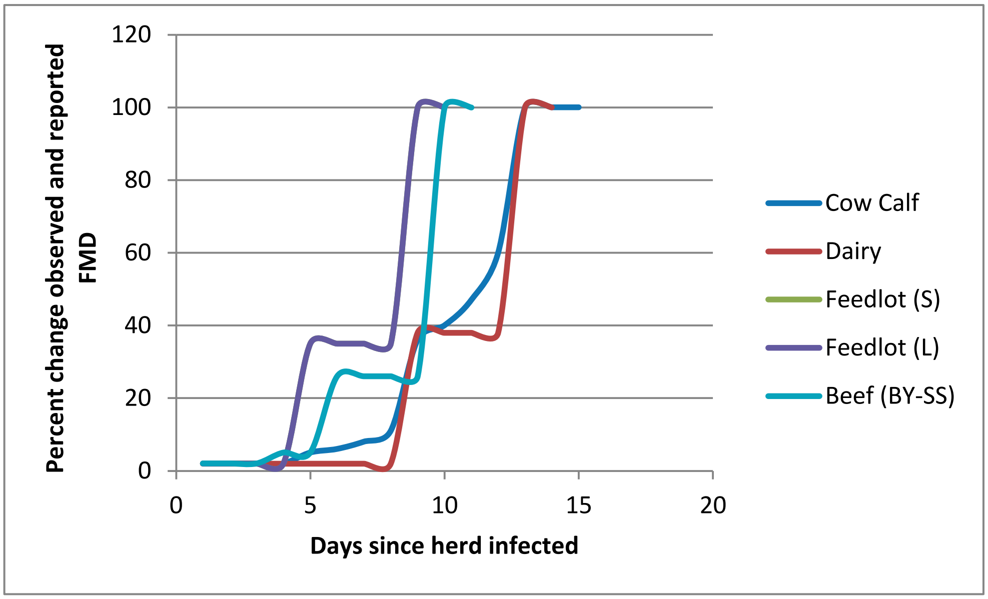


Figure 168: Colorado Cattle Production Type "obs and rep fxs" (NAADSM observation functions)

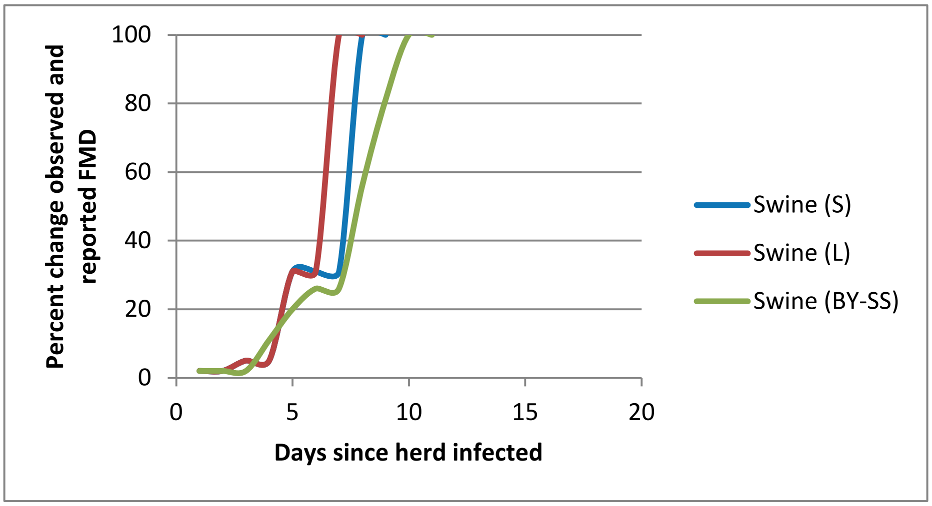


Figure 169: Colorado Swine Production Type "obs and rep fxs" (NAADSM observation functions)

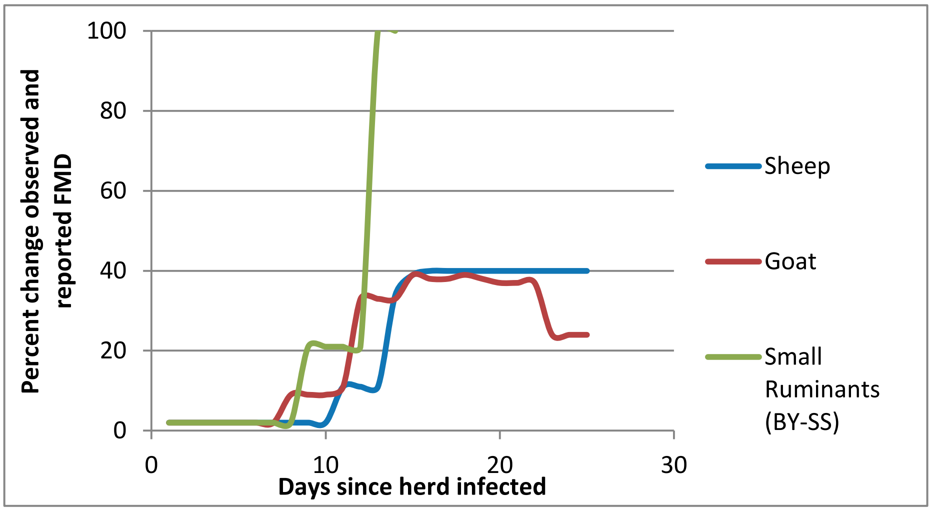


Figure 170 Colorado Small Ruminants Production Type "obs and rep fxs" (NAADSM observation functions)

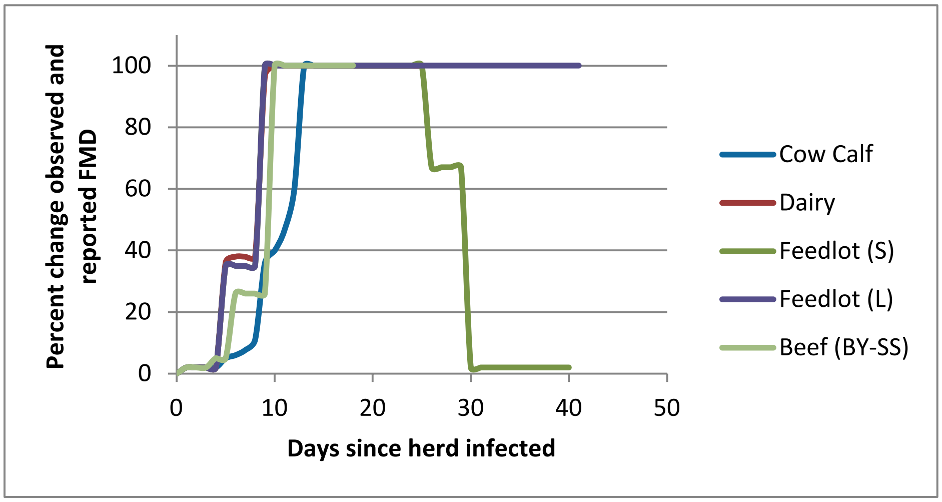


Figure 171: Missouri Cattle Production Type "obs and rep fxs" (NAADSM observation functions)

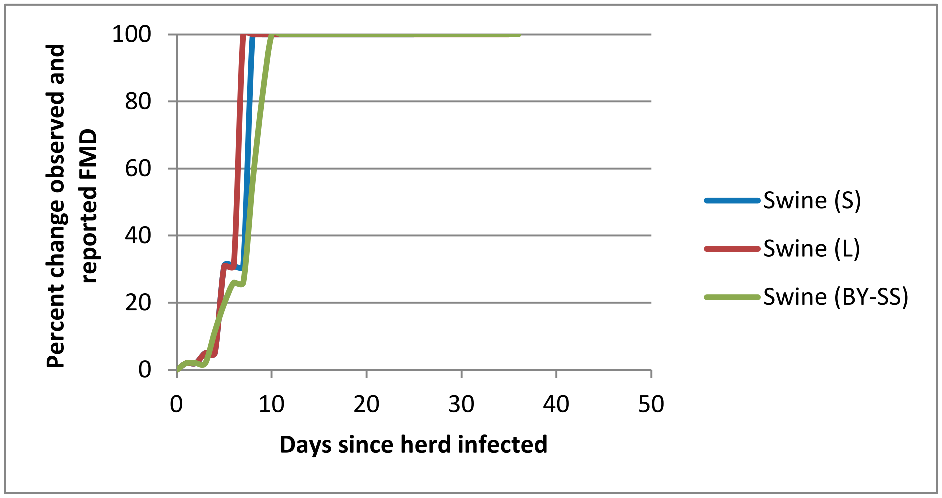


Figure 172: Missouri Swine Production Type "obs and rep fxs" (NAADSM observation functions)

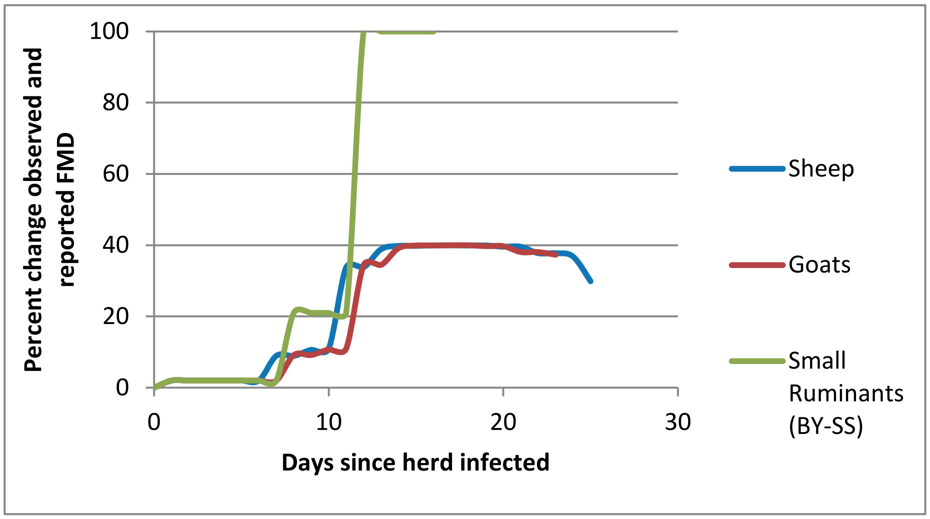


Figure 173: Missouri Small Ruminants Production Type “obs and rep fxs” (NAADSM observation functions)

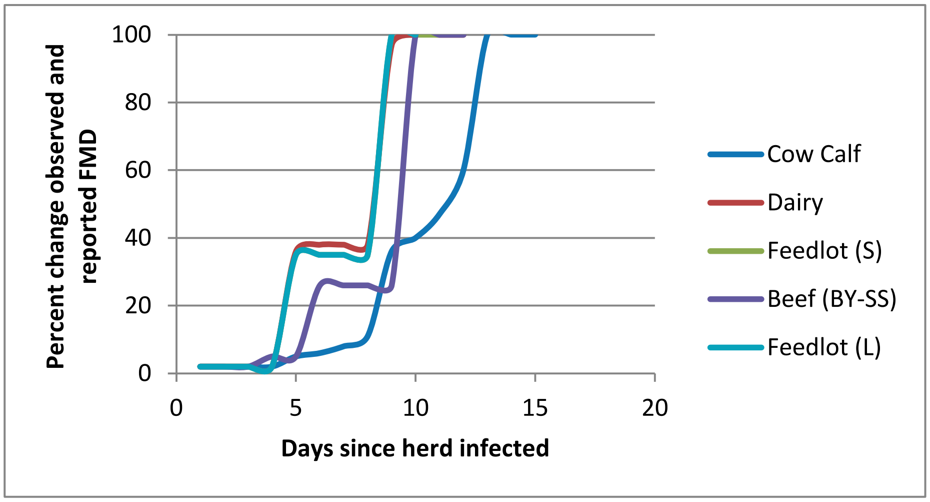


Figure 174: Nebraska Cattle Production Type “obs and rep fxs” (NAADSM observation functions)

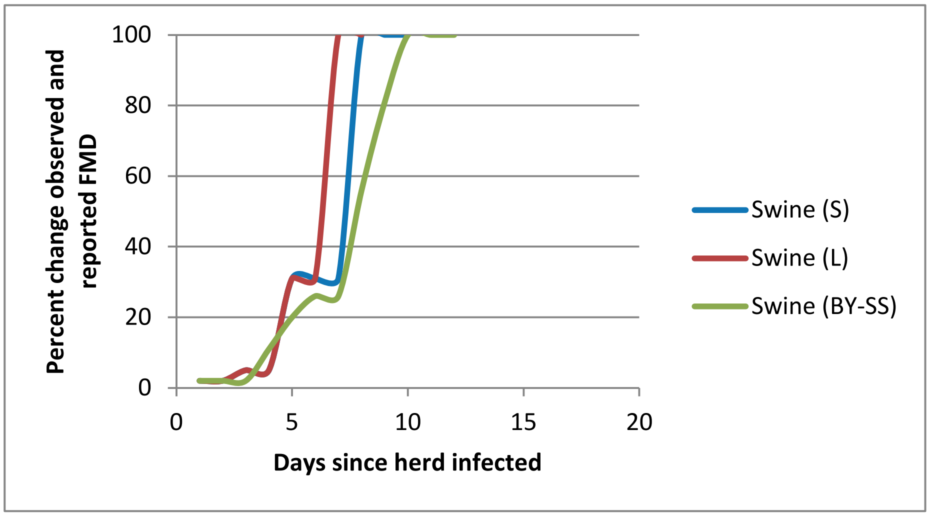


Figure 175: Nebraska Swine Production Type “obs and rep fxs” (NAADSM observation functions)

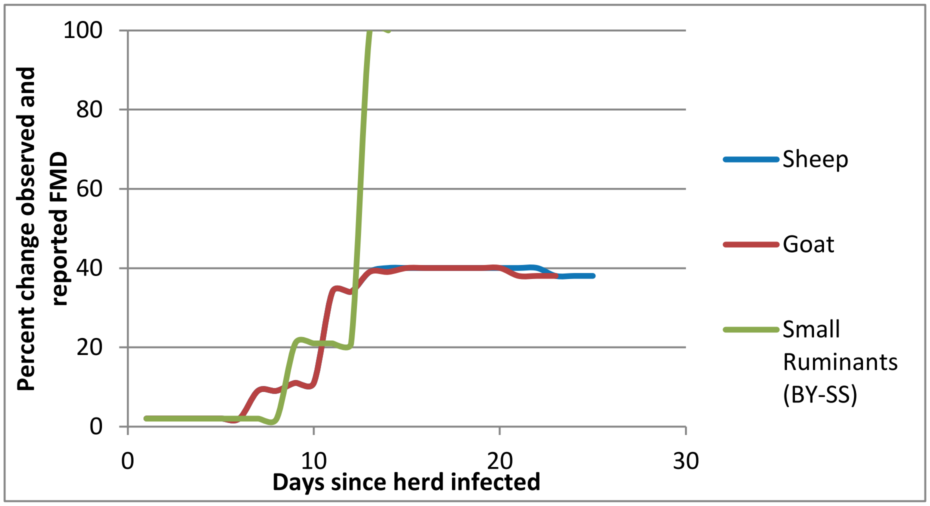


Figure 176: Nebraska Small Ruminants Production Type “obs and rep fxs” (NAADSM observation functions)

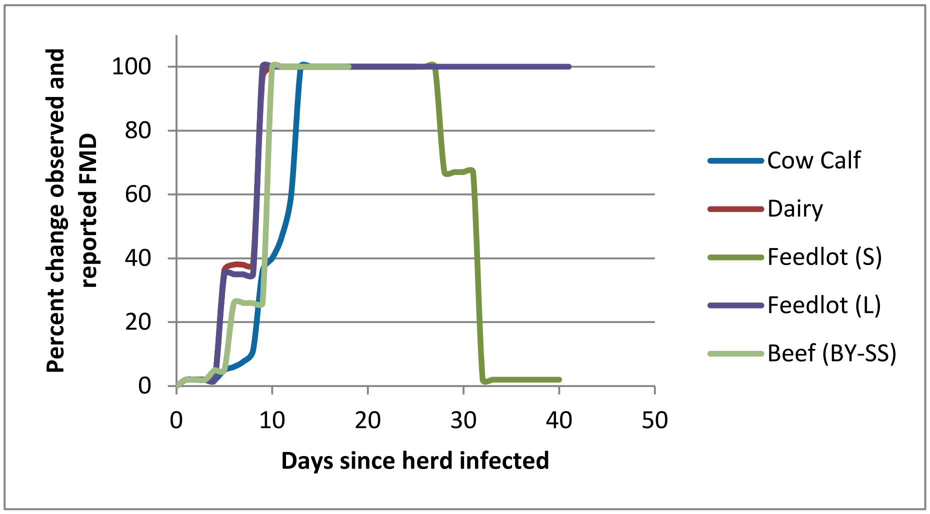


Figure 177: Iowa Cattle Production Type “obs and rep fxs” (NAADSM observation functions)

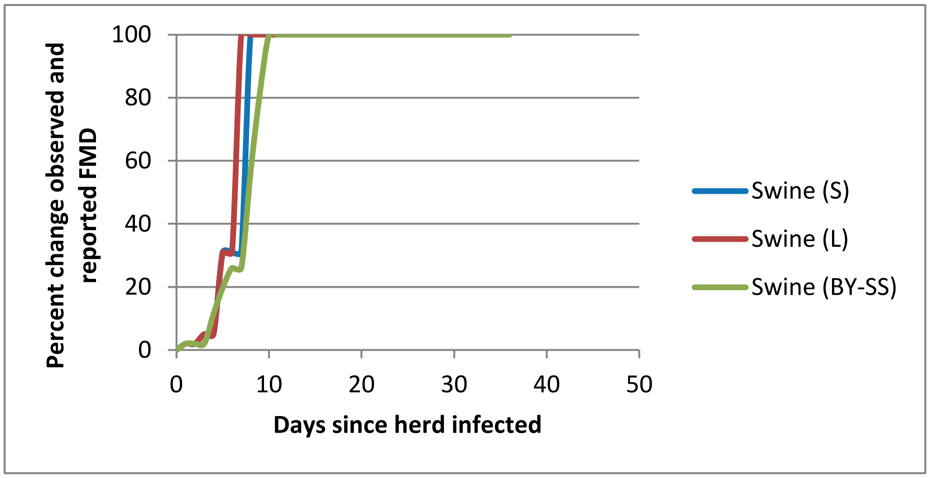


Figure 178: Iowa Swine Production Type “obs and rep fxs” (NAADSM observation functions)

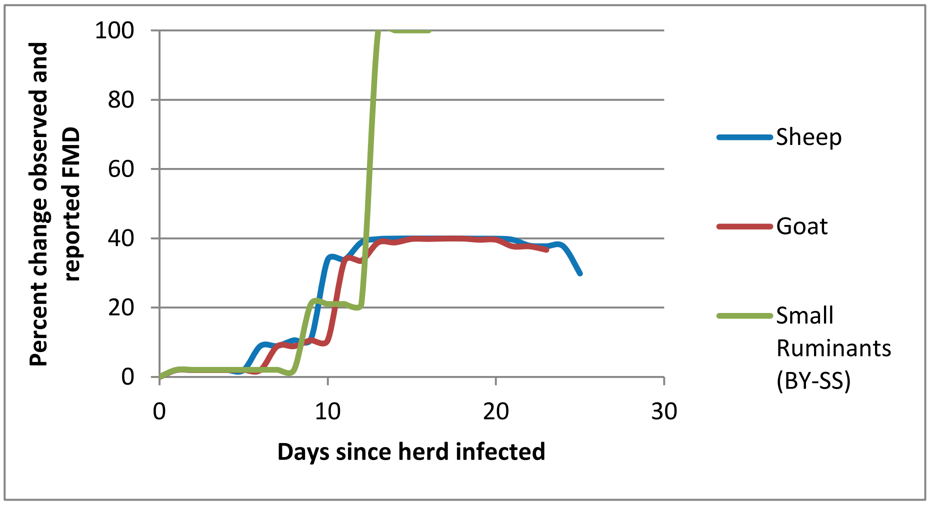


Figure 179: Iowa Small Ruminants Production Type “obs and rep fxs” (NAADSM observation functions)

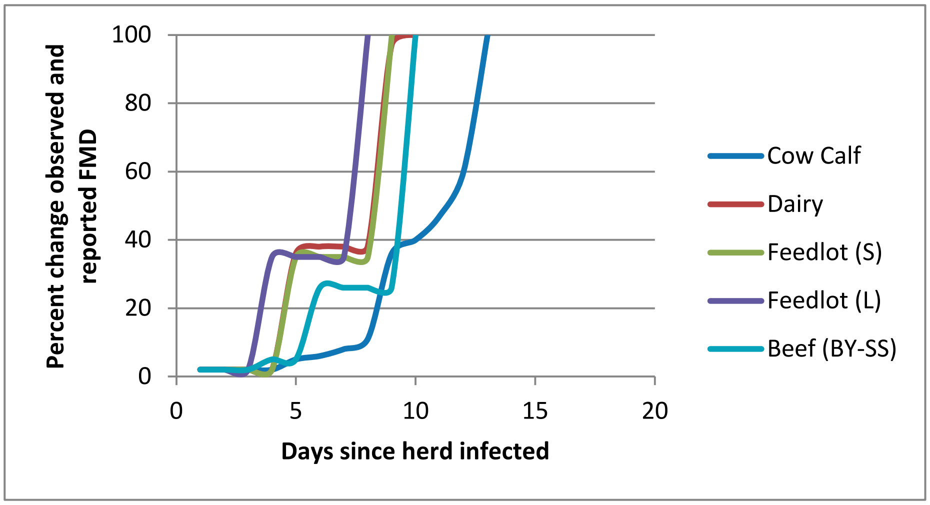


Figure 180: Texas Cattle Production Type “obs and rep fxs” (NAADSM observation functions)

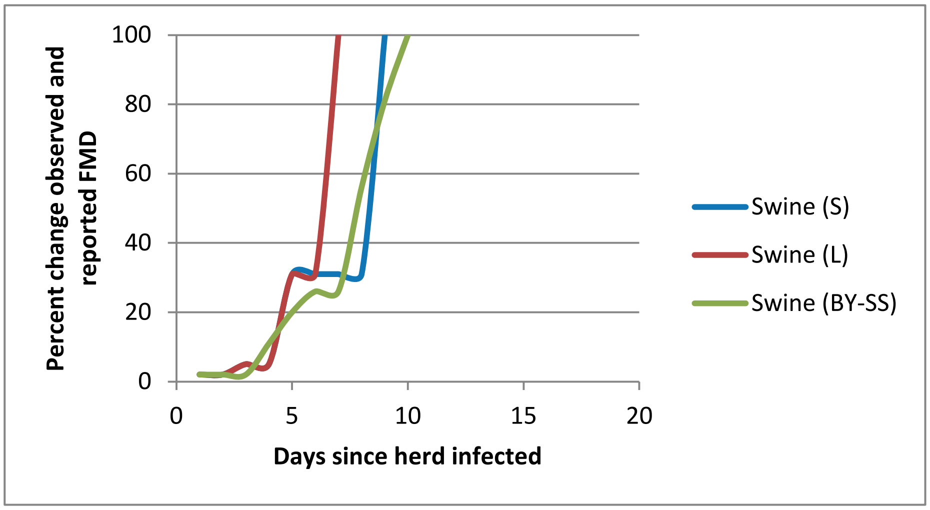


Figure 181: Texas Swine Production Type “obs and rep fxs” (NAADSM observation functions)

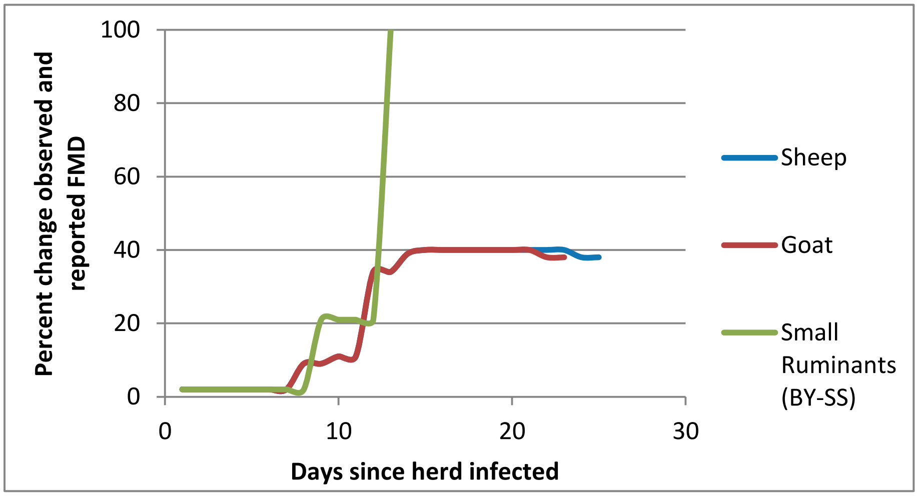


Figure 182: Texas Small Ruminants Production Type “obs and rep fxs” (NAADSM observation functions)

Table 84: Colorado “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days Since Herd Infected	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	0.02	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	0.02	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	0.02	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	0.02	5.00	11.00	2.00
5	5.00	2.00	35.00	35.00	31.00	31.00	2.00	0.02	5.00	20.00	2.00
6	6.00	2.00	35.00	35.00	31.00	31.00	2.00	0.02	26.00	26.00	2.00
7	8.00	2.00	35.00	35.00	31.00	100.00	2.00	0.02	26.00	26.00	2.00
8	11.00	2.00	35.00	35.00	100.00	100.00	2.00	0.09	26.00	56.00	2.00
9	36.00	38.00	100.00	100.00	100.00		2.00	0.09	26.00	81.00	21.00
10	40.00	38.00	100.00	100.00			2.00	0.09	100.00	100.00	21.00
11	47.00	38.00					11.00	0.11	100.00	100.00	21.00
12	60.00	38.00					11.00	0.33			21.00
13	100.00	100.00					11.00	0.33			100.00
14	100.00	100.00					34.00	0.33			100.00
15	100.00						39.00	0.39			
16							40.00	0.38			
17							40.00	0.38			
18							40.00	0.39			
19							40.00	0.38			
20							40.00	0.37			
21							40.00	0.37			
22							40.00	0.37			
23							40.00	0.24			
24							40.00	0.24			
25							40.00	0.24			

Table 85: Nebraska "obs and rep fxs" (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	11.00	2.00
5	5.00	36.00	35.00	35.00	31.00	31.00	2.00	2.00	5.00	20.00	2.00
6	6.00	38.00	35.00	35.00	31.00	31.00	2.00	2.00	26.00	26.00	2.00
7	8.00	38.00	35.00	35.00	31.00	100.00	9.00	9.00	26.00	26.00	2.00
8	11.00	38.00	35.00	35.00	100.00	100.00	9.00	9.00	26.00	56.00	2.00
9	36.00	97.00	100.00	100.00	100.00		11.00	11.00	26.00	81.00	21.00
10	40.00	100.00	100.00	100.00	100.00		11.00	11.00	100.00	100.00	21.00
11	47.00	100.00	100.00				34.00	34.00	100.00	100.00	21.00
12	60.00	100.00					34.00	34.00	100.00	100.00	21.00
13	100.00						39.00	39.00			100.00
14	100.00						40.00	39.00			100.00
15	100.00						40.00	40.00			
16							40.00	40.00			
17							40.00	40.00			
18							40.00	40.00			
19							40.00	40.00			
20							40.00	40.00			
21							40.00	38.00			
22							40.00	38.00			
23							38.00	38.00			
24							38.00				
25							38.00				

Table 86: Oklahoma "obs and rep fxs" (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	11.42	2.00
5	5.00	2.00	35.00	35.00	31.00	31.00	2.00	2.00	5.00	19.75	2.00
6	6.00	2.00	35.00	35.00	31.00	31.00	2.00	2.00	26.00	26.00	2.00

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
7	7.67	2.00	35.00	35.00	31.00	100.00	9.06	2.00	26.00	26.00	2.00
8	11.00	38.00	35.00	35.00	100.00	100.00	9.06	9.15	26.00	56.25	2.00
9	36.00	38.00	100.00	100.00	100.00	100.00	10.67	9.15	26.00	81.25	21.00
10	40.00	38.00	100.00	100.00	100.00	100.00	10.67	10.72	100.00	100.00	21.00
11	46.67	38.00	100.00	100.00	100.00	100.00	34.12	10.97	100.00	100.00	21.00
12	60.00	100.00	100.00	100.00	100.00	100.00	34.16	34.41	100.00	100.00	21.00
13	100.00	100.00	100.00	100.00	100.00	100.00	39.00	34.44	100.00	100.00	100.00
14	100.00	100.00	100.00	100.00	100.00	100.00	39.00	39.14	100.00	100.00	100.00
15	100.00	100.00	100.00	100.00	100.00	100.00	39.85	39.89	100.00	100.00	100.00
16	100.00	100.00	100.00	100.00	100.00	100.00	39.98	39.89	100.00	100.00	100.00
17	100.00	100.00	100.00	100.00	100.00	100.00	39.99	39.96	100.00	100.00	
18	100.00	100.00	100.00	100.00	100.00	100.00	39.99	39.96	100.00	100.00	
19	100.00	100.00	100.00	100.00	100.00	100.00	39.95	39.71		100.00	
20	100.00	100.00	100.00	100.00	100.00	100.00	39.95	39.71		100.00	
21	100.00	100.00	100.00	100.00	100.00	100.00	39.65	38.05		100.00	
22	100.00	64.00	100.00	100.00	100.00	100.00	38.04	38.05		100.00	
23	100.00	64.00	100.00	100.00	71.00	100.00	37.91	37.29		100.00	
24	100.00	64.00	100.00	100.00	71.00	100.00	37.91			100.00	
25	100.00	64.00	100.00	100.00	71.00	100.00	30.00			100.00	
26		2.00	100.00	100.00		100.00				100.00	
27		2.00	100.00	100.00		100.00				100.00	
28		2.00	67.00	100.00		100.00				100.00	
29		2.00	67.00	100.00		100.00				100.00	
30		2.00	67.00	100.00		100.00				100.00	
31		2.00	67.00	100.00		100.00				100.00	
32			2.00	100.00		100.00				100.00	
33			2.00	100.00		100.00				100.00	
34			2.00	100.00		100.00				100.00	
35			2.00	100.00		100.00				100.00	
36			2.00	100.00		100.00				100.00	
37			2.00	100.00		100.00					
38			2.00	100.00		100.00					
39			2.00	100.00		100.00					
40			2.00	100.00		100.00					
41				100.00		100.00					
42				100.00		100.00					
43				100.00		100.00					
44				100.00		100.00					
45				100.00		100.00					

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
46				100.00		100.00					
47				100.00		100.00					
48				100.00		100.00					
49				100.00		100.00					
50				100.00		100.00					
51				100.00		100.00					
52				100.00		100.00					
53				100.00		100.00					
54				100.00		100.00					
55				100.00		100.00					
56				100.00		100.00					
57				100.00		100.00					
58				100.00		100.00					
59				100.00		100.00					
60				100.00		100.00					
61				100.00		100.00					
62				100.00		100.00					
63				100.00							
64				100.00							
65				100.00							
66				100.00							
67				100.00							
68				100.00							
69				100.00							
70				100.00							
71				100.00							
72				100.00							
73				100.00							
74				100.00							
75				100.00							
76				100.00							
77				100.00							
78				100.00							
79				100.00							
80				100.00							
81				100.00							
82				100.00							
83				100.00							
84				100.00							

Table 86: Oklahoma "obs and rep fxs" (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
85				100.00							
86				100.00							
87				100.00							
88				100.00							
89				100.00							
90				100.00							
91				100.00							
92				100.00							
93				100.00							
94				100.00							
95				100.00							
96				100.00							
97				100.00							
98				100.00							
99				100.00							
100				100.00							
101				100.00							
102				100.00							
103				100.00							
104				100.00							
105				100.00							
106				100.00							
107				100.00							
108				100.00							
109				100.00							
110				100.00							
111				100.00							
112				100.00							
113				100.00							
114				100.00							
115				100.00							
116				100.00							
117				100.00							
118				100.00							
119				100.00							
120				100.00							
121				100.00							
122				100.00							
123				100.00							

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
124				100.00							
125				100.00							
126				100.00							
127				100.00							
128				100.00							
129				100.00							
130				100.00							
131				100.00							
132				100.00							
133				100.00							
134				100.00							
135				100.00							
136				100.00							
137				100.00							
138				100.00							
139				100.00							
140				100.00							
141				100.00							
142				100.00							
143				100.00							
144				100.00							
145				100.00							
146				100.00							
147				100.00							
148				100.00							
149				100.00							
150				100.00							
151				100.00							
152				100.00							
153				100.00							
154				100.00							
155				100.00							
156				100.00							
157				100.00							
158				100.00							
159				100.00							
160				100.00							
161				100.00							
162				100.00							

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
163				100.00							
164				100.00							
165				100.00							
166				100.00							
167				100.00							
168				100.00							
169				100.00							
170				100.00							
171				100.00							
172				100.00							
173				100.00							
174				100.00							
175				100.00							
176				100.00							
177				100.00							
178				100.00							
179				100.00							
180				100.00							
181				100.00							
182				100.00							
183				100.00							
184				100.00							
185				100.00							
186				100.00							
187				100.00							
188				100.00							
189				100.00							
190				100.00							
191				100.00							
192				100.00							
193				100.00							
194				100.00							
195				100.00							
196				100.00							
197				100.00							
198				100.00							
199				100.00							
200				100.00							
201				100.00							

Table 86: Oklahoma "obs and rep fxs" (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
202				100.00							
203				100.00							
204				100.00							
205				100.00							
206				100.00							
207				100.00							
208				100.00							
209				100.00							
210				100.00							
211				100.00							
212				100.00							
213				100.00							
214				100.00							
215				100.00							
216				100.00							
217				100.00							
218				100.00							
219				100.00							
220				100.00							
221				100.00							
222				100.00							
223				100.00							
224				100.00							
225				100.00							
226				100.00							
227				100.00							
228				100.00							
229				100.00							
230				100.00							
231				100.00							
232				100.00							
233				100.00							
234				100.00							
235				100.00							
236				100.00							
237				100.00							
238				100.00							
239				100.00							
240				100.00							

Table 86: Oklahoma "obs and rep fxs" (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
241				100.00							
242				67.00							
243				67.00							
244				67.00							
245				67.00							
246				2.00							
247				2.00							
248				2.00							
249				2.00							
250				2.00							
251				2.00							
252				2.00							
253				2.00							
254				2.00							
255				2.00							
256				2.00							
257				2.00							
258				2.00							
259				2.00							
260				2.00							
261				2.00							
262				2.00							
263				2.00							
264				2.00							
265				2.00							
266				2.00							
267				2.00							
268				2.00							
269				2.00							
270				2.00							
271				2.00							
272				2.00							
273				2.00							
274				2.00							
275				2.00							
276				2.00							
277				2.00							
278				2.00							
279				2.00							

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
280				2.00							
281				2.00							
282				2.00							
283				2.00							
284				2.00							
285				2.00							
286				2.00							
287				2.00							
288				2.00							
289				2.00							
290				2.00							
291				2.00							
292				2.00							
293				2.00							
294				2.00							
295				2.00							
296				2.00							
297				2.00							
298				2.00							
299				2.00							
300				2.00							
301				2.00							
302				2.00							
303				2.00							
304				2.00							
305				2.00							
306				2.00							
307				2.00							
308				2.00							
309				2.00							
310				2.00							
311				2.00							
312				2.00							
313				2.00							
314				2.00							
315				2.00							
316				2.00							
317				2.00							
318				2.00							

Table 86: Oklahoma “obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
319				2.00							
320				2.00							
321				2.00							
322				2.00							
323				2.00							
324				2.00							
325				2.00							
326				2.00							
327				2.00							
328				2.00							
329				2.00							
330				2.00							
331				2.00							
332				2.00							

Table 87: Texas obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	35.00	5.00	5.00	2.00	2.00	5.00	11.00	2.00
5	5.00	36.00	35.00	35.00	31.00	31.00	2.00	2.00	5.00	20.00	2.00
6	6.00	38.00	35.00	35.00	31.00	31.00	2.00	2.00	26.00	26.00	2.00
7	8.00	38.00	35.00	35.00	31.00	100.00	2.00	2.00	26.00	26.00	2.00
8	11.00	38.00	35.00	100.00	31.00		9.00	9.00	26.00	56.00	2.00
9	36.00	97.00	100.00		100.00		9.00	9.00	26.00	81.00	21.00
10	40.00	100.00					11.00	11.00	100.00	100.00	21.00
11	47.00						11.00	11.00			21.00
12	60.00						34.00	34.00			21.00
13	100.00						34.00	34.00			100.00
14							39.00	39.00			
15							40.00	40.00			
16							40.00	40.00			
17							40.00	40.00			
18							40.00	40.00			

Table 87: Texas obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
19							40.00	40.00			
20							40.00	40.00			
21							40.00	40.00			
22							40.00	38.00			
23							40.00	38.00			
24							38.00				

Table 88: Missouri obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	11.42	2.00
5	5.00	36.15	35.00	35.00	31.00	31.00	2.00	2.00	5.00	19.75	2.00
6	6.00	38.00	35.00	35.00	31.00	31.00	2.00	2.00	26.00	26.00	2.00
7	7.67	38.00	35.00	35.00	31.00	100.00	8.94	2.00	26.00	26.00	2.00
8	11.00	38.00	35.00	35.00	100.00	100.00	8.94	9.15	26.00	56.25	21.00
9	36.00	96.85	100.00	100.00	100.00	100.00	10.63	9.15	26.00	81.25	21.00
10	40.00	100.00	100.00	100.00	100.00	100.00	10.94	10.72	100.00	100.00	21.00
11	46.67	100.00	100.00	100.00	100.00	100.00	33.77	10.97	100.00	100.00	21.00
12	60.00	100.00	100.00	100.00	100.00	100.00	33.82	34.41	100.00	100.00	100.00
13	100.00	100.00	100.00	100.00	100.00	100.00	38.88	34.44	100.00	100.00	100.00
14	100.00	100.00	100.00	100.00	100.00	100.00	39.82	39.14	100.00	100.00	100.00
15	100.00	100.00	100.00	100.00	100.00	100.00	39.82	39.89	100.00	100.00	100.00
16	100.00	100.00	100.00	100.00	100.00	100.00	39.97	39.89	100.00	100.00	100.00
17	100.00	100.00	100.00	100.00	100.00	100.00	39.99	39.96	100.00	100.00	
18	100.00	100.00	100.00	100.00	100.00	100.00	39.94	39.96	100.00	100.00	
19	100.00	100.00	100.00	100.00	100.00	100.00	39.94	39.71		100.00	
20	100.00	100.00	100.00	100.00	100.00	100.00	39.60	39.71		100.00	
21	100.00	100.00	100.00	100.00	100.00	100.00	39.60	38.05		100.00	
22	100.00	100.00	100.00	100.00	100.00	100.00	37.77	38.05		100.00	
23	100.00	100.00	100.00	100.00	100.00	100.00	37.77	37.29		100.00	

Table 88: Missouri obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
24	100.00	100.00	100.00	100.00	100.00	100.00	36.82			100.00	
25	100.00	100.00	100.00	100.00	100.00	100.00	29.88			100.00	
26			67.00	100.00		100.00				100.00	
27			67.00	100.00		100.00				100.00	
28			67.00	100.00		100.00				100.00	
29			67.00	100.00		100.00				100.00	
30			2.00	100.00		100.00				100.00	
31			2.00	100.00		100.00				100.00	
32			2.00	100.00		100.00				100.00	
33			2.00	100.00		100.00				100.00	
34			2.00	100.00		100.00				100.00	
35			2.00	100.00		100.00				100.00	
36			2.00	100.00						100.00	
37			2.00	100.00							
38			2.00	100.00							
39			2.00	100.00							
40			2.00	100.00							
41				100.00							

Table 89: Iowa obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	11.42	2.00
5	5.00	36.15	35.00	35.00	31.00	31.00	2.00	2.00	5.00	19.75	2.00
6	6.00	38.00	35.00	35.00	31.00	31.00	8.95	2.00	26.00	26.00	2.00
7	7.67	38.00	35.00	35.00	31.00	100.00	8.95	8.86	26.00	26.00	2.00
8	11.00	38.00	35.00	35.00	100.00	100.00	10.62	8.86	26.00	56.25	2.00
9	36.00	96.85	100.00	100.00	100.00	100.00	10.94	10.60	26.00	81.25	21.00
10	40.00	100.00	100.00	100.00	100.00	100.00	33.85	10.60	100.00	100.00	21.00
11	46.67	100.00	100.00	100.00	100.00	100.00	33.86	33.51	100.00	100.00	21.00
12	60.00	100.00	100.00	100.00	100.00	100.00	38.86	33.51	100.00	100.00	21.00
13	100.00	100.00	100.00	100.00	100.00	100.00	39.81	38.80	100.00	100.00	100.00
14	100.00	100.00	100.00	100.00	100.00	100.00	39.97	38.80	100.00	100.00	100.00
15	100.00	100.00	100.00	100.00	100.00	100.00	40.00	39.81	100.00	100.00	100.00
16	100.00	100.00	100.00	100.00	100.00	100.00	40.00	39.81	100.00	100.00	100.00

Table 89: Iowa   obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
17	100.00	100.00	100.00	100.00	100.00	100.00	40.00	39.92	100.00	100.00	
18	100.00	100.00	100.00	100.00	100.00	100.00	39.99	39.92	100.00	100.00	
19	100.00	100.00	100.00	100.00	100.00	100.00	39.94	39.58		100.00	
20	100.00	100.00	100.00	100.00	100.00	100.00	39.94	39.58		100.00	
21	100.00	100.00	100.00	100.00	100.00	100.00	39.62	37.67		100.00	
22	100.00	100.00	100.00	100.00	100.00	100.00	37.93	37.67		100.00	
23	100.00	100.00	100.00	100.00	100.00	100.00	37.76	36.67		100.00	
24	100.00	100.00	100.00	100.00	100.00	100.00	37.76			100.00	
25	100.00	100.00	100.00	100.00	100.00	100.00	29.86			100.00	
26			100.00	100.00		100.00				100.00	
27			100.00	100.00		100.00				100.00	
28			67.00	100.00		100.00				100.00	
29			67.00	100.00		100.00				100.00	
30			67.00	100.00		100.00				100.00	
31			67.00	100.00		100.00				100.00	
32			2.00	100.00		100.00				100.00	
33			2.00	100.00		100.00				100.00	
34			2.00	100.00		100.00				100.00	
35			2.00	100.00		100.00				100.00	
36			2.00	100.00						100.00	
37			2.00	100.00							
38			2.00	100.00							
39			2.00	100.00							
40			2.00	100.00							
41				100.00							
42				100.00							
43				100.00							
44				100.00							
45				100.00							
46				100.00							
47				100.00							
48				100.00							
49				100.00							
50				100.00							
51				100.00							
52				100.00							
53				100.00							
54				100.00							
55				100.00							
56				100.00							
57				100.00							
58				100.00							
59				100.00							
60				100.00							

Table 89: Iowa obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
61				100.00							
62				100.00							
63				100.00							
64				100.00							
65				100.00							
66				100.00							
67				100.00							
68				100.00							
69				100.00							
70				100.00							
71				100.00							
72				100.00							
73				100.00							
74				100.00							
75				100.00							
76				100.00							
77				100.00							
78				100.00							
79				100.00							
80				100.00							
81				100.00							
82				100.00							
83				100.00							
84				100.00							
85				100.00							
86				100.00							
87				100.00							
88				100.00							
89				100.00							
90				100.00							
91				100.00							
92				100.00							
93				100.00							
94				100.00							
95				100.00							
96				100.00							
97				100.00							
98				100.00							
99				100.00							
100				100.00							
101				100.00							
102				100.00							
103				100.00							
104				100.00							

Table 89: Iowa obs and rep fxs” (NAADSM observation functions)

Percent observation and reporting before outbreak detected

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
105				100.00							
106				100.00							
107				100.00							
108				100.00							
109				100.00							
110				100.00							
111				100.00							
112				100.00							
113				100.00							
114				100.00							
115				100.00							
116				100.00							
117				100.00							
118				100.00							
119				100.00							
120				100.00							
121				100.00							
122				100.00							
123				100.00							
124				100.00							
125				100.00							
126				100.00							
127				100.00							
128				100.00							
129				100.00							
130				100.00							
131				100.00							
132				100.00							
133				100.00							
134				100.00							
135				100.00							
136				100.00							
137				100.00							
138				100.00							

Table 90: Colorado Multiplier Functions (NAADSM reporting functions)

Days Since Herd Infected	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	50	5000	5000	5000	5000	4800	3900	2000	3800	5000
4	1300	50	5000	5000	5000	5000	4800	3900	2000	3800	5000
5	1300	50	5000	5000	5000	5000	4800	3900	2000	3800	5000
6	1300	50	5000	5000	5000	5000	4800	3900	2000	3800	5000

Table 91: Nebraska Multiplier Functions (NAADSM reporting functions)

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1250	5000	5000	5000	5000	5000	4000	4000	2000	2000	5000
4	1250	5000	5000	5000	5000	5000	4000	4000	2000	2000	5000
5	1250	5000	5000	5000	5000	5000	4000	4000	2000	2000	5000
6	1250	5000	5000	5000	5000	5000	4000	4000	2000	2000	5000

Table 92: Oklahoma Multiplier Functions (NAADSM reporting functions)

Days	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	5000	5000	5000	5000	5000	4000	4100	2000	870	5000
4	1300	5000	5000	5000	5000	5000	4000	4100	2000	870	5000
5	1300	5000	5000	5000	5000	5000	4000	4100	2000	870	5000
6	1300	5000	5000	5000	5000	5000	4000	4100	2000	870	5000

Table 93: Texas Multiplier Functions (NAADSM reporting functions)

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1250	5000	5000	5000	2000	5000	4000	3900	2000	3750	5000
4	1250	5000	5000	5000	2000	5000	4000	3900	2000	3750	5000
5	1250	5000	5000	5000	2000	5000	4000	3900	2000	3750	5000
6	1250	5000	5000	5000	2000	5000	4000	3900	2000	3750	5000

Table 94: Missouri “Multiplier Functions (NAADSM reporting functions)

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	5000	5000	5000	5000	5000	4000	4100	2000	3800	5000
4	1300	5000	5000	5000	5000	5000	4000	4100	2000	3800	5000
5	1300	5000	5000	5000	5000	5000	4000	4100	2000	3800	5000
6	1300	5000	5000	5000	5000	5000	4000	4100	2000	3800	5000

Table 95: Iowa Multiplier Functions (NAADSM reporting functions)

Day	Cow Calf	Dairy	Feedlot (S)	Feedlot (L)	Swine (S)	Swine (L)	Sheep	Goat	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	5000	5000	5000	5000	5000	1100	940	2000	870	5000
4	1300	5000	5000	5000	5000	5000	1100	940	2000	870	5000
5	1300	5000	5000	5000	5000	5000	1100	940	2000	870	5000
6	1300	5000	5000	5000	5000	5000	1100	940	2000	870	5000

A6.3.3 State Specific Direct Contact Rates and Distance Distributions

As stated in Chapter 6, USDA SMEs expressed concern that production practices in Missouri and Iowa are significantly different from Kansas and recommended that the Updated SSRA team develop new contact rates for these states. Due to time constraints, a full set of direct contact parameters could not be created. Instead, several SMEs from each state were interviewed to determine how the contact parameters for their state would vary from the contact rates developed for Kansas, shown in Appendix Section A6.3.3.2. Direct contact rates and distances for Texas were developed for the USDA 2011 study, the evidence basis for these parameters can be found in Appendix Section A63.3.1 and the parameters themselves in Appendix Section A6.3.3.2.

A6.3.3.1 Texas Direct Contact Parameter Evidence Basis, Entire Section Quoted from USDA 2011

"Overall direct contact rates and distance distributions of direct contacts were obtained from two studies: a survey of 77 livestock producers in 8 counties located in the Texas panhandle [Dominguez et al., 2007a], and another survey 156 livestock producers in 9 counties of southwest Texas [Dominguez et al., 2007b]. A matrix was created with marginal row and column values equal to the estimates of overall direct contacts on to and off of premises reported by the two surveys. The contact rates of individual cells in the matrix were distributed so that the sums of the rows and columns were as close to the marginal values as possible. Relative differences in direct contact rates between pairs of production type combinations were guided by estimates from NAHMS beef, swine, and dairy reports on the percentages of shipments to various destinations, and information provided by the southwest Texas study on the destinations of shipments from sale yards. The sum of all production type contact rates off of premises was 0.07/day less than the sum of contact rates onto premises. Therefore it was not possible to perfectly reconcile the marginal totals. These discrepancies were distributed among the feedlot production types. Distances travelled by contacts were reported as minimum, most likely and maximum values in the two Texas studies. These reported values were used to assign BetaPERT distance distributions for direct contacts.

All Feedlots

It was assumed that all cattle leaving company feedlots, stockholder feedlots, and custom feedlots were consigned to slaughter and had no direct contacts shipped to other production types. All cattle leaving yearling-pasture feedlots were assumed to go to one of the other three feedlot types. The Texas panhandle study found that the average daily rate of direct contact shipments onto all feedlots was 0.27/day (sd = 0.83). To reflect the variability in feedlot direct contacts observed in that study, it was assumed that contact rates increased with increasing feedlot capacity. Using the numbers of each feedlot category that participated in the Texas panhandle study, weighted average daily contact rates were calculated so that the combined total for all categories equaled 0.27. According to the Texas panhandle study, yearling-pasture feedlots and stocker operations shipped animals to other feedlots at the same rate. Therefore direct contacts off of yearling pasture feedlots were assumed to be the same as those reported for stocker operations (0.21/day, see below).

Cow-calf and stocker operations

According to the southwest Texas survey, there was an average of 0.32 direct contacts/day originating from large cow-calf operations, 0.20 direct contacts/day originating from small cow-calf operations, and 0.21 direct contacts/day originating from stocker operations. The average direct contacts/day onto large cow-calf, small cow-calf, and stocker operations were 0.05, 0.02, and 0.17, respectively. It was assumed that all contacts from large and small cow-calf operations *were to other beef operations, feedlots, or small ruminants (see small ruminant section below), and all contacts from stocker operations were to feedlots only.*

Dairy

The Texas panhandle study surveyed 21 dairy operations (4 small and 17 large). The rate of direct contacts onto dairy premises was estimated to be 0.01/day and the rate off of diary premises was 0.07/day. It was assumed that the destinations of all animal shipments from dairies were to other dairies or to feedlots. According to NAHMS dairy [2007], approximately three times as many dairies shipped animals directly to feedlots than shipped directly to other dairies. Therefore the assigned contact rates between dairies and feedlots were higher than the contact rates between dairies. All dairy production types were assumed to have direct contacts with each other at equal rates.

Swine

The Texas panhandle study surveyed 16 swine producers (7 small and 9 large) and estimated the average daily rate of direct contacts off of all swine premises to be 0.01/day (sd = 0.02). The average reported direct contact rate onto swine premises was rounded to 0 (sd = 0.01). According to NAHMS swine (2007), 8% of large swine operations in the south region (including Texas) had a combination of all phases of swine production present, indicating that most large swine premises specialized in one or more production phases. According to NAHMS small enterprise – swine (2007), 67% of small swine operations shipped 1 or more pigs off of premises in the prior 12 months and 22% of these shipments were to other premises. Based on this information, it was assumed that large swine premises had more frequent shipments of pigs off of premises to other specialty operations than small swine operations. It was also assumed that small and large swine operations had direct contact only within their respective production types.

Small Ruminants

According to the southwest Texas survey, 79% of sheep operations also owned cattle and 67% of goat operations owned cattle. Therefore small ruminant production types were permitted to have direct contact with other non-dairy, cattle production types. The southwest Texas study reported direct contact rates for mixed small ruminant/cattle operations as 0.20/day off of premises and 0.04/day onto premises.” [USDA 2011]

A6.3.3.2 Direct Contact Rate and Distance Distribution Parameters

State specific direct contact rates and distance distributions are shown in the tables below.

Table 96: State Specific Direct Contact Rates Cattle

Production Types	Kansas, Oklahoma, Nebraska, Colorado	Iowa	Missouri	Texas
Cow Calf to Cow Calf	0.0099	0.0049	0.0049	0.0248
Cow Calf to Dairy	0.0000	0.0000	0.0001	0.0000
Cow Calf to Feedlot (S)	0.0051	0.0041	0.0083	0.0302
Cow Calf to Feedlot (L)	0.0076	0.0041	0.0041	0.0666
Cow Calf to Sheep	0.0000	0.0000	0.0000	0.0000
Cow Calf to Goats	0.0000	0.0000	0.0000	0.0000
Cow Calf to Swine (S)	0.0000	0.0000	0.0000	0.0000
Cow Calf to Swine (L)	0.0000	0.0000	0.0000	0.0000
Cow Calf to Beef (BY SS)	0.0003	0.0003	0.0003	0.0003
Cow Calf to Swine (BY SS)	0.0000	0.0000	0.0000	0.0000
Cow Calf to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Dairy to Cow Calf	0.0028	0.0028	0.0028	0.0028
Dairy to Dairy	0.0070	0.0068	0.0068	0.0068
Dairy to Feedlot(S)	0.0000	0.0000	0.0000	0.0000
Dairy to Feedlot (L)	0.0639	0.0626	0.0626	0.0626
Dairy to Sheep	0.0000	0.0000	0.0000	0.0000
Dairy to Goats	0.0000	0.0000	0.0000	0.0000
Dairy to Swine (S)	0.0000	0.0000	0.0000	0.0000
Dairy to Swine (L)	0.0000	0.0000	0.0000	0.0000
Dairy to Beef (BY SS)	0.0016	0.0016	0.0016	0.0016
Dairy to Swine (BY SS)	0.0000	0.0000	0.0000	0.0000
Dairy to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot(S) to Cow Calf	0.0003	0.0000	0.0000	0.0000
Feedlot(S) to Dairy	0.0003	0.0000	0.0000	0.0000
Feedlot(S) to Feedlot(S)	0.0000	0.0000	0.0000	0.0000
Feedlot(S) to Feedlot(L)	0.0634	0.0007	0.0558	0.0950
Feedlot(S) to Swine (L)	0.0000	0.0000	0.0000	0.0000
Feedlot(S) to Swine (L)	0.0000	0.0000	0.0000	0.0000
Feedlot (S) to Sheep	0.0000	0.0000	0.0000	0.0000
Feedlot (S) to Goats	0.0000	0.0000	0.0000	0.0000
Feedlot (S) to Beef (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot (S) to Swine (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot (S) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Cow Calf	0.0003	0.0000	0.0000	0.0000

Table 96: State Specific Direct Contact Rates Cattle

Production Types	Kansas, Oklahoma, Nebraska, Colorado	Iowa	Missouri	Texas
Feedlot (L) to Dairy	0.0003	0.0000	0.0003	0.0000
Feedlot (L) to Feedlot(S)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Feedlot(L)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Sheep	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Goats	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Swine (S)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Swine (L)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Beef (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Swine (BY SS)	0.0000	0.0000	0.0000	0.0000
Feedlot (L) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Cow Calf	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Dairy	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Feedlot (S)	0.0058	0.0058	0.0058	0.0058
Beef (BY SS) to Feedlot (L)	0.0058	0.0058	0.0058	0.0058
Beef (BY SS) to Sheep	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Goats	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Swine (S)	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Swine (L)	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Beef (BY SS)	0.0018	0.0018	0.0018	0.0018
Beef (BY SS) to Swine (BY SS)	0.0000	0.0000	0.0000	0.0000
Beef (BY SS) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000

Table 97: State Specific Direct Contract Rates for Swine

Production Types	Kansas, Oklahoma, Nebraska, Colorado	Iowa	Missouri	Texas
Swine (S) to Cow Calf	0.0000	0.0000	0.0000	0.0000
Swine (S) to Dairy	0.0000	0.0000	0.0000	0.0000
Swine (S) to Feedlot (S)	0.0000	0.0000	0.0000	0.0000
Swine (S) to Feedlot (L)	0.0000	0.0000	0.0000	0.0000

Table 97: State Specific Direct Contract Rates for Swine

Production Types	Kansas, Oklahoma, Nebraska, Colorado	Iowa	Missouri	Texas
Swine (S) to Sheep	0.0000	0.0000	0.0000	0.0000
Swine (S) to Goats	0.0000	0.0000	0.0000	0.0000
Swine (S) to Swine (S)	0.0138	0.0274	0.0137	0.0050
Swine (S) to Swine (L)	0.0000	0.0000	0.0000	0.0000
Swine (S) to Beef (BY SS)	0.0000	0.0000	0.0000	0.0000
Swine (S) to Swine (BY SS)	0.0020	0.0020	0.0020	0.0020
Swine (S) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Swine (L) to Cow Calf	0.0000	0.0000	0.0000	0.0000
Swine (L) to Dairy	0.0000	0.0000	0.0000	0.0000
Swine (L) to Feedlot (S)	0.0000	0.0000	0.0000	0.0000
Swine (L) to Feedlot (L)	0.0000	0.0000	0.0000	0.0000
Swine (L) to Sheep	0.0000	0.0000	0.0000	0.0000
Swine (L) to Goats	0.0000	0.0000	0.0000	0.0000
Swine (L) to Swine (S)	0.0000	0.0000	0.0000	0.0000
Swine (L) to Swine (L)	0.2860	0.2740	0.2900	0.0300
Swine (L) to Beef (BY SS)	0.0000	0.0000	0.0000	0.0000
Swine (L) to Swine (BY SS)	.0021	.0021	.0021	.0021
Swine (L) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Cow Calf	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Dairy	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Feedlot (S)	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Feedlot (L)	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Sheep	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Goats	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Swine (S)	0.0001	0.0001	0.0001	0.0001
Swine (BY SS) to Swine (L)	0.0001	0.0001	0.0001	0.0001
Swine (BY SS) to Beef (BY SS)	0.0000	0.0000	0.0000	0.0000
Swine (BY SS) to Swine (BY SS)	0.0014	0.0014	0.0014	0.0014
Swine (BY SS) to Small Ruminants (BY SS)	0.0000	0.0000	0.0000	0.0000

Table 98: Direct Contact Movement Distance Distributions

Production Type Combination	All State Direct Contact: Movement Distance (km)	Texas Direct Contact: Movement Distance (km)
Cow Calf to Cow Calf	BetaPERT (1.6, 32.2, 752)	BetaPert (5,32,805)
Cow Calf to Dairy	BetaPERT (1.6, 80.5, 752)	no contact
Cow Calf to Feedlot (L)	BetaPERT (1.6, 193.1, 752)	BetaPert (5,32,805)
Cow Calf to Feedlot (S)	BetaPERT (1.6, 96.5, 752)	BetaPert (5,32,805)
Cow Calf to Goats	N/A	N/A
Cow Calf to Sheep	N/A	N/A
Cow Calf to Swine (L)	N/A	N/A
Cow Calf to Swine (S)	N/A	N/A
Dairy to Cow Calf	BetaPERT (1.6, 80.5, 752)	no contact
Dairy to Dairy	BetaPERT (1.6, 80.5, 752)	BetaPert (1,30,90)
Dairy to Feedlot (L)	BetaPERT (1.6, 80.5, 752)	BetaPert (1,30,90)
Dairy to Feedlot (S)	N/A	N/A
Dairy to Goats	N/A	N/A
Dairy to Sheep	N/A	N/A
Dairy to Swine (L)	N/A	N/A
Dairy to Swine (S)	N/A	N/A
Feedlot (L) to Cow Calf	BetaPERT (1.6, 80.5, 752)	no contact
Feedlot (L) to Dairy	BetaPERT (1.6, 80.5, 752)	no contact
Feedlot (L) to Feedlot (L)	N/A	N/A
Feedlot (L) to Feedlot (S)	N/A	N/A
Feedlot (L) to Goats	N/A	N/A
Feedlot (L) to Sheep	N/A	N/A
Feedlot (L) to Swine (L)	N/A	N/A
Feedlot (L) to Swine (S)	N/A	N/A
Feedlot (S) to Cow Calf	BetaPERT (1.6, 80.5, 752)	no contact
Feedlot (S) to Dairy	BetaPERT (1.6, 80.5, 752)	no contact
Feedlot (S) to Feedlot (L)	BetaPERT (1.6, 160.9, 752)	BetaPERT(20,175,1,480)
Feedlot (S) to Feedlot (S)	N/A	N/A
Feedlot (S) to Goats	N/A	N/A
Feedlot (S) to Sheep	N/A	N/A
Feedlot (S) to Swine (L)	N/A	N/A
Feedlot (S) to Swine (S)	N/A	N/A
Goats to Cow Calf	N/A	N/A
Goats to Dairy	N/A	N/A
Goats to Feedlot (S)	N/A	N/A
Goats to Feedlot (L)	N/A	N/A
Goats to Goats	BetaPERT (1.6, 80.5, 752)	BetaPert(3,29,129)
Goats to Sheep	N/A	N/A

Table 98: Direct Contact Movement Distance Distributions

Production Type Combination	All State Direct Contact: Movement Distance (km)	Texas Direct Contact: Movement Distance (km)
Goats to Swine (S)	N/A	N/A
Goats to Swine (L)	N/A	N/A
Sheep to Cow Calf	N/A	N/A
Sheep to Dairy	N/A	N/A
Sheep to Feedlot (L)	N/A	N/A
Sheep to Feedlot (S)	N/A	N/A
Sheep to Goats	N/A	N/A
Sheep to Sheep	BetaPERT (1.6, 80.5, 752)	BetaPert(3,29,129)
Sheep to Swine (L)	N/A	N/A
Sheep to Swine (S)	N/A	N/A
Swine (L) to Cow Calf	N/A	N/A
Swine (L) to Dairy	N/A	N/A
Swine (L) to Feedlot (L)	N/A	N/A
Swine (L) to Feedlot (S)	N/A	N/A
Swine (L) to Goats	N/A	N/A
Swine (L) to Sheep	N/A	N/A
Swine (L) to Swine (L)	BetaPERT (0, 20, 752)	BetaPert (1,50,1500)
Swine (L) to Swine (S)	N/A	N/A
Swine (S) to Cow Calf	N/A	N/A
Swine (S) to Dairy	N/A	N/A
Swine (S) to Feedlot (L)	N/A	N/A
Swine (S) to Feedlot (S)	N/A	N/A
Swine (S) to Goats	N/A	N/A
Swine (S) to Sheep	N/A	N/A
Swine (S) to Swine (L)	N/A	N/A
Swine (S) to Swine (S)	BetaPERT (0, 20, 752)	BetaPert (1,50,1500)
Beef (BY SS) to Cow Calf	N/A	N/A
Beef (BY SS) to Dairy	N/A	N/A
Beef (BY SS) to Feedlot(L)	Loglogistic(0,44.241,16.755)	Loglogistic(0,44.241,16.755)
Beef (BY SS) to Feedlot(S)	Invgauss(378.8,18.226)	Invgauss(378.8,18.226)
Beef (BY SS) to Goats	N/A	N/A
Beef (BY SS) to Sheep	N/A	N/A
Beef (BY SS) to Small Ruminant (BY SS)	N/A	N/A
Beef (BY SS) to Swine (S)	N/A	N/A
Beef (BY SS) to Swine (L)	N/A	N/A
Beef (BY SS) to Beef (BY SS)	Triang(0,47.013,52.438)	Triang(0,47.013,52.438)
Beef (BY SS) to Swine (BY	N/A	N/A

Table 98: Direct Contact Movement Distance Distributions

Production Type Combination	All State Direct Contact: Movement Distance (km)	Texas Direct Contact: Movement Distance (km)
SS)		
Cow Calf to Beef (BY SS)	Loglogistic(0,22.439,2.9175)	Loglogistic(0,22.439,2.9175)
Cow Calf to Small Ruminants (BY SS)	N/A	N/A
Cow Calf to Swine (BY SS)	N/A	N/A
Dairy to Beef (BY SS)	Uniform(8,200)	Uniform(8,200)
Dairy to Small Ruminants (BY SS)	N/A	N/A
Dairy to Swine (BY SS)	N/A	N/A
Feedlot (L) to Small Ruminants (BY SS)	N/A	N/A
Feedlot (L) to Swine (BY SS)	N/A	N/A
Feedlot (S) to Small Ruminants (BY SS)	N/A	N/A
Feedlot (S) to Swine (BY SS)	N/A	N/A
Feedlot (L) to Beef (BY SS)	N/A	N/A
Feedlot (S) to Beef (BY SS)	N/A	N/A
Goats to Beef (BY SS)	N/A	N/A
Goats to Small Ruminants (BY SS)	Weibull(1.7902,7.075)	Weibull(1.7902,7.075)
Goats to Swine (BY SS)	N/A	N/A
Sheep to Beef (BY SS)	N/A	N/A
Sheep to Small Ruminants (BY SS)	Beta(0.6281,1.7056,0,585.04)	Beta(0.6281,1.7056,0,585.04)
Sheep to Swine (BY SS)	N/A	N/A
Small Ruminant (BY SS) to Beef (BY SS)	N/A	N/A
Small Ruminants (BY SS) to Cow Calf	N/A	N/A
Small Ruminants (BY SS) to Dairy	N/A	N/A
Small Ruminants (BY SS) to Feedlot (L)	N/A	N/A
Small Ruminants (BY SS) to Feedlot (S)	N/A	N/A
Small Ruminants (BY SS) to Sheep	Uniform(16,120)	Uniform(16,120)
Small Ruminants (BY SS) to Small Ruminants (BY	N/A	N/A

Table 98: Direct Contact Movement Distance Distributions

Production Type Combination	All State Direct Contact: Movement Distance (km)	Texas Direct Contact: Movement Distance (km)
SS)		
Small Ruminants (BY SS) to Swine (L)	N/A	N/A
Small Ruminants (BY SS) to Swine (S)	N/A	N/A
Small Ruminants (BY SS) to Swine (BY SS)	N/A	N/A
Small Ruminants (BY SS)to Goats	Uniform(16,24)	Uniform(16,24)
Swine (BY SS) to Beef (BY SS)	N/A	N/A
Swine (BY SS) to Cow Calf	N/A	N/A
Swine (BY SS) to Dairy	N/A	N/A
Swine (BY SS) to Feedlot (L)	N/A	N/A
Swine (BY SS) to Feedlot (S)	N/A	N/A
Swine (BY SS) to Goats	N/A	N/A
Swine (BY SS) to Sheep	N/A	N/A
Swine (BY SS) to Small Ruminants (BY SS)	N/A	N/A
Swine (BY SS) to Swine (BY SS)	Uniform(16,160)	Uniform(16,160)
Swine (BY SS) to Swine (L)	Gaussian(80,2)	Gaussian(80,2)
Swine (BY SS) to Swine (S)	Gaussian(80,2)	Gaussian(80,2)
Swine (L) to Small Ruminants (BY SS)	N/A	N/A
Swine (L) to Swine (BY SS)	Triang(0,32.018,124.88)	
Swine (L) to Beef (BY SS)	N/A	N/A
Swine (S) to Small Ruminants (BY SS)	N/A	N/A
Swine (S) to Swine (BY SS)	Triang(0,32.018,124.88)	
Swine (S) to Beef (BY SS)	N/A	N/A

A6.3.4 State Specific Indirect Contact Rates

Indirect contact rates and distances for Texas were developed for the USDA 2011 study, the evidence basis for these parameters can be found in Appendix Section 6.3.4.1 and the parameters themselves in Appendix Section A6.3.4.2.

A6.3.4.1 Texas Indirect Contact Parameter Evidence Basis, Entire Section Quoted from USDA 2011

> *“Both the Texas panhandle survey and the southwest Texas survey reported indirect contact as high risk and low risk contacts (Dominguez et al., 2007a; Dominguez et al., 2007b). High risk contacts are those that involved contact with animals and low risk contacts were vehicles and people who came onto premises but did not have contact with animals. All premises in the two studies reported high risk contacts during the previous year but only a proportion of each production type reported low risk contacts. NAADSM does not differentiate between high risk and low risk contacts so these two types of indirect contacts were combined into averages that were weighted by the proportion of premises in each production type that reported those contacts.*
>
> *The indirect contact rates reported by the Texas panhandle study were for broad production type classes, feedlots, dairies, and swine. The southwest Texas study reported one combined indirect contact rate for all premises. These rates were applied to the specific production types in our study by using the 50% and 75% confidence limits of the production type classes. For example, for the four feedlot production types, it was assumed that indirect contacts increase with increasing feedlot capacity. The indirect contact rate for company feedlots was assumed to be the upper 75% confidence limit for all feedlots reported in the Texas panhandle study. The indirect contact rate was the upper 50% confidence limit for stockholder feedlots, the lower 50% confidence limit for custom feedlots, and the lower 75% confidence limit for yearling-pasture feedlots. For the four production types represented in the southwest Texas study, it was assumed that the indirect contact rates were highest for large cow-calf operations followed by small cow-calf, small ruminant, and stocker operations. Upper and lower 50% and 75% confidence limits were applied to these four production types in the same way as for the feedlots.*

To estimate the contact rates between particular pairs of production types, sources of indirect contact were classified into eight groups (veterinarians/extension, feed trucks, drug sales, nutritionists, external processors, milk trucks, neighbors, and contract haulers). The proportions of visits collectively made by each of these eight sources to each production type were estimated from NAHMS reports and expert opinion [Mike Sanderson, personal communication].

> *From these estimates, normalized proportions of overall contact visits for each production type were calculated. The contact rate from one production type to another was the product of the contact rate for the source production type and the normalized proportion of visits by all contact sources to the recipient production type.*

Laboratory transmission data were obtained from published studies involving experimental infection with FMD. In cases where no empirical disease transmission data were published, the probability of disease transmission was assumed to be 1.0 (100%). The data collected from the literature were used to calculate the probability of infection given exposure for each production type combination. To account for a variety of biosecurity measures implemented by various livestock sectors, an average reduction factor was calculated using published National Animal Health Monitoring Systems (NAHMS) data. This reduction factor was then multiplied to the probability of indirect disease transmission for each livestock sector (cattle, swine, & small ruminants).” [USDA 2011]

A6.3.4.2 Indirect Contact Rate Parameters

State specific indirect contact is shown in the table below.

Table 99: Indirect Contact Rates

Production Type	All States Except Texas	Texas
Cow Calf to Cow Calf	0.02	0.021875
Cow Calf to Dairy	0.104	0.03165
Cow Calf to Feedlot (S)	0.147	0.0097
Cow Calf to Feedlot (L)	1.152	0.033266667
Cow Calf to Sheep	0.005	0.00215
Cow Calf to Goats	0.005	0.00215
Cow Calf to Swine (S)	0.004	0.0109
Cow Calf to Swine (L)	0.035	0.02175
Dairy to Cow Calf	0.026	0.1646
Dairy to Dairy	0.172	0.23825
Dairy to Feedlot (S)	0.199	0.08335
Dairy to Feedlot (L)	1.549	0.250166667
Dairy to Sheep	0.005	0.0161
Dairy to Goats	0.005	0.0161
Dairy to Swine (S)	0.006	0.0819
Dairy to Swine (L)	0.049	0.16385
Feedlot (S) to Cow Calf	0.005	0.1605
Feedlot (S) to Dairy	0.022	0.23235
Feedlot (S) to Feedlot (S)	0.036	0.0813
Feedlot (S) to Feedlot (L)	0.266	0.243966667
Feedlot (S) to Sheep	0.005	0.0157
Feedlot (S) to Goats	0.005	0.0157
Feedlot (S) to Swine (S)	0.002	0.0799
Feedlot (S) to Swine (L)	0.031	0.1598
Feedlot (L) to Cow Calf	0.055	0.197983333
Feedlot (L) to Dairy	0.259	0.2866
Feedlot (L) to Feedlot (S)	0.395	0.1003
Feedlot (L) to Feedlot (L)	3.011	0.300933333
Feedlot (L) to Sheep	0.005	0.019366667
Feedlot (L) to Goats	0.005	0.019366667

Table 99: Indirect Contact Rates

Production Type	All States Except Texas	Texas
Feedlot (L) to Swine (S)	0.017	0.127033333
Feedlot (L) to Swine (L)	0.22	0.1686
Sheep to Cow Calf	0.005	0.0103
Goats to Cow Calf	0.005	0.0103
Sheep to Dairy	0.005	0.01495
Goats to Dairy	0.005	0.01495
Sheep to Feedlot (L)	0.005	0.015666667
Sheep to Feedlot (S)	0.005	0.0052
Goats to Feedlot (S)	0.005	0.0052
Goats to Feedlot (L)	0.005	0.015666667
Sheep to Sheep	0.01	0.001
Sheep to Goats	0.005	0.001
Sheep to Swine (L)	0.005	0.0103
Sheep to Swine (S)	0.005	0.0051
Goats to Swine (L)	0.005	0.0103
Goats to Swine (S)	0.005	0.0051
Goats to Sheep	0.005	0.001
Goats to Goats	0.01	0.001
Swine (S) to Cow Calf	0.003	0.00205
Swine (S) to Dairy	0.017	0.003
Swine (S) to Feedlot (S)	0.023	0.001
Swine (S) to Feedlot (L)	0.175	0.003133333
Swine (S) to Sheep	0.005	0.0002

Table 99: Indirect Contact Rates

Production Type	All States Except Texas	Texas
Swine (S) to Goats	0.005	0.0002
Swine (S) to Swine (S)	0.003	0.001
Swine (S) to Swine (L)	0.022	0.0021
Swine (L) to Cow Calf	0.01	0.00325
Swine (L)to Dairy	0.033	0.00475
Swine (L) to Feedlot (S)	0.061	0.0017
Swine (L) to Feedlot (L)	0.432	0.004966667
Swine (L) to Sheep	0.005	0.0003
Swine (L) to Goats	0.005	0.0003
Swine (L) to Swine (S)	0.009	0.0016
Swine (L) to Swine (L)	0.128	0.0032
Beef (BY SS) to Cow Calf	0.009819	.009819
Beef (BY SS) to Dairy	0.055171	0.055171
Beef (BY SS) to Feedlot (L)	0.540488	0.540488
Beef (BY SS) to Feedlot (S)	0.073698	0.073698
Beef (BY SS) to Goats	0.002455	0.002455
Beef (BY SS) to Sheep	0.002221	0.002221
Beef (BY SS) to Small Ruminant (BY SS)	0.033797	0.033797
Beef (BY SS) to Swine (L)	0.026183	0026183
Beef (BY SS) to Swine (S)	0.00374	0.00374
Beef (BY SS) to Beef (BY SS)	0.006798	0.006798
Beef (BY SS) to Swine (BY SS)	0.000323	0.000323
Cow Calf to Beef (BY SS)	0.016033	0.016033
Cow Calf to Small Ruminants (BY SS)	0.07971	0.07971
Cow Calf to Swine (BY SS)	0.000761	0.000761
Dairy to Beef (BY SS)	0.020112	0.020112
Dairy to Small Ruminants (BY SS)	0.099988	0.099988
Dairy to Swine (BY SS)	0.000954	0.000954
Feedlot (L) to Beef (BY SS)	0.022575	0.022575
Feedlot (L) to Small Ruminants (BY SS)	0.112231	0.112231
Feedlot (L) to Swine (BY SS)	0.001071	0.001071
Feedlot (S) to Beef (BY SS)	0.002608	0.002608
Feedlot (S) to Small Ruminants (BY SS)	0.012966	0.012966

Table 99: Indirect Contact Rates		
Production Type	**All States Except Texas**	**Texas**
Feedlot (S) to Swine (BY SS)	0.000124	0.000124
Goats to Beef (BY SS)	0.002736	0.002736
Goats to Small Ruminants (BY SS)	0.013604	0.013604
Goats to Swine (BY SS)	0.00013	0.00013
Sheep to Beef (BY SS)	0.002736	0.002736
Sheep to Small Ruminants (BY SS)	0.013604	0.013604
Sheep to Swine (BY SS)	0.00013	0.00013
Small Ruminant (BY SS) to Beef (BY SS)	0.000428	0.000428
Small Ruminant (BY SS) to Swine (BY SS)	0.00002	0.00002
Small Ruminant (BY SS) to Swine (L)	0.001647	0.001647
Small Ruminant (BY SS) to Swine (S)	0.000235	0.000235
Small Ruminants (BY SS) to Cow Calf	0.000618	0.000618
Small Ruminants (BY SS) to Dairy	0.00347	0.00347
Small Ruminants (BY SS) to Feedlot (L)	0.033993	0.033993
Small Ruminants (BY SS) to Feedlot (S)	0.004635	0.004635
Small Ruminants (BY SS) to Goats	0.000154	0.000154
Small Ruminants (BY SS) to Sheep	0.00014	0.00014
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0.002126	0.002126
Swine (BY SS) to Beef (BY SS)	0.000513	0.000513
Swine (BY SS) to Cow Calf	0.000741	0.000741
Swine (BY SS) to Dairy	0.004164	0.004164
Swine (BY SS) to Feedlot (L)	0.040792	0.040792
Swine (BY SS) to Feedlot (S)	0.005562	0.005562
Swine (BY SS) to Goats	0.000185	0.000185
Swine (BY SS) to Sheep	0.000168	0.000168
Swine (BY SS) to Small Ruminants (BY SS)	0.002551	0.002551
Swine (BY SS) to Swine (BY SS)	0.000024	0.000024
Swine (BY SS) to Swine (L)	0.001976	0.001976
Swine (BY SS) to Swine (S)	0.000282	0.000282
Swine (L) to Beef (BY SS)	0.003335	0.003335
Swine (L) to Small Ruminants (BY SS)	0.01658	0.01658
Swine (L) to Swine (BY SS)	0.000158	0.000158

Table 99: Indirect Contact Rates

Production Type	All States Except Texas	Texas
Swine (S) to Beef (BY SS)	0.001796	0.001796
Swine (S) to Small Ruminants (BY SS)	0.008927	0.008927
Swine (S) to Swine (BY SS)	0.000085	0.000085

A6.4 Parameter Entry Guide

The 2010 SSRA was criticized for not providing adequate information on NAADSM input parameters, to aid in the independent validation of results. This parameter data entry guide offers step by step instructions for creating a working NAADSM scenario file using Updated SSRA parameters for the state of Kansas. In the case of destruction capacity, the median destruction capacity function for all states modeled is provided, although each state was modeled with a destruction capacity based on its specific resources (if available). Population files may be requested, but are only available with the permission of DHS and LLNL, whose datasets contributed significantly to the creation of these files.

A6.4.1 Start Set Up

- Scenario description: Fill on the detail of your experiment here for personal tracking.
- Number of iterations: 200
- Use random number generator seed
- Proceed to the next screen (hit next)

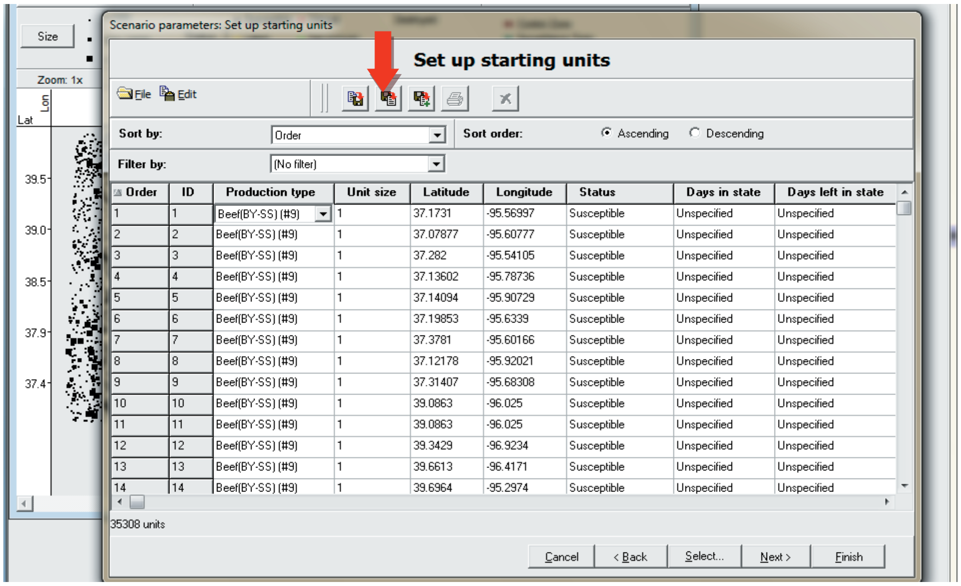
A6.4.2 Production Types

- For each production type, select “Add production type”
- Enter each production type exactly as it appears in Table 100.
- Proceed to the next screen (hit next)

Table 100: Updated SSRA Production Types

Production type
Cow calf
Dairy
Feedlot (L)
Feedlot (S)
Swine (L)
Swine (S)
Goat
Sheep
Beef (BY SS)
Swine (BY SS)
SmRu (BY SS)

A6.4.3 Starting Units



Scenario parameters: Set up starting units

Set up starting units

Sort by: Order

Sort order: ● Ascending ○ Descending

Filter by: (No filter)

Order	ID	Production type	Unit size	Latitude	Longitude	Status	Days in state	Days left in state
1	1	Beef(BY-SS) (#9)	1	37.1731	-95.56997	Susceptible	Unspecified	Unspecified
2	2	Beef(BY-SS) (#9)	1	37.07877	-95.60777	Susceptible	Unspecified	Unspecified
3	3	Beef(BY-SS) (#9)	1	37.282	-95.54105	Susceptible	Unspecified	Unspecified
4	4	Beef(BY-SS) (#9)	1	37.13602	-95.78736	Susceptible	Unspecified	Unspecified
5	5	Beef(BY-SS) (#9)	1	37.14094	-95.90729	Susceptible	Unspecified	Unspecified
6	6	Beef(BY-SS) (#9)	1	37.19853	-95.6339	Susceptible	Unspecified	Unspecified
7	7	Beef(BY-SS) (#9)	1	37.3781	-95.60166	Susceptible	Unspecified	Unspecified
8	8	Beef(BY-SS) (#9)	1	37.12178	-95.92021	Susceptible	Unspecified	Unspecified
9	9	Beef(BY-SS) (#9)	1	37.31407	-95.68308	Susceptible	Unspecified	Unspecified
10	10	Beef(BY-SS) (#9)	1	39.0863	-96.025	Susceptible	Unspecified	Unspecified
11	11	Beef(BY-SS) (#9)	1	39.0863	-96.025	Susceptible	Unspecified	Unspecified
12	12	Beef(BY-SS) (#9)	1	39.3429	-96.9234	Susceptible	Unspecified	Unspecified
13	13	Beef(BY-SS) (#9)	1	39.6613	-96.4171	Susceptible	Unspecified	Unspecified
14	14	Beef(BY-SS) (#9)	1	39.6964	-95.2974	Susceptible	Unspecified	Unspecified

35308 units

Figure 183: Set Up Starting Units Screen

Under the “Set Up Starting Units” Menu:

- For the “Set Up Starting Units” interface:
- Select “File – Import and replace existing unit list.” (click button indicated by red arrow in Figure 183)
- Upload animal population file. Files must be uploaded as .csv files. Status must be changed for at least one herd (either in Excel or in NAADSM) so that it is infected (it can be latent, subclinical, or clinical).
- Proceed to the next screen (hit next)
- Table 101 provides an example of the table produced by one of these files when loaded into Microsoft Excel. Status must be changed for at least one herd (either in Excel or in NAADSM) so that it is infected (it can be latent, subclinical, or clinical).
- Proceed to the next screen (hit next)

Table 101: Sample of Animal Population Data Loaded into NAADSM

HerdID	ProductionType	HerdSize	Lat*	Lon*	Status	daysleftinstatus
5471	SmRu(BY-SS)	10	36.0000	-101.101	L	-1
2407	Beef (BY-SS)	8	36.0000	-95.0000	S	-1
14767	Cow-calf	55	36.0000	-95.0000	S	-1
17524	Cow-calf	70	36.0000	-95.0000	S	-1
20656	Sheep	88	36.0000	-95.0000	S	-1

***Notional latitude and longitude are provided.**

A6.4.4 Disease

Under the “Disease” Menu:

For the “Disease options” interface:

- Select “Yes, use within-unit prevalence.”
- Proceed to the next screen (hit next)

For the “Disease” interface:

- Check box “Simulate disease progression for units in this production type” for all production types.
- Enter disease phase distributions for each production type by
  - Selecting a production type
  - clicking the “new” button next to each disease period
  - Selecting the appropriate function from the drop down menu and entering the necessary parameters
  - Distributions are provided based on the Updated SSRA population files for Kansas in Table 102. Select distributions from only one table, depending on which state you wish to model
- Enter within-unit prevalence
  - For all production types, select a production type
  - Click the “new” button next to “within-unit prevalence”
  - The Updated SSRA team recommends saving each within-unit prevalence function as a csv file and then uploading the file (from the file drop down menu, select import from file, select import relational function). Within-unit prevalence functions have been provided for each production type for Kansas in Table 103.
- Proceed to the next screen (hit next)

Table 102: Kansas Herd Level Disease Progression Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Cow Calf	Lognormal(2.55,1.81)	Beta(1.77,2.86,0,3.45)	Beta(18.2,37.14,0,60.11)	Gaussian (μ=1095,σ=180)
Dairy	LogLogistic(0,1.94,2.62)	Uniform(0,2.74)	Beta(28.09,40.32,0,54.65)	Gaussian (μ=1095,σ=180)

Table 102: Kansas Herd Level Disease Progression Parameters

Production Types	Latent	Subclinical	Clinical	Immune
Feedlot(L)	Gamma(2.41,0.97)	Beta(2.27,2.69,0,2.27)	Lognormal(94.44,67.72)	Gaussian (μ=1095,σ=180)
Feedlot(S)	LogLogistic(0, 2.02,2.44)	Weibull (1.97,1.31)	Beta(18.14,14.91,0,40.18)	Gaussian (μ=1095,σ=180)
Swine(L)	Pearson5(6.3941,8.1169)	Pearson5(9.9744,12.164)	Lognormal(32.009,4.3721)	Weibull (α=5,β=985)
Swine(S)	Pearson5(5.7556,7.2082)	InvGaussian(1.4895,11.7969)	Beta(13.881,19.284,0,48.730)	Weibull (α=5,β=985)
Goats	Beta(2.55,112.5,0,148.92)	Beta(2.09,4.36,0,5.97)	Gamma(32.13,0.48)	Gaussian(μ=930,σ=90)
Sheep	InvGaussian(3.71,7.3)	Triangular(0,1.41,4.2)	Beta(19.13,19.2,0,36.63)	Gaussian(μ=930,σ=90)
Beef (BY SS)	Lognormal(2.63,2.01)	Weibull(1.6,1.9)	Weibull(3.92,13.50)	Gaussian (μ=1095,σ=180)
Swine(BY SS)	Pearson5(4.4724,5.7095)	Pearson5(4.9380,7.0388)	Weibull(2.9572,12.659)	Weibull (α=5,β=985)
Small Ruminants (BY SS)	Lognormal(4.03,3.27)	LogLogistic(0,2.05,2.59)	Triangular(0,11.51,17.71)	Gaussian(μ=930,σ=90)

Table 103: Kansas Within Herd Prevalence (percentage)

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
1	98.91	79.92	8.76	91.06	100.00	68.1	17.96	52.99	50.00	60.00	50.00
2	99.79	97.87	30.44	97.49	100.00	100.00	23.43	64.27	50.00	60.00	50.00
3	100.00	100.00	89.68	100.00	100.00	100.00	38.37	85.60	62.50	80.00	66.67
4	100.00	100.00	99.96	100.00	100.00	100.00	71.32	98.67	75.00	80.00	66.67
5	100.00	100.00	100.00	100.00	100.00	100.00	88.3	99.94	87.50	80.00	66.67
6	100.00	100.00	100.00	100.00	100.00	100.00	96.07	100.00	87.50	80.00	83.33
7	100.00	100.00	100.00	100.00	100.00	100.00	98.73	100.00	87.50	80.00	83.33
8	100.00	100.00	100.00	100.00	100.00	100.00	99.51	100.00	75.00	80.00	66.67
9	100.00	100.00	100.00	100.00	100.00	100.00	99.68	100.00	62.50	60.00	66.67
10	100.00	100.00	100.00	100.00	100.00	100.00	99.31	100.00	62.50	60.00	66.67
11	100.00	100.00	100.00	100.00	100.00	100.00	98.73	99.98	50.00	40.00	50.00
12	100.00	100.00	100.00	100.00	100.00	100.00	97.37	99.88	37.50	40.00	50.00
13	100.00	100.00	100.00	100.00	100.00	100.00	94.4	99.54	37.50	20.00	33.33
14	100.00	100.00	100.00	100.00	100.00	100.00	88.3	97.87	25.00	20.00	33.33
15	100.00	100.00	100.00	100.00	100.00	100.00	81.06	95.07	12.50	20.00	16.67
16	100.00	100.00	100.00	100.00	100.00	100.00	71.32	85.60	12.50	20.00	16.67
17	99.99	99.91	100.00	100.00	100.00	100.00	58.72	73.21	12.50	0.00	16.67
18	99.91	99.34	100.00	100.00	100.00	100.00	47.16	64.27	12.50		16.67
19	98.91	96.88	100.00	99.83	99.99	100.00	33.63	52.99	0.00		0.00
20	94.80	90.36	99.99	99.33	99.95	100.00	28.65	38.89			
21	88.88	75.92	99.98	97.49	99.63	100.00	17.96	21.43			
22	76.55	65.46	99.96	91.06	97.42	100.00	12.23	21.43			
23	51.25	50.62	99.92	69.49	83.33	100.00	6.25	21.43			
24	51.25	29.62	99.85	69.49	83.33	99.97	6.25	0.00			
25	0.00	16.08	99.73	0.00	0.00	99.58	0				

Table 103: Kansas Within Herd Prevalence (percentage)

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
26		16.08	99.55			97.59					
27		16.08	99.27			92.39					
28		0.00	98.87			82.01					
29			98.35			68.10					
30			97.67			57.54					
31			96.89			43.50					
32			95.88			24.82					
33			94.79			24.82					
34			93.52			24.82					
35			92.03			0.00					
36			90.63								
37			88.99								
38			87.21								
39			85.38								
40			83.65								
41			81.62								
42			79.13								
43			77.17								
44			75.03								
45			72.40								
46			70.14								
47			68.20								
48			67.70								
49			66.15								
50			64.52								
51			62.81								

Table 103: Kansas Within Herd Prevalence (percentage)

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
52			62.03								
53			61.43								
54			58.51								
55			56.75								
56			54.92								
57			53.01								
58			50.51								
59			48.68								
60			47.61								
61			45.4								
62			45.96								
63			45.68								
64			44.54								
65			43.68								
66			42.80								
67			41.61								
68			41.91								
69			41.00								
70			39.46								
71			38.83								
72			37.88								
73			37.56								
74			36.59								
75			34.94								
76			33.58								
77			32.20								

Table 103: Kansas Within Herd Prevalence (percentage)

Days Since Herd Infected	Cow Calf	Feedlot(S)	Feedlot(L)	Dairy	Swine(S)	Swine(L)	Sheep	Goat	Beef (BY SS)	Swine(BY SS)	SmRu(BY SS)
78			30.80								
79			29.36								
80			28.27								
81			26.40								
82			25.64								
83			24.49								
84			24.10								
85			23.32								
86			23.71								
87			0.00								

A6.4.5 Spread Options

Under the “Disease Spread” Menu:

For the “Spread Options” interface:

- Select “Both airborne and contact” for type of spread.
- Select “Rate of disease transfer declines exponentially from the source” for airborne spread.
- Proceed to the next screen (hit next)

Production Type Combinations

For the “Production Type Combinations” interface:

- Select all production type combinations in “Choose from all combinations” field.
- Click “Add.”
- Proceed to the next screen (hit next)

Contact Spread

For the “Contact Spread” interface:

For each production type combination:

- Check “Model direct contact spread” if a numerical value (not 0) is provided for that production type combination in Table 104
    - Check boxes:
        - “Latent units can spread disease”
        - “Subclinical units can spread disease”
    - Enter contact rate from Table 105 in box next to “Mean baseline contact rate (recipient units/unit/day)”
    - Click the “new” button next to “distance distribution of recipient units”
        - Select the appropriate function from the drop down menu and entering the necessary parameters
        - Distance distributions are provided. Select distributions from only one table, depending on which state you wish to model (see Table 86)
    - For “Shipping delay” click the “new button” and create a universal function to apply to all production types (you only need one function)
        - Select function type “fixed value”

    - Enter value “0”

- For “effect of movement controls on baseline contact rate, after detection in any production type” click the “new button” and create a universal function to apply to all production types (you only need one function). Enter the following function:
    - x-axis: 0, 2, 5
    - y-axis: 100, 50, 20

Table 104: Direct Contact Rates (shipments/day)

Production Types	Kansas
Cow Calf to Cow Calf	0.009856994
Cow Calf to Dairy	6.97E-06
Cow Calf to Feedlot (S)	0.00508001
Cow Calf to Feedlot (L)	0.007613585
Cow Calf to Sheep	0
Cow Calf to Goats	0
Cow Calf to Swine (S)	0
Cow Calf to Swine (L)	0
Dairy to Cow Calf	0.002844332
Dairy to Dairy	0.006973808
Dairy to Feedlot(S)	0
Dairy to Feedlot (L)	0.063871468
Dairy to Sheep	0
Dairy to Goats	0
Dairy to Swine (S)	0
Dairy to Swine (L)	0
Feedlot(S) to Cow Calf	0.000284433
Feedlot(S) to Dairy	0.000278952
Feedlot(S) to Feedlot(S)	0
Feedlot(S) to Feedlot(L)	0.063378487
Feedlot(S) to Swine (L)	0
Feedlot(S) to Swine (L)	0
Feedlot (S) to Sheep	0
Feedlot (S) to Goats	0
Feedlot(L) to Cow Calf	0.000284433
Feedlot(L) to Dairy	0.000278952
Feedlot(L) to Feedlot(S)	0
Feedlot(L) to Feedlot(L)	0
Feedlot (L) to Sheep	0
Feedlot (L) to Goats	0

Table 104: Direct Contact Rates (shipments/day)

Production Types	Kansas
Feedlot(L) to Swine (S)	0
Feedlot(L) to Swine (L)	0
Sheep to Cow Calf	0
Goats to Cow Calf	0
Sheep to Dairy	0
Goats to Dairy	0
Sheep to Feedlot (L)	0
Sheep to Feedlot (S)	0
Goats to Feedlot (S)	0
Goats to Feedlot (L)	0
Sheep to Sheep	0.047451714
Sheep to Goats	0
Goats to Sheep	0
Goats to Goats	0.043593549
Sheep to Swine (S)	0
Sheep to Swine (L)	0
Goats to Swine (S)	0
Goats to Swine (L)	0
Swine (S) to Cow Calf	0
Swine (S) to Dairy	0
Swine (S) to Feedlot (S)	0
Swine (S) to Feedlot (L)	0
Swine (S) to Sheep	0
Swine (S) to Goats	0
Swine (S) to Swine (S)	0.013797557
Swine (S) to Swine (L)	0
Swine (L) to Cow Calf	0
Swine (L) to Dairy	0
Swine (L) to Feedlot (S)	0
Swine (L) to Feedlot (L)	0
Swine (L) to Sheep	0
Swine (L) to Goats	0
Swine (L) to Swine (S)	0
Swine (L) to Swine (L)	0.285806548
Beef (BY SS) to Cow Calf	0
Beef (BY SS) to Dairy	0
Beef (BY SS) to Feedlot(L)	0.00577078
Beef (BY SS) to Feedlot(S)	0.005759427

Table 104: Direct Contact Rates (shipments/day)

Production Types	Kansas
Beef (BY SS) to Goats	0
Beef (BY SS) to Sheep	0
Beef (BY SS) to Small Ruminant (BY SS)	0
Beef (BY SS) to Swine (S)	0
Beef (BY SS) to Swine (L)	0
Beef (BY SS) to Beef (BY SS)	0.001750381
Beef (BY SS) to Swine (BY SS)	0
Cow Calf to Beef (BY SS)	0.000346089
Cow Calf to Small Ruminants (BY SS)	0
Cow Calf to Swine (BY SS)	0
Dairy to Beef (BY SS)	0.001601183
Dairy to Small Ruminants (BY SS)	0
Dairy to Swine (BY SS)	0
Feedlot (L) to Swine (BY SS)	0
Feedlot (S) to Swine (BY SS)	0
Feedlot (L) to Small Ruminants (BY SS)	0
Feedlot (S) to Small Ruminants (BY SS)	0
Feedlot (S) to Beef (BY SS)	0
Feedlot (L) to Beef (BY SS)	0
Goats to Beef (BY SS)	0
Goats to Small Ruminants (BY SS)	0.001365635
Goats to Swine (BY SS)	0
Sheep to Beef (BY SS)	0
Sheep to Small Ruminants (BY SS)	0.002454934
Sheep to Swine (BY SS)	0
Small Ruminant (BY SS) to Beef (BY SS)	0
Small Ruminants (BY SS) to Cow Calf	0
Small Ruminants (BY SS) to Dairy	0
Small Ruminants (BY SS) to Feedlot (S)	0
Small Ruminants (BY SS) to Feedlot (L)	0
Small Ruminants (BY SS) to Goats	0.000803
Small Ruminants (BY SS) to Sheep	0.001011
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0
Small Ruminants (BY SS) to Swine (BY SS)	0
Small Ruminants (BY SS) to Swine (L)	0
Small Ruminants (BY SS) to Swine (S)	0
Swine (BY SS) to Beef (BY SS)	0

Table 104: Direct Contact Rates (shipments/day)

Production Types	Kansas
Swine (BY SS) to Cow Calf	0
Swine (BY SS) to Dairy	0
Swine (BY SS) to Feedlot (L)	0
Swine (BY SS) to Feedlot (S)	0
Swine (BY SS) to Goats	0
Swine (BY SS) to Sheep	0
Swine (BY SS) to Small Ruminants (BY SS)	0
Swine (BY SS) to Swine (BY SS)	0.001369863
Swine (BY SS) to Swine (L)	9.96608E-05
Swine (BY SS) to Swine (S)	0.000136209
Swine (L) to Small Ruminants (BY SS)	0
Swine (L) to Swine (BY SS)	0.002055228
Swine (L) to Beef (BY SS)	0
Swine (S) to Small Ruminants (BY SS)	0
Swine (S) to Swine (BY SS)	0.002034061
Swine (S) to Beef (BY SS)	0

Table 105: Direct Contact Movement Distance Functions for Kansas

Production Type	Function
Beef (BY SS) to Cow Calf	N/A
Beef (BY SS) to Dairy	N/A
Beef (BY SS) to Feedlot(L)	Loglogistic(0,44.241,16.755)
Beef (BY SS) to Feedlot(S)	Invgauss(378.8,18.226)
Beef (BY SS) to Goats	N/A
Beef (BY SS) to Sheep	N/A
Beef (BY SS) to Small Ruminant (BY SS)	N/A
Beef (BY SS) to Swine (S)	N/A
Beef (BY SS) to Swine (L)	N/A
Beef (BY SS) to Beef (BY SS)	Triang(0,47.013,52.438)
Beef (BY SS) to Swine (BY SS)	N/A
Cow Calf to Beef (BY SS)	Loglogistic(0,22.439,2.9175)
Cow Calf to Small Ruminants (BY SS)	N/A
Cow Calf to Swine (BY SS)	N/A
Dairy to Beef (BY SS)	uniform(8,200)
Dairy to Small Ruminants (BY SS)	N/A
Dairy to Swine (BY SS)	N/A
Feedlot (L) to Small Ruminants (BY SS)	N/A
Feedlot (L) to Swine (BY SS)	N/A
Feedlot (S) to Small Ruminants (BY SS)	N/A

Table 105: Direct Contact Movement Distance Functions for Kansas

Production Type	Function
Feedlot (S) to Swine (BY SS)	N/A
Feedlot (L) to Beef (BY SS)	N/A
Feedlot (S) to Beef (BY SS)	N/A
Goats to Beef (BY SS)	N/A
Goats to Small Ruminants (BY SS)	Weibull(1.7902,7.075)
Goats to Swine (BY SS)	N/A
Sheep to Beef (BY SS)	N/A
Sheep to Small Ruminants (BY SS)	Beta(0.6281,1.7056,0,585.04)
Sheep to Swine (BY SS)	N/A
Small Ruminant (BY SS) to Beef (BY SS)	N/A
Small Ruminants (BY SS) to Cow Calf	N/A
Small Ruminants (BY SS) to Dairy	N/A
Small Ruminants (BY SS) to Feedlot (L)	N/A
Small Ruminants (BY SS) to Feedlot (S)	N/A
Small Ruminants (BY SS) to Sheep	uniform(16,120)
Small Ruminants (BY SS) to Small Ruminants (BY SS)	N/A
Small Ruminants (BY SS) to Swine (L)	N/A
Small Ruminants (BY SS) to Swine (S)	N/A
Small Ruminants (BY SS) to Swine (BY SS)	N/A
Small Ruminants (BY SS)to Goats	uniform(16,24)
Swine (BY SS) to Beef (BY SS)	N/A
Swine (BY SS) to Cow Calf	N/A
Swine (BY SS) to Dairy	N/A
Swine (BY SS) to Feedlot (L)	N/A
Swine (BY SS) to Feedlot (S)	N/A
Swine (BY SS) to Goats	N/A
Swine (BY SS) to Sheep	N/A
Swine (BY SS) to Small Ruminants (BY SS)	N/A
Swine (BY SS) to Swine (BY SS)	uniform(16,160)
Swine (BY SS) to Swine (L)	gaussian(80,2)
Swine (BY SS) to Swine (S)	gaussian(80,2)
Swine (L) to Small Ruminants (BY SS)	N/A
Swine (L) to Swine (BY SS)	Triang(0,32.018,124.88)
Swine (L) to Beef (BY SS)	
Swine (S) to Small Ruminants (BY SS)	N/A
Swine (S) to Swine (BY SS)	Triang(0,32.018,124.88)
Swine (S) to Beef (BY SS)	N/A
Cow Calf to Cow Calf	BetaPERT (1.6, 32.2, 752)
Cow Calf to Dairy	BetaPERT (1.6, 80.5, 752)
Cow Calf to Feedlot (L)	BetaPERT (1.6, 193.1, 752)
Cow Calf to Feedlot (S)	BetaPERT (1.6, 96.5, 752)

Table 105: Direct Contact Movement Distance Functions for Kansas

Production Type	Function
Cow Calf to Goats	N/A
Cow Calf to Sheep	N/A
Cow Calf to Swine (L)	N/A
Cow Calf to Swine (S)	N/A
Dairy to Cow Calf	BetaPERT (1.6, 80.5, 752)
Dairy to Dairy	BetaPERT (1.6, 80.5, 752)
Dairy to Feedlot (L)	BetaPERT (1.6, 80.5, 752)
Dairy to Feedlot (S)	N/A
Dairy to Goats	N/A
Dairy to Sheep	N/A
Dairy to Swine (L)	N/A
Dairy to Swine (S)	N/A
Feedlot (L) to Cow Calf	BetaPERT (1.6, 80.5, 752)
Feedlot (L) to Dairy	BetaPERT (1.6, 80.5, 752)
Feedlot (L) to Feedlot (L)	N/A
Feedlot (L) to Feedlot (S)	N/A
Feedlot (L) to Goats	N/A
Feedlot (L) to Sheep	N/A
Feedlot (L) to Swine (L)	N/A
Feedlot (L) to Swine (S)	N/A
Feedlot (S) to Cow Calf	BetaPERT (1.6, 80.5, 752)
Feedlot (S) to Dairy	BetaPERT (1.6, 80.5, 752)
Feedlot (S) to Feedlot (L)	BetaPERT (1.6, 160.9, 752)
Feedlot (S) to Feedlot (S)	N/A
Feedlot (S) to Goats	N/A
Feedlot (S) to Sheep	N/A
Feedlot (S) to Swine (L)	N/A
Feedlot (S) to Swine (S)	N/A
Goats to Cow Calf	N/A
Goats to Dairy	N/A
Goats to Feedlot (S)	N/A
Goats to Feedlot (L)	N/A
Goats to Goats	BetaPERT (1.6, 80.5, 752)
Goats to Sheep	N/A
Goats to Swine (S)	N/A
Goats to Swine (L)	N/A
Sheep to Cow Calf	N/A
Sheep to Dairy	N/A
Sheep to Feedlot (L)	N/A
Sheep to Feedlot (S)	N/A
Sheep to Goats	N/A
Sheep to Sheep	BetaPERT (1.6, 80.5, 752)

Table 105: Direct Contact Movement Distance Functions for Kansas

Production Type	Function
Sheep to Swine (L)	N/A
Sheep to Swine (S)	N/A
Swine (L) to Cow Calf	N/A
Swine (L) to Dairy	N/A
Swine (L) to Feedlot (L)	N/A
Swine (L) to Feedlot (S)	N/A
Swine (L) to Goats	N/A
Swine (L) to Sheep	N/A
Swine (L) to Swine (L)	BetaPERT (0, 20, 752)
Swine (L) to Swine (S)	N/A
Swine (S) to Cow Calf	N/A
Swine (S) to Dairy	N/A
Swine (S) to Feedlot (L)	N/A
Swine (S) to Feedlot (S)	N/A
Swine (S) to Goats	N/A
Swine (S) to Sheep	N/A
Swine (S) to Swine (L)	N/A
Swine (S) to Swine (S)	BetaPERT (0, 20, 752)

For “Model indirect contact spread”:

- Check “Model indirect contact spread” for all production type combinations
  - Check box:
    - “Subclinical units can spread disease”
  - Enter contact rate from Table 106 in box next to “Mean baseline contact rate (recipient units/unit/day)”
  - Enter probability of infection transfer from Table 107 in box next to “Probability of infection transfer (if source positive) (0 to 1)”
  - Click the “new” button next to “distance distribution of recipient units” and create a universal function to apply to all production types (you only need one function)
    - Select BetaPERT from the drop down menu , enter:
      - Minimum: 1.6
      - Mode: 40.2
      - Maximum: 160.9
  - For “Shipping delay” click the “new button” and create a universal function to apply to all production types (you only need one function)

        - Select function type “fixed value”
        - Enter value “0”
    - For “effect of movement controls on baseline contact rate, after detection in any production type” click the “new button” and create a universal function to apply to all production types (you only need one function). Enter the following function:
        - x-axis: 0, 21
        - y-axis: 100, 50

Table 106: Indirect Contact Rate (shipments/day)

Production Type	Kansas
Beef (BY SS) to Cow Calf	0.009819
Beef (BY SS) to Dairy	0.055171
Beef (BY SS) to Feedlot (L)	0.540488
Beef (BY SS) to Feedlot (S)	0.073698
Beef (BY SS) to Goats	0.002455
Beef (BY SS) to Sheep	0.002221
Beef (BY SS) to Small Ruminant (BY SS)	0.033797
Beef (BY SS) to Swine (L)	0.026183
Beef (BY SS) to Swine (S)	0.00374
Beef (BY SS) to Beef (BY SS)	0.006798
Beef (BY SS) to Swine (BY SS)	0.000323
Cow Calf to Beef (BY SS)	0.016033
Cow Calf to Small Ruminants (BY SS)	0.07971
Cow Calf to Swine (BY SS)	0.000761
Dairy to Beef (BY SS)	0.020112
Dairy to Small Ruminants (BY SS)	0.099988
Dairy to Swine (BY SS)	0.000954
Feedlot (L) to Beef (BY SS)	0.022575
Feedlot (L) to Small Ruminants (BY SS)	0.112231
Feedlot (L) to Swine (BY SS)	0.001071
Feedlot (S) to Beef (BY SS)	0.002608
Feedlot (S) to Small Ruminants (BY SS)	0.012966
Feedlot (S) to Swine (BY SS)	0.000124
Goats to Beef (BY SS)	0.002736
Goats to Small Ruminants (BY SS)	0.013604
Goats to Swine (BY SS)	0.00013
Sheep to Beef (BY SS)	0.002736
Sheep to Small Ruminants (BY SS)	0.013604

Table 106: Indirect Contact Rate (shipments/day)

Production Type	Kansas
Sheep to Swine (BY SS)	0.00013
Small Ruminant (BY SS) to Beef (BY SS)	0.000428
Small Ruminant (BY SS) to Swine (BY SS)	0.00002
Small Ruminant (BY SS) to Swine (L)	0.001647
Small Ruminant (BY SS) to Swine (S)	0.000235
Small Ruminants (BY SS) to Cow Calf	0.000618
Small Ruminants (BY SS) to Dairy	0.00347
Small Ruminants (BY SS) to Feedlot (L)	0.033993
Small Ruminants (BY SS) to Feedlot (S)	0.004635
Small Ruminants (BY SS) to Goats	0.000154
Small Ruminants (BY SS) to Sheep	0.00014
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0.002126
Swine (BY SS) to Beef (BY SS)	0.000513
Swine (BY SS) to Cow Calf	0.000741
Swine (BY SS) to Dairy	0.004164
Swine (BY SS) to Feedlot (L)	0.040792
Swine (BY SS) to Feedlot (S)	0.005562
Swine (BY SS) to Goats	0.000185
Swine (BY SS) to Sheep	0.000168
Swine (BY SS) to Small Ruminants (BY SS)	0.002551
Swine (BY SS) to Swine (BY SS)	0.000024
Swine (BY SS) to Swine (L)	0.001976
Swine (BY SS) to Swine (S)	0.000282
Swine (L) to Beef (BY SS)	0.003335
Swine (L) to Small Ruminants (BY SS)	0.01658
Swine (L) to Swine (BY SS)	0.000158
Swine (S) to Beef (BY SS)	0.001796
Swine (S) to Small Ruminants (BY SS)	0.008927
Swine (S) to Swine (BY SS)	0.000085
Cow Calf to Cow Calf	0.02
Cow Calf to Dairy	0.104
Cow Calf to Feedlot (S)	0.147
Cow Calf to Feedlot (L)	1.152
Cow Calf to Sheep	0.005
Cow Calf to Goats	0.005
Cow Calf to Swine (S)	0.004
Cow Calf to Swine (L)	0.035
Dairy to Cow Calf	0.026

Table 106: Indirect Contact Rate (shipments/day)

Production Type	Kansas
Dairy to Dairy	0.172
Dairy to Feedlot (S)	0.199
Dairy to Feedlot (L)	1.549
Dairy to Sheep	0.005
Dairy to Goats	0.005
Dairy to Swine (S)	0.006
Dairy to Swine (L)	0.049
Feedlot (S) to Cow Calf	0.005
Feedlot (S) to Dairy	0.022
Feedlot (S) to Feedlot (S)	0.036
Feedlot (S) to Feedlot (L)	0.266
Feedlot (S) to Sheep	0.005
Feedlot (S) to Goats	0.005
Feedlot (S) to Swine (S)	0.002
Feedlot (S) to Swine (L)	0.031
Feedlot (L) to Cow Calf	0.055
Feedlot (L) to Dairy	0.259
Feedlot (L) to Feedlot (S)	0.395
Feedlot (L) to Feedlot (L)	3.011
Feedlot (L) to Sheep	0.005
Feedlot (L) to Goats	0.005
Feedlot (L) to Swine (S)	0.017
Feedlot (L) to Swine (L)	0.22
Sheep to Cow Calf	0.005
Goats to Cow Calf	0.005
Sheep to Dairy	0.005
Goats to Dairy	0.005
Sheep to Feedlot (L)	0.005
Sheep to Feedlot (S)	0.005
Goats to Feedlot (S)	0.005
Goats to Feedlot (L)	0.005
Sheep to Sheep	0.01
Sheep to Goats	0.005
Sheep to Swine (L)	0.005
Sheep to Swine (S)	0.005
Goats to Swine (L)	0.005
Goats to Swine (S)	0.005
Goats to Sheep	0.005

Table 106: Indirect Contact Rate (shipments/day)

Production Type	Kansas
Goats to Goats	0.01
Swine (S) to Cow Calf	0.003
Swine (S) to Dairy	0.017
Swine (S) to Feedlot (S)	0.023
Swine (S) to Feedlot (L)	0.175
Swine (S) to Sheep	0.005
Swine (S) to Goats	0.005
Swine (S) to Swine (S)	0.003
Swine (S) to Swine (L)	0.022
Swine (L) to Cow Calf	0.01
Swine (L)to Dairy	0.033
Swine (L) to Feedlot (S)	0.061
Swine (L) to Feedlot (L)	0.432
Swine (L) to Sheep	0.005
Swine (L) to Goats	0.005
Swine (L) to Swine (S)	0.009
Swine (L) to Swine (L)	0.128

Table 107: Indirect Contact: Probability of Infection Given Exposure for All States

Production Type	Indirect Contact: Probability of Infection Given Exposure
Cow Calf to Cow Calf	0.1263
Cow Calf to Dairy	0.2795
Cow Calf to Feedlot (L)	0.1384
Cow Calf to Feedlot (S)	0.1384
Cow Calf to Goats	0.4286
Cow Calf to Sheep	0.4286
Cow Calf to Swine (L)	0.5937
Cow Calf to Swine (S)	0.5937
Dairy to Cow Calf	0.1263
Dairy to Dairy	0.2795
Dairy to Feedlot (L)	0.1384
Dairy to Feedlot (S)	0.1384
Dairy to Goats	0.4286
Dairy to Sheep	0.4286

Table 107: Indirect Contact: Probability of Infection Given Exposure for All States

Production Type	Indirect Contact: Probability of Infection Given Exposure
Dairy to Swine (L)	0.5937
Dairy to Swine (S)	0.5937
Feedlot (L) to Cow Calf	0.1263
Feedlot (L) to Dairy	0.2795
Feedlot (L) to Feedlot (L)	0.1384
Feedlot (L) to Feedlot (S)	0.1384
Feedlot (L) to Goats	0.4286
Feedlot (L) to Sheep	0.4286
Feedlot (L) to Swine (L)	0.5937
Feedlot (L) to Swine (S)	0.5937
Feedlot (S) to Cow Calf	0.1263
Feedlot (S) to Dairy	0.2795
Feedlot (S) to Feedlot (L)	0.1384
Feedlot (S) to Feedlot (S)	0.1384
Feedlot (S) to Goats	0.4286
Feedlot (S) to Sheep	0.4286
Feedlot (S) to Swine (L)	0.5937
Feedlot (S) to Swine (S)	0.5937
Goats to Cow Calf	0.1263
Goats to Dairy	0.2795
Goats to Feedlot (L)	0.1384
Goats to Feedlot (S)	0.1384
Goats to Goats	0.2143
Goats to Sheep	0.2143
Goats to Swine (L)	0.5937
Goats to Swine (S)	0.5937
Sheep to Cow Calf	0.1263
Sheep to Dairy	0.2795
Sheep to Feedlot (L)	0.1384
Sheep to Feedlot (S)	0.1384
Sheep to Goats	0.2143
Sheep to Sheep	0.2143
Sheep to Swine (L)	0.5937
Sheep to Swine (S)	0.5937
Swine (S) to Cow Calf	0.1083
Swine (L) to Cow Calf	0.1083

Table 107: Indirect Contact: Probability of Infection Given Exposure for All States

Production Type	Indirect Contact: Probability of Infection Given Exposure
Swine (L) to Dairy	0.2396
Swine (S) to Dairy	0.2396
Swine (S) to Feedlot (S)	0.1186
Swine (L) to Feedlot (S)	0.1186
Swine (S) o Feedlot (L)	0.1186
Swine (L) to Feedlot (L)	0.1186
Swine (L) to Goats	0.4286
Swine (S) to Goats	0.4286
Swine (L) to Sheep	0.4286
Swine (S) to Sheep	0.4286
Swine (L) to Swine (L)	0.3299
Swine (S) to Swine (L)	0.3299
Swine (L) to Swine (S)	0.3299
Swine (S) to Swine (S)	0.3299
Beef (BY SS) to Cow Calf	0.1263
Beef (BY SS) to Dairy	0.2795
Beef (BY SS) to Feedlot (L)	0.1384
Beef (BY SS) to Feedlot (S)	0.1384
Beef (BY SS) to Goats	0.4286
Beef (BY SS) to Sheep	0.4286
Beef (BY SS) to Small Ruminant (BY SS)	0.4286
Beef (BY SS) to Swine (S)	0.5937
Beef (BY SS) to Swine (L)	0.5937
Beef (BY SS) to Beef (BY SS)	0.2795
Beef (BY SS) to Swine (BY SS)	0.5937
Cow Calf to Beef (BY SS)	0.2795
Cow Calf to Small Ruminants (BY SS)	0.4286
Cow Calf to Swine (BY SS)	0.5937
Dairy to Beef (BY SS)	0.2795
Dairy to Small Ruminants (BY SS)	0.4286
Dairy to Swine (BY SS)	0.5937
Feedlot (L) to Beef (BY SS)	0.2795
Feedlot (L) to Small Ruminants (BY SS)	0.4286
Feedlot (L) to Swine (BY SS)	0.5937
Feedlot (S) to Beef (BY SS)	0.2795
Feedlot (S) to Small Ruminants (BY SS)	0.4286
Feedlot (S) to Swine (BY SS)	0.5937

Table 107: Indirect Contact: Probability of Infection Given Exposure for All States

Production Type	Indirect Contact: Probability of Infection Given Exposure
Goats to Beef (BY SS)	0.2795
Goats to Small Ruminants (BY SS)	0.2143
Goats to Swine (BY SS)	0.5937
Sheep to Beef (BY SS)	0.2795
Sheep to Small Ruminants (BY SS)	0.2143
Sheep to Swine (BY SS)	0.5937
Small Ruminant (BY SS) to Beef (BY SS)	0.2795
Small Ruminants (BY SS to Goats	0.2143
Small Ruminants (BY SS) to Cow Calf	0.1263
Small Ruminants (BY SS) to Dairy	0.2795
Small Ruminants (BY SS) to Feedlot (L)	0.1384
Small Ruminants (BY SS) to Feedlot (S)	0.1384
Small Ruminants (BY SS) to Sheep	0.2143
Small Ruminants (BY SS) to Small Ruminants (BY SS)	0.2143
Small Ruminants (BY SS) to Swine (L)	0.5937
Small Ruminants (BY SS) to Swine (S)	0.5937
Small Ruminants (BY SS) to Swine (BY SS)	0.5937
Swine (BY SS) to Beef (BY SS)	0.2396
Swine (BY SS) to Cow Calf	0.1083
Swine (BY SS) to Dairy	0.2396
Swine (BY SS) to Feedlot (L)	0.1186
Swine (BY SS) to Feedlot (S)	0.1186
Swine (BY SS) to Goats	0.4286
Swine (BY SS) to Sheep	0.4286
Swine (BY SS) to Small Ruminants (BY SS)	0.4286
Swine (BY SS) to Swine (BY SS)	0.3299
Swine (BY SS) to Swine (L)	0.3299
Swine (BY SS) to Swine (S)	0.3299
Swine (L) to Swine (BY SS)	0.3299
Swine (S) to Swine (BY SS)	0.3299
Swine (L) to Beef (BY SS)	0.2396
Swine (S) to Beef (BY SS)	0.2396
Swine (S) to Small Ruminants (BY SS)	0.4286
Swine (L) to Small Ruminants (BY SS)	0.4286

Airborne Spread

For the “Airborne Spread” interface:

For each production type combination:

- Check box “Model airborne spread between these production types.”
- Enter “Airborne: Probability of Spread between Two Herds of Average Size Located 1 km Apart Input Value” from Table 108 in field “Probability of spread/contg. a day, at 1 km, average unit sizes.”
- Enter “0” in “Start” field.
- Enter “360” in “End” field.
- Click “New” on “Airborne transport delay.”
    - Under “Function type” select “Fixed value.”
    - In the “Value” field enter “0.”

Table 108: Airborne: Probability of Spread Between Two Herds of Average Size Located 1 km Apart

Production Type	Probability
Cow Calf, Dairy, Feedlot, Beef (BY SS) and Small Ruminant to all production types	0.008
Swine to All Cattle	0.1
Swine(S) to Sheep	0.01
Swine(L) to Sheep	0.01
Swine(S) to Goats	0.01
Swine(L) to Goats	0.01
Swine(S) to Small Ruminants (BY SS)	0.01
Swine(L) to Small Ruminants (BY SS)	0.01
Swine(S) to Swine(S)	0.008
Swine(S) to Swine(L)	0.008
Swine(L) to Swine(S)	0.008
Swine(L) to Swine(S)	0.008
Swine(S) to Swine (BY SS)	0.008
Swine(L) to Swine (BY SS)	0.008

A6.4.6 Detection

Under “Detection” menu:

For the “Detection options” interface:

- Check box “Yes, include detection.”

For “Detection” interface:

For each production type:

- Check box “Model disease detection in this production type.”
- Click “New” on “Probability of observing clinical signs.”
    - Enter probability of observation from Table 109
- Click “New” on “Probability of reporting an observed clinical unit.”
    - Enter probability of reporting for that production type from Table 110

Table 109: Kansas Probability of Observing” (Observation and Reporting Before Outbreak Detected)

Day	Cow Calf	Feedlot (S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00
4	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	5.00	9.30	2.00
5	5.00	35.00	35.00	2.00	31.00	31.00	2.00	2.00	5.00	16.00	2.00
6	6.00	35.00	35.00	38.00	31.00	31.00	2.00	2.00	26.00	21.00	2.00
7	7.67	35.00	35.00	38.00	31.00	100.00	2.00	8.92	26.00	26.00	2.00
8	11.00	35.00	35.00	38.00	31.00	100.00	8.92	8.92	26.00	50.00	2.00
9	36.00	100.00	100.00	38.00	100.00		10.60	10.60	26.00	70.00	21.00
10	40.00	100.00	100.00	100.00	100.00		10.60	10.99	100.00	85.00	21.00
11	46.67	100.00		100.00			10.99	33.75	100.00	100.00	21.00
12	60.00			100.00			33.75	33.75	100.00	100.00	21.00
13	100.00						38.80	38.80			100.00
14	100.00						38.80	39.97			100.00
15	100.00						39.97	40.00			
16							40.00	40.00			
17							40.00	40.00			
18							40.00	40.00			
19							40.00	39.99			
20							39.99	39.93			
21							39.93	39.60			

Table 109: Kansas Probability of Observing” (Observation and Reporting Before Outbreak Detected)

Day	Cow Calf	Feedlot (S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY SS)	Swine (BY SS)	Small Ruminants (BY SS)
22							39.60	39.60			
23							39.60	37.88			
24							37.88				
25							37.71				

Table 110: Kansas Reporting Functions

Day	Cow Calf	Feedlot (S)	Feedlot (L)	Dairy	Swine (S)	Swine (L)	Sheep	Goats	Beef (BY-SS)	Swine (BY-SS)	Small Ruminants (BY-SS)
0	100	100	100	100	100	100	100	100	100	100	100
1	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100
3	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
4	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
5	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000
6	1300	5000	5000	5000	2000	2000	5000	4000	2000	3000	5000

A6.4.7 Tracing

Under the “Tracing” menu:

For the “Global Tracing Options” interface:

- Check box “Conduct tracing for some or all production types.”
- Check box “Examine some or all traced units for clinical signs of disease.”
- Check box “Perform diagnostic testing for some or all traced herds.”

For the “Tracing” interface:

For each production type:

- Check box “Conduct TRACE FORWARD investigations to search for DIRECT contacts.”
- Check box “Conduct TRACE FORWARD investigations to search for INDIRECT contacts.”
- Check box “Conduct TRACE BACK investigations to search for DIRECT contacts.”
- Check box “Conduct TRACE BACK investigations to search for INDIRECT contacts.”

- For tracing of direct contacts:
    - Enter “28” in “Days before detection” field.
    - Enter “Tracing: Probability of Direct Tracing Input Value” for that production type from Table 111 in “Probability of trace success” field.

Table 111: Tracing: Probability of Direct Tracing for All States

Production Type	Probability
Cow Calf	0.86
Dairy	0.93
Feedlot(S)	0.86
Feedlot(L)	0.86
Sheep	0.87
Goats	0.87
Swine(L)	0.91
Swine(S)	0.91
Beef (BY SS)	0.93
Swine(BY SS)	0.93
SmRu(BY SS)	0.93

- For tracing of indirect contacts:
    - Enter “28” in “Days before detection” field.
    - Enter “Tracing: Probability of Indirect Tracing Input Value” for that production type from Table 112 in “Probability of trace success” field.

Table 112: Tracing: Probability of Indirect Tracing for All States

Production Type	Probability
Cow Calf	0.7
Dairy	0.7
Feedlot(S)	0.7
Feedlot(L)	0.7
Sheep	0.5
Goats	0.5
Swine(L)	0.7
Swine(S)	0.7
Beef (BY SS)	0.7
Swine(BY SS)	0.7
SmRu(BY SS)	0.7

- For any trace investigation:
    - Click “New” on “Probability of reporting an observed clinical unit.”
        - Enter “Tracing: Delay in results Input Function” for that production type from Table 113.

Table 113: Tracing: Delay in Results (Both for Direct and Indirect Tracing) for All States	
Production Type	Function
Cow Calf	BetaPERT (0, 5.97, 28)
Dairy	BetaPERT (0, 3.63, 28)
Feedlot(S)	BetaPERT (0, 7.38, 28)
Feedlot(L)	BetaPERT (0, 7.38, 28)
Sheep	BetaPERT (0, 5.57, 28)
Goats	BetaPERT (0, 5.57, 28)
Swine(L)	BetaPERT (0, 3.72, 28)
Swine(S)	BetaPERT (0, 3.72, 28)
Beef (BY SS)	BetaPERT (0, 3.63, 28)
Swine(BY SS)	BetaPERT (0, 3.63, 28)
SmRu(BY SS)	BetaPERT (0, 3.63, 28)

For the “Unit examination for clinical signs” interface:

For each production type:

- Check all four boxes
    - Enter “Unit Examination for Clinical Signs Input Value” for that production type from Table 114 in all four “Multiplier for the probability of observing clinical signs” fields.

Table 114: Unit Examination for Clinical Signs	
Production Type	Value
Cow Calf	13
Feedlot(S)	50
Feedlot(L)	50
Dairy	50
Swine(S)	20
Swine(L)	20
Sheep	50
Goats	40
Beef (BY SS)	20
Swine(BY SS)	30
SmRu(BY SS)	50

For “Diagnostic testing” interface:

For all production types:

- Check all four boxes.
- Enter "Diagnostic Testing: Sensitivity Input Value" from Table 115 in "Unit-level test sensitivity" field.

Table 115: Diagnostic Testing: Sensitivity, Specificity, and Delay in Obtaining Test Results for All Production Types in All States

Diagnostic Parameter	Value
Sensitivity	0.9
Specificity	0.98
Delay in Obtaining Results	BetaPERT (0, 1, 2)

- Enter "Diagnostic Testing: Specificity Input Value" from Table 115 in "Unit-level test specificity" field.
- Click "New" on "Delay in obtaining test results."
    - Enter "Diagnostic Testing: Delay in obtaining test results" function from Table 115.

A6.4.8 Zone

Under the "Zones" menu:

For the "Zone Options" interface:

- Check box "No, do not include zones."

A6.4.9 Destruction

Under the "Destruction" menu:

For the "Global Destruction Options" interface:

- Check box "Use destruction for disease control for some or all production types."
- Enter "2" in "Delay before implementing destruction program" field.
- Click "New" on "Destruction capacity"
    - Enter "Median Culling Capacity Input Function" from Table 116.

Table 116: Median Culling Capacity

Day	Units per day
1	0
2	0
3	2
4	1

Table 116: Median Culling Capacity

Day	Units per day
5	0
6	3
7	1
8	1
9	3
10	2
11	1
12	4
13	3
14	1
15	5
16	3
17	2
18	5
19	4
20	2
21	6
22	4
23	2
24	6
25	4
26	2
27	6
28	4
29	2
30	6
31	4
32	2
33	6
34	4
35	2
36	6
37	4
38	2
39	6
40	4
41	2
42	6

Table 116: Median Culling Capacity

Day	Units per day
43	4
44	2
45	6
46	4
47	3
48	6
49	4
50	3
51	6
52	4
53	3
54	6
55	4
56	3
57	6
58	4
59	3
60	6
61	4
62	3
63	6
64	4
65	3
66	6
67	4
68	3
69	6
70	4
71	5

For “Destruction” interface:

For all production types:

- Check box “Destroy detected disease units of this production type.”
- Check box “Destroy units of this production type that have had DIRECT contact with a detected unit as identified by TRACE FORWARD.”

- Check box “Destroy units of this production type that have had INDIRECT contact with a detected unit as identified by TRACE FORWARD.”
- Check box “Destroy units of this production type that have had DIRECT contact with a detected unit as identified by TRACE BACK.”
- Check box “Destroy units of this production type that have had INDIRECT contact with a detected unit as identified by TRACE BACK.”

For “Destruction priorities” interface:

- In “Primary” field drag:
  - “Reason for destruction” to highest priority
  - “Production type” to second priority
  - “Days holding” to last priority.
- Click on “Reason for destruction” in “Primary” field. In “Secondary” field drag reasons into the following order:
  - Detected
  - Trace forward of direct contact
  - Trace back of direct contact
  - Trace forward of direct contact
  - Trace back of indirect contact
- Click on “Production type” in “Primary” field. In “Secondary” field drag production types into the following order:
  - Swine (L)
  - Swine (S)
  - Swine (BY-SS)
  - Feedlot (L)
  - Feedlot (S)
  - Dairy
  - Cow-calf
  - Beef (BY-SS)
  - Sheep
  - Goats
  - SmRu (BY-SS)

A6.4.10 Vaccination

Under the “Vaccination” menu:

For the “Global Vaccination Options” interface:

- Check box “Use vaccination for disease control for some or all production types.”
- Enter “1” in “How many diseased units must be detected before the vaccination program begins?” field.
- Click “New” on “Vaccination capacity.”
    - Enter desired vaccination capacity function

For the “Vaccination” interface:

For each production type:

- Check box “Vaccinate units of this production type as part of disease control efforts.”
- Click “New” on “Vaccine Immune Period.”
    - Enter “Vaccine immune period in days Input Function,” BetaPERT (28, 180, 220)
- Enter “Delay in Immunity Input Value” for that production type from Table 117 in “Delay in immunity following vaccination” field.

Table 117: Delay in Immunity (Days) for All States

Production Type	Delay in Immunity (Days)
Cow Calf	10
Dairy	10
Feedlot(S)	10
Feedlot(L)	16
Swine(S)	24
Swine(L)	24
Sheep	10
Goats	10
Beef (BY SS)	10
Swine (BY SS)	24
Small ruminants (BY SS)	10

- Enter “180” in “Minimum time between vaccinations.”
- Check box “Trigger a vaccination ring upon disease detection in units of this production type.”
- Enter “10” in “Radius of vaccination ring” field.

For “Vaccination priorities” interface:

- In “Primary” field drag:
    - “Reason for vaccination” to highest priority
    - “Days holding” to second priority
    - “Production type” to last priority.
- Click on “Production type” in “Primary” field. In “Secondary” field drag production types into the following order:
    - Feedlot (L)
    - Feedlot (S)
    - Swine (L)
    - Swine (S)
    - Cow-calf
    - Dairy
    - Sheep
    - Goats
    - Beef (BY-SS)
    - Swine (BY-SS)
    - SmRu (BY-SS)

Appendix A8: Risk Calculation Details

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
Pathway: Aerosol, Tree:AA (BSL-3Ag AHR)															
AA1	All 4 filters are normal	9.41E-01	1735	167	1.63E+03	4.38E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA2	Three filters are normal, 1 filter is degraded	5.73E-02	1735	167	9.95E+01	4.03E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA3	Both filters in one column are normal while both filters in the other column are degraded	4.37E-04	1735	167	7.57E-01	3.62E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA4	One filters in each column is normal, one filters in each column is degraded	8.73E-04	1735	167	1.51E+00	5.12E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA5	Three filters are degraded, 1 filter is normal	1.33E-05	1735	167	2.31E-02	6.33E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA6	All 4 filters are degraded	5.06E-08	1735	167	8.78E-05	3.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA7	One column fails (but at least one alarm works) while both filters in the other column are normal	3.88E-04	1735	167	6.73E-01	3.42E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA8	One column fails (but at least one alarm works) while in the other column one filter is normal and one filter is degraded	1.18E-05	1735	167	2.05E-02	5.96E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA9	One column fails (but at least one alarm works) while both filters in the other column are degraded	9.00E-08	1735	167	1.56E-04	5.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA10	Total HEPA failure	1.00E-34	1735	167	1.74E-31	1.74E-14	4.70E-02	4.70E-36	2.17E-18	8.15E-33	8.15E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AA11	Both columns fail (but at least one alarm works on each column). HEPA is closed off	4.00E-08	1735	167	6.94E-05	3.47E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pathway: Aerosol, Tree:EA (BSL-3E and SP)															
EA0	Nominal BSL-3E	9.98E-01	52500	7425	5.24E+04	7.77E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA1	All 4 filters are normal and spill	1.88E-03	52500	7425	9.88E+01	2.28E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA2	Three filters are normal, 1 filter is degraded	1.15E-04	52500	7425	6.02E+00	5.62E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA3	Both filters in one column are normal while both filters in the other column are degraded	8.73E-07	52500	7425	4.58E-02	4.91E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA4	One filters in each column is normal, one filters in each column is degraded	1.75E-06	52500	7425	9.17E-02	6.94E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA5	Three filters are degraded, 1 filter is normal	2.66E-08	52500	7425	1.40E-03	8.56E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA6	All 4 filters are degraded	1.01E-10	52500	7425	5.32E-06	5.28E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA7	One column fails (but at least one alarm works) while both filters in the other column are normal	7.76E-07	52500	7425	4.07E-02	4.62E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA8	One column fails (but at least one alarm works) while in the other column one filter is normal and one filter is degraded	2.36E-08	52500	7425	1.24E-03	8.07E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA9	One column fails (but at least one alarm works) while both filters in the other column are degraded	1.80E-10	52500	7425	9.45E-06	7.04E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA10	Total HEPA failure	2.00E-37	52500	7425	1.05E-32	2.35E-14	5.00E-05	1.00E-41	3.16E-21	5.25E-37	1.17E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EA11	Both columns fail (but at least one alarm works on each column). HEPA is closed off	8.00E-11	52500	7425	4.20E-06	4.70E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
Pathway: Aerosol, Tree:NA (BSL-3Ag Necropsy)															
NA1	All 4 filters are normal	9.41E-01	42.25	4.225	3.98E+01	1.07E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA2	Three filters are normal, 1 filter is degraded	5.73E-02	42.25	4.225	2.42E+00	9.82E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA3	Both filters in one column are normal while both filters in the other column are degraded	4.37E-04	42.25	4.225	1.84E-02	8.83E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA4	One filters in each column is normal, one filters in each column is degraded	8.73E-04	42.25	4.225	3.69E-02	1.25E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA5	Three filters are degraded, 1 filter is normal	1.33E-05	42.25	4.225	5.62E-04	1.54E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA6	All 4 filters are degraded	5.06E-08	42.25	4.225	2.14E-06	9.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA7	One column fails (but at least one alarm works) while both filters in the other column are normal	3.88E-04	42.25	4.225	1.64E-02	8.32E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA8	One column fails (but at least one alarm works) while in the other column one filter is normal and one filter is degraded	1.18E-05	42.25	4.225	4.99E-04	1.45E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA9	One column fails (but at least one alarm works) while both filters in the other column are degraded	9.00E-08	42.25	4.225	3.80E-06	1.27E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA10	Total HEPA failure	1.00E-34	42.25	4.225	4.23E-33	4.23E-16	5.00E-05	5.00E-39	7.07E-20	2.11E-37	2.11E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NA11	Both columns fail (but at least one alarm works on each column). HEPA is closed off	4.00E-08	42.25	4.225	1.69E-06	8.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pathway: Aerosol, Tree:OA (Non containment)															
OA1	Shipment of viable FMDv, primary and secondary containers work	1.00E+00	500	50	5.00E+02	5.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E+05	2.99E+04	0.00E+00	0.00E+00
OA2	Primary and secondary fail, tertiary works	1.99E-06	500	50	9.94E-04	7.05E-01	2.00E-04	3.98E-10	1.99E-05	1.99E-07	1.42E-04	1.08E+05	2.99E+04	2.15E-02	1.53E+01
OA3	Primary and secondary fail, tertiary fails	1.99E-09	500	50	9.95E-07	2.23E-02	2.00E-04	3.98E-13	6.31E-07	1.99E-10	4.46E-06	1.08E+05	2.99E+04	2.15E-05	4.82E-01
Pathway: Liquid Waste, Tree:AL (BSL-3Ag AHR)															
AL1	Nominal Liquid Waste Disposal	9.51E-01	113.49195	85.87	1.08E+02	8.53E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL2	Decon works, cook tank works, and wastewater fails	9.51E-06	113.49195	85.87	1.08E-03	3.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL3	Decon works cook tank fails and performance indicator fails, and wastewater work	9.51E-11	113.49195	85.87	1.08E-08	1.11E-03	6.87E-01	6.53E-11	8.08E-06	7.41E-09	7.60E-04	1.07E+05	3.20E+04	7.97E-04	8.17E+01
AL4	Decon works, cook tank fails and performance indicator fails, and wastewater fails	9.51E-16	113.49195	85.87	1.08E-13	3.50E-06	8.63E-01	8.21E-16	2.86E-08	9.31E-14	3.02E-06	1.08E+05	3.17E+04	1.00E-08	3.25E-01
AL5	Decon fails, cook tank works, and wastewater work	4.89E-02	113.49195	85.87	5.55E+00	2.48E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL6	Decon fails, cook tank works, and wastewater fails	4.89E-07	113.49195	85.87	5.55E-05	7.94E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL7	Decon fails cook tank fails and performance indicator fails, and wastewater work	4.89E-12	113.49195	85.87	5.55E-10	2.51E-04	7.43E-01	3.63E-12	1.91E-06	4.12E-10	1.86E-04	1.07E+05	3.19E+04	4.43E-05	2.00E+01
AL8	Decon fails, cook tank fails and performance indicator fails, and wastewater fails	4.89E-17	113.49195	85.87	5.55E-15	7.94E-07	8.97E-01	4.39E-17	6.62E-09	4.98E-15	7.12E-07	1.08E+05	3.17E+04	5.36E-10	7.66E-02
Pathway: Liquid Waste, Tree:EL (BSL-3E and SP)															
EL1	Nominal case; follows protocol	1.00E+00	52500	7425	5.25E+04	7.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
EL2	Failure to follow protocol and pouring down drain; cook tank and wastewater work	1.00E-04	52500	7425	5.25E+00	5.25E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EL3	Failure to follow protocol, cook tank fails and performance indicator fails, wastewater works	1.00E-14	52500	7425	5.25E-10	5.25E-03	4.36E-01	4.36E-15	6.60E-08	2.29E-10	2.29E-03	1.08E+05	3.19E+04	2.47E-05	2.47E+02
EL4	Failure to follow protocol, cook tank works, wastewater fails	1.00E-09	52500	7425	5.25E-05	1.66E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EL5	Failure to follow protocol, cook tank fails and performance indicator fails, wastewater fails	1.00E-19	52500	7425	5.25E-15	1.66E-05	7.14E-01	7.14E-20	2.67E-10	3.75E-15	1.19E-05	1.08E+05	3.13E+04	4.04E-10	1.28E+00
Pathway: Liquid Waste, Tree:NL (BSL-3Ag Necropsy)															
NL1	Nominal case	9.90E-01	42.25	4.225	4.18E+01	5.93E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NL2	Decon works, cook tank works, and wastewater fails	9.90E-06	42.25	4.225	4.18E-04	1.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NL3	Decon works cook tank fails and performance indicator fails, and wastewater work	9.90E-11	42.25	4.225	4.18E-09	4.20E-04	7.77E-02	7.70E-12	2.77E-06	3.25E-10	3.27E-05	1.07E+05	3.12E+04	3.49E-05	3.50E+00
NL4	Decon works, cook tank fails and performance indicator fails, and wastewater fails	9.90E-16	42.25	4.225	4.18E-14	1.33E-06	4.98E-01	4.93E-16	2.22E-08	2.08E-14	6.62E-07	1.08E+05	3.25E+04	2.25E-09	7.14E-02
NL5	Decon fails, cook tank works, and wastewater work	9.97E-03	42.25	4.225	4.21E-01	4.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NL6	Decon fails, cook tank works, and wastewater fails	9.97E-08	42.25	4.225	4.21E-06	1.33E-02	2.25E-02	2.24E-09	4.74E-05	9.48E-08	3.00E-04	1.08E+05	3.28E+04	1.02E-02	3.24E+01
NL7	Decon fails cook tank fails and performance indicator fails, and wastewater work	9.97E-13	42.25	4.225	4.21E-11	4.22E-05	9.29E-01	9.27E-13	9.63E-07	3.92E-11	3.92E-05	1.08E+05	3.15E+04	4.22E-06	4.23E+00
NL8	Decon fails, cook tank fails and performance indicator fails, and wastewater fails	9.98E-18	42.25	4.225	4.21E-16	1.33E-07	9.84E-01	9.82E-18	3.13E-09	4.15E-16	1.31E-07	1.08E+05	3.15E+04	4.48E-11	1.42E-02
Pathway: Solid Waste, Tree:AS (BSL-3Ag AHR)															
AS1	Solid waste bulk batch processed normally	1.00E+00	113.49195	85.87	1.13E+02	8.59E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS2	Single autoclave failure	2.00E-05	113.49195	85.87	2.27E-03	5.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS3	Incinerator failure	1.00E-10	113.49195	85.87	1.13E-08	1.13E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS4	Both autoclaves fail	1.00E-10	113.49195	85.87	1.13E-08	1.13E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS5	Single autoclave failure and incinerator failure	2.00E-15	113.49195	85.87	2.27E-13	5.08E-06	6.73E-02	1.35E-16	1.16E-08	1.53E-14	3.42E-07	2.47E+04	3.02E+04	3.77E-10	8.43E-03
AS6	Failure of all systems	1.00E-20	113.49195	85.87	1.13E-18	1.13E-08	9.99E-01	9.99E-21	1.00E-10	1.13E-18	1.13E-08	2.78E+04	3.37E+04	3.16E-14	3.16E-04
Pathway: Solid Waste, Tree:ES (BSL-3 and SP)															
ES1	Solid waste bulk batch processed normally	1.00E+00	250	0	2.50E+02	1.12E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ES2	Single autoclave failure	2.00E-05	250	0	5.00E-03	1.12E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ES3	Incinerator failure	1.00E-10	250	0	2.50E-08	2.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ES4	Both autoclaves fail	1.00E-10	250	0	2.50E-08	2.50E-03	3.76E-02	3.76E-12	1.94E-06	9.40E-10	9.40E-05	2.46E+04	3.02E+04	2.32E-05	2.32E+00
ES5	Single autoclave failure and incinerator failure	2.00E-15	250	0	5.00E-13	1.12E-05	9.44E-02	1.89E-16	1.37E-08	4.72E-14	1.06E-06	2.47E+04	3.02E+04	1.17E-09	2.61E-02
ES6	Failure of all systems	1.00E-20	250	0	2.50E-18	2.50E-08	9.99E-01	9.99E-21	9.99E-11	2.50E-18	2.50E-08	2.78E+04	3.36E+04	6.94E-14	6.94E-04
Pathway: Solid Waste, Tree:NSW (BSL-3Ag Necropsy)															
NSW1	Solid waste bulk batch processed normally	1.00E+00	42.25	4.225	4.22E+01	4.23E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NSW2	Single autoclave failure	2.00E-05	42.25	4.225	8.45E-04	1.89E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NSW3	Incinerator failure	1.00E-10	42.25	4.225	4.22E-09	4.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NSW4	Both autoclaves fail	1.00E-10	42.25	4.225	4.22E-09	4.22E-04	7.55E-02	7.55E-12	2.75E-06	3.19E-10	3.19E-05	2.47E+04	3.02E+04	7.87E-06	7.87E-01
NSW5	Single autoclave failure and incinerator failure	2.00E-15	42.25	4.225	8.45E-14	1.89E-06	9.73E-02	1.95E-16	1.40E-08	8.22E-15	1.84E-07	2.47E+04	3.02E+04	2.03E-10	4.54E-03
NSW6	Failure of all systems	1.00E-20	42.25	4.225	4.23E-19	4.23E-09	1.00E+00	1.00E-20	1.00E-10	4.22E-19	4.22E-09	2.80E+04	3.38E+04	1.18E-14	1.18E-04
Pathway: Solid Waste (Carcasses/Tissue), Tree:NST (BSL-3Ag Necropsy)															

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
NST1	Nominal (Tissue Autoclave or performance indicator, and incinerator working)	1.00E+00	42.25	4.225	4.22E+01	4.23E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NST2	Tissue autoclave or performance indicator works, incinerator fails	1.00E-10	42.25	4.225	4.22E-09	4.22E-04	6.77E-01	6.77E-11	8.23E-06	2.86E-09	2.86E-04	2.56E+04	3.12E+04	7.31E-05	7.31E+00
NST3	Tissue Autoclave Fails and performance indicator fails, incinerator works	1.00E-10	42.25	4.225	4.22E-09	4.22E-04	8.59E-02	8.59E-12	2.93E-06	3.63E-10	3.63E-05	2.47E+04	3.02E+04	8.97E-06	8.97E-01
NST4	Tissue Autoclave fails and performance indicator fails, incinerator fails	1.00E-20	42.25	4.225	4.23E-19	4.23E-09	1.00E+00	1.00E-20	1.00E-10	4.22E-19	4.22E-09	2.80E+04	3.38E+04	1.18E-14	1.18E-04
Pathway: Transference (Body), Tree:ETB (BSL-3E and SP)															
ETB0	Nominal case - no spill and no transference to hand.	9.98E-01	21000	2100	2.10E+04	2.30E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
ETB1	Spill and transference to body. Tyvek suit work and 2 body showers.	1.96E-03	21000	2100	4.12E+01	9.29E+02	3.92E-12	7.69E-15	8.77E-08	1.61E-10	8.15E-05	8.20E+04	2.23E+04	1.32E-05	6.69E+00
ETB2	Spill and transference to body. Tyvek suit fail and 2 body showers	1.98E-05	21000	2100	4.16E-01	9.34E+01	1.15E-08	2.29E-13	4.78E-07	4.80E-09	4.47E-05	8.20E+04	2.23E+04	3.94E-04	3.67E+00
ETB3	Spill and transference to body. Tyvek suit work and 1 body shower.	1.97E-05	21000	2100	4.14E-01	9.32E+01	1.66E-10	3.27E-15	5.72E-08	6.87E-11	5.33E-06	8.20E+04	2.23E+04	5.64E-06	4.37E-01
ETB4	Spill and transference to body. Tyvek suit fail and 1 body shower.	1.99E-07	21000	2100	4.18E-03	9.37E+00	2.88E-07	5.74E-14	2.40E-07	1.21E-09	3.51E-06	8.20E+04	2.23E+04	9.89E-05	2.88E-01
ETB5	Spill and transference to body. Tyvek suit work and 0 body showers.	4.95E-08	21000	2100	1.04E-03	4.67E+00	1.98E-09	9.82E-17	9.91E-09	2.06E-12	4.72E-08	8.20E+04	2.23E+04	1.69E-07	3.87E-03
ETB6	Spill and transference to body. Tyvek suit fail and 0 body showers.	5.00E-10	21000	2100	1.05E-05	4.70E-01	6.36E-07	3.18E-16	1.78E-08	6.67E-12	2.99E-07	8.20E+04	2.23E+04	5.47E-07	2.45E-02
Pathway: Transference (Body), Tree:NTB (BSL-3Ag Necropsy)															
NTB1	Transference to body. Tyvek suit work and 2 body showers.	9.80E-01	169	16.9	1.66E+02	2.88E+01	1.24E-12	1.22E-12	1.10E-06	2.06E-10	1.85E-04	8.20E+04	2.23E+04	1.69E-05	1.52E+01
NTB2	Transference to body. Tyvek suit fail and 2 body showers	9.90E-03	169	16.9	1.67E+00	1.67E+01	3.01E-09	2.98E-11	5.46E-06	5.03E-09	9.17E-05	8.20E+04	2.23E+04	4.13E-04	7.53E+00
NTB3	Transference to body. Tyvek suit work and 1 body shower.	9.85E-03	169	16.9	1.66E+00	1.67E+01	5.62E-12	5.53E-14	2.35E-07	9.35E-12	3.95E-06	8.20E+04	2.23E+04	7.67E-07	3.24E-01
NTB4	Transference to body. Tyvek suit fail and 1 body shower.	9.95E-05	169	16.9	1.68E-02	1.69E+00	3.14E-08	3.12E-12	1.77E-06	5.27E-10	2.98E-06	8.20E+04	2.23E+04	4.32E-05	2.44E-01
NTB5	Transference to body. Tyvek suit work and 0 body showers.	2.48E-05	169	16.9	4.18E-03	8.41E-01	8.22E-11	2.04E-15	4.51E-08	3.44E-13	3.79E-08	8.20E+04	2.23E+04	2.82E-08	3.11E-03
NTB6	Transference to body. Tyvek suit fail and 0 body showers.	2.50E-07	169	16.9	4.23E-05	8.45E-02	7.37E-08	1.84E-14	1.36E-07	3.11E-12	1.31E-08	8.20E+04	2.23E+04	2.55E-07	1.07E-03
Pathway: Transference (Body), Tree:OTB (Non containment)															
OTB1	Shipment of viable FMDv, primary and secondary containers work	1.00E+00	500	50	5.00E+02	5.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
OTB2	Primary and secondary fail, tertiary works; Tyvek suit work and body shower (recognition of potential exposure)	1.98E-06	500	50	9.89E-04	7.03E-01	5.39E-04	1.07E-09	3.27E-05	5.33E-07	3.80E-04	8.20E+04	2.23E+04	4.37E-02	3.12E+01
OTB3	Primary and secondary fail, tertiary fails; Tyvek suit work and body shower (recognition of potential exposure)	1.98E-09	500	50	9.90E-07	2.22E-02	5.58E-04	1.10E-12	1.05E-06	5.52E-10	1.24E-05	8.20E+04	2.23E+04	4.53E-05	1.02E+00
OTB4	Primary and secondary fail, tertiary works; no Tyvek suit and no body shower	9.94E-09	500	50	4.97E-06	4.98E-02	1.38E-02	1.37E-10	1.17E-05	6.85E-08	6.87E-04	8.20E+04	2.23E+04	5.62E-03	5.64E+01

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
OTB5	Primary and secondary fail, tertiary fails; no Tyvek suit and no body shower	9.95E-12	500	50	4.98E-09	1.58E-03	1.37E-02	1.37E-13	3.70E-07	6.84E-11	2.17E-05	8.20E+04	2.23E+04	5.61E-06	1.78E+00
Pathway: Transference (Fomite), Tree:ATF (BSL-3Ag AHR)															
ATF1	Transference to fomite and 2 disinfections (dunks or wipe-downs)	9.90E-01	567.45975	429.35	5.62E+02	4.29E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
ATF2	Transference to fomite and 1 disinfection (dunk or wipe-down)	9.95E-03	567.45975	429.35	5.65E+00	5.65E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
ATF3	Transference to fomite and 0 disinfections (dunks or wipedowns)	2.50E-05	567.45975	429.35	1.42E-02	2.84E+00	1.76E-05	4.40E-10	2.10E-05	2.50E-07	7.77E-05	8.20E+04	2.23E+04	2.05E-02	6.37E+00
Pathway: Transference (Fomite), Tree:OTFom (Non containment)															
OTFom1	Nominal transference to fomite	1.00E+00	1	0	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
Pathway: Transference (Foot), Tree:OTF (Non containment)															
OTF1	Shipment of viable FMDv, primary and secondary containers work or recognition of potential contamination upon spill	1.00E+00	500	50	5.00E+02	5.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
OTF2	Primary and secondary fail, tertiary works; failed recognition of potential contamination	9.94E-09	500	50	4.97E-06	4.98E-02	3.12E-02	3.10E-10	1.76E-05	1.55E-07	1.55E-03	8.20E+04	2.23E+04	1.27E-02	1.28E+02
OTF3	Primary and secondary fail, tertiary fails; failed recognition of potential contamination	9.95E-12	500	50	4.98E-09	1.58E-03	3.00E-02	2.98E-13	5.46E-07	1.49E-10	4.73E-05	8.20E+04	2.23E+04	1.22E-05	3.88E+00
Pathway: Transference (Hand), Tree:ETP-1 (BSL-3E and SP)															
ETP0	Nominal case - no spill and no transference to hand.	9.98E-01	21000	2100	2.10E+04	2.30E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
ETP1	Spill and transference to hand. Gloves work and 2 body showers.	1.83E-03	21000	2100	3.84E+01	8.97E+02	2.25E-14	4.11E-17	6.41E-09	8.63E-13	5.76E-06	8.20E+04	2.23E+04	7.08E-08	4.72E-01
ETP2	Spill and transference to hand. Gloves fail and 2 body showers	1.52E-04	21000	2100	3.19E+00	2.59E+02	4.54E-10	6.89E-14	2.63E-07	1.45E-09	6.80E-05	8.20E+04	2.23E+04	1.19E-04	5.57E+00
ETP3	Spill and transference to hand. Gloves work and 1 body shower.	1.84E-05	21000	2100	3.86E-01	9.00E+01	1.82E-12	3.35E-17	5.78E-09	7.03E-13	5.21E-07	8.20E+04	2.23E+04	5.76E-08	4.27E-02
ETP4	Spill and transference to hand. Gloves fail and 1 body shower.	1.53E-06	21000	2100	3.21E-02	2.59E+01	6.00E-09	9.16E-15	9.57E-08	1.92E-10	2.49E-06	8.20E+04	2.23E+04	1.58E-05	2.04E-01
ETP5	Spill and transference to hand. Gloves work and 0 body showers.	4.62E-08	21000	2100	9.69E-04	4.51E+00	4.24E-12	1.96E-19	4.42E-10	4.11E-15	2.00E-09	8.20E+04	2.23E+04	3.37E-10	1.64E-04
ETP6	Spill and transference to hand. Gloves fail and 0 body showers.	3.84E-09	21000	2100	8.05E-05	1.30E+00	6.54E-08	2.51E-16	1.58E-08	5.27E-12	8.76E-08	8.20E+04	2.23E+04	4.32E-07	7.18E-03
Pathway: Transference (Hand), Tree:ETP-2 (BSL-3E and SP)															
ETP7	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 2 body showers.	4.93E-03	21000	2100	1.03E+02	1.47E+03	3.82E-15	1.88E-17	4.34E-09	3.95E-13	6.39E-06	8.20E+04	2.23E+04	3.24E-08	5.24E-01
ETP8	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 1 body showers.	4.95E-05	21000	2100	1.04E+00	1.48E+02	4.75E-12	2.35E-16	1.53E-08	4.94E-12	2.27E-06	8.20E+04	2.23E+04	4.05E-07	1.86E-01
ETP9	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 0 body showers.	1.24E-07	21000	2100	2.61E-03	7.41E+00	3.50E-12	4.35E-19	6.59E-10	9.13E-15	4.88E-09	8.20E+04	2.23E+04	7.49E-10	4.01E-04

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
ETP10	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 2 body showers.	2.48E-05	21000	2100	5.20E-01	1.04E+02	3.06E-08	7.58E-13	8.71E-07	1.59E-08	9.10E-05	8.20E+04	2.23E+04	1.31E-03	7.47E+00
ETP11	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 1 body showers.	2.49E-07	21000	2100	5.22E-03	1.05E+01	1.77E-07	4.39E-14	2.10E-07	9.22E-10	2.87E-06	8.20E+04	2.23E+04	7.57E-05	2.35E-01
ETP12	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 0 body showers.	6.25E-10	21000	2100	1.31E-05	5.25E-01	1.05E-06	6.58E-16	2.56E-08	1.38E-11	5.53E-07	8.20E+04	2.23E+04	1.13E-06	4.53E-02
Pathway: Transference (Hand), Tree:NTH 1 (BSL-3Ag Necropsy)															
NTH1	Transference to hand. Gloves work and 2 body showers.	9.14E-01	169	16.9	1.54E+02	4.98E+01	4.45E-16	4.06E-16	2.02E-08	6.87E-14	3.26E-06	8.20E+04	2.23E+04	5.64E-09	2.67E-01
NTH2	Transference to hand. Gloves fail and 2 body showers	7.59E-02	169	16.9	1.28E+01	4.48E+01	6.32E-11	4.80E-12	2.19E-06	8.11E-10	1.02E-04	8.20E+04	2.23E+04	6.65E-05	8.37E+00
NTH3	Transference to hand. Gloves work and 1 body shower.	9.19E-03	169	16.9	1.55E+00	1.61E+01	3.33E-14	3.06E-16	1.75E-08	5.17E-14	2.83E-07	8.20E+04	2.23E+04	4.24E-09	2.32E-02
NTH4	Transference to hand. Gloves fail and 1 body shower.	7.63E-04	169	16.9	1.29E-01	4.67E+00	7.39E-10	5.64E-13	7.51E-07	9.54E-11	3.51E-06	8.20E+04	2.23E+04	7.82E-06	2.88E-01
NTH5	Transference to hand. Gloves work and 0 body showers.	2.31E-05	169	16.9	3.90E-03	8.12E-01	2.38E-12	5.50E-17	7.42E-09	9.30E-15	6.02E-09	8.20E+04	2.23E+04	7.63E-10	4.94E-04
NTH6	Transference to hand. Gloves fail and 0 body showers.	1.92E-06	169	16.9	3.24E-04	2.34E-01	4.96E-09	9.52E-15	9.76E-08	1.61E-12	2.29E-08	8.20E+04	2.23E+04	1.32E-07	1.88E-03
Pathway: Transference (Hand), Tree:NTH 2 (BSL-3Ag Necropsy)															
NTH7	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 2 body showers.	4.93E-03	169	16.9	8.32E-01	1.18E+01	4.45E-16	2.19E-18	1.48E-09	3.70E-16	1.76E-08	8.20E+04	2.23E+04	3.04E-11	1.44E-03
NTH8	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 1 body showers.	4.95E-05	169	16.9	8.37E-03	1.19E+00	6.93E-15	3.43E-19	5.86E-10	5.80E-17	6.96E-10	8.20E+04	2.23E+04	4.76E-12	5.71E-05
NTH9	Transference to hand. Failed removal of gloves and transfer to hands. Spot decon & 0 body showers.	1.24E-07	169	16.9	2.10E-05	5.96E-02	7.45E-13	9.26E-20	3.04E-10	1.57E-17	1.81E-11	8.20E+04	2.23E+04	1.28E-12	1.49E-06
NTH10	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 2 body showers.	2.48E-05	169	16.9	4.18E-03	8.41E-01	4.62E-09	1.14E-13	3.38E-07	1.93E-11	2.84E-07	8.20E+04	2.23E+04	1.59E-06	2.33E-02
NTH11	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 1 body showers.	2.49E-07	169	16.9	4.20E-05	8.43E-02	2.95E-08	7.33E-15	8.56E-08	1.24E-12	7.63E-09	8.20E+04	2.23E+04	1.02E-07	6.26E-04
NTH12	Transference to hand. Failed removal of gloves and transfer to hands. No spot decon & 0 body showers.	6.25E-10	169	16.9	1.06E-07	4.22E-03	6.16E-07	3.85E-16	1.96E-08	6.51E-14	2.61E-09	8.20E+04	2.23E+04	5.34E-09	2.14E-04
Pathway: Transference (Hand), Tree:OTP (Non containment)															
OTP1	Shipment of viable FMDv, primary and secondary containers work	1.00E+00	500	50	5.00E+02	5.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
OTP2	Primary and secondary fail, tertiary works; gloves work and body shower (recognition of potential exposure)	1.98E-06	500	50	9.89E-04	7.03E-01	1.20E-04	2.38E-10	1.54E-05	1.19E-07	8.52E-05	8.20E+04	2.23E+04	9.75E-03	6.99E+00

Table A8-1: Risk Calculations by Event

Event	Description	P_{Loss}	R_o	Sigma - R_o	F_{loss}	Sigma - F_{loss}	P_i	P_{Event}	Sigma - P_{Event}	F_{Event}	Sigma - F_{Event}	C_{event} ($M)	Sigma - C_{event} ($M)	$Risk_{Event}$ ($M)	Sigma - $Risk_{Event}$ ($M)
OTP3	Primary and secondary fail, tertiary fails; gloves work and body shower (recognition of potential contamination)	1.98E-09	500	50	9.90E-07	2.22E-02	1.33E-04	2.64E-13	5.13E-07	1.32E-10	2.96E-06	8.20E+04	2.23E+04	1.08E-05	2.43E-01
OTP4	Primary and secondary fail, tertiary works; no gloves and no body shower	9.94E-09	500	50	4.97E-06	4.98E-02	1.14E-02	1.13E-10	1.06E-05	5.67E-08	5.68E-04	8.20E+04	2.23E+04	4.65E-03	4.66E+01
OTP5	Primary and secondary fail, tertiary fails; no gloves and no body shower	9.95E-12	500	50	4.98E-09	1.58E-03	1.21E-02	1.21E-13	3.48E-07	6.04E-11	1.92E-05	8.20E+04	2.23E+04	4.96E-06	1.57E+00
Pathway: Transference (Hand), Tree:OTPalm (Non containment)															
OTPalm1	Nominal transference to hand. Reduction by gloves and body shower.	1.00E+00	1	0	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E+04	2.23E+04	0.00E+00	0.00E+00
Pathway: Transference (Respiratory), Tree:ATR (BSL-3Ag AHR)															
ATR1	Transference to nasal passages. N95 mask is used properly and nose blow.	9.70E-01	567.45975	429.35	5.51E+02	4.28E+02	2.79E-17	2.71E-17	5.20E-09	1.54E-14	2.91E-06	8.20E+04	2.23E+04	1.26E-09	2.38E-01
ATR2	Transference to nasal passages. N95 mask is not used properly and nose blow.	2.49E-02	567.45975	429.35	1.41E+01	8.90E+01	3.35E-16	8.34E-18	2.89E-09	4.73E-15	2.59E-07	8.20E+04	2.23E+04	3.88E-10	2.12E-02
ATR3	Transference to nasal passages. N95 mask is used properly and no nose blow.	4.88E-03	567.45975	429.35	2.77E+00	3.96E+01	1.01E-18	4.93E-21	7.02E-11	2.80E-18	2.78E-09	8.20E+04	2.23E+04	2.29E-13	2.28E-04
ATR4	Transference to nasal passages. N95 mask is not used properly and no nose blow.	1.25E-04	567.45975	429.35	7.09E-02	6.34E+00	1.28E-15	1.60E-19	4.00E-10	9.07E-17	2.54E-09	8.20E+04	2.23E+04	7.44E-12	2.08E-04
Catastrophic Events															
Earthquake	Earthquake	4.00E-04	1	0	4.00E-04	2.00E-02	5.00E-02	2.00E-05	4.47E-03	2.00E-05	1.00E-03	2.82E+04	3.35E+04	5.64E-01	2.83E+01
Tornado	Tornado, >228 mph	7.06E-08	1	0	7.06E-08	2.66E-04	9.61E-01	6.78E-08	2.60E-04	6.78E-08	2.55E-04	3.01E+04	3.38E+04	2.04E-03	7.69E+00

Table A8-2: Pi Calculations by Event

Pathway	Tree	Event	P_i	Estimated P_i values (by Q term) for All but Solid and Liquid			Estimated P_i values (by Q term and location) for Solid and Liquid Waste Events												Overall P_i values by location for Solid and Liquid Waste Events			
				P_i- Low	P_i- Med	P_i- High	Site 1 (Transfer Station)/ Premises A			Site 2 (Landfill)/Premises B			Premises C			Premises D			Overall Pi for Site 1/ Premises A	Overall Pi for Site 2/ Premises B	Overall Pi for Premises C	Overall Pi for Premises D
							P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	Pi.1	Pi.2	Pi.3	Pi.4
Aerosol	AA	AA1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA2	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA3	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA4	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA5	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA6	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA7	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA8	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA9	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	AA	AA10	4.70E-02	0.00E+00	0.00E+00	9.39E-01																
Aerosol	AA	AA11	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA0	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA2	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA3	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA4	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA5	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA6	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA7	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA8	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA9	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	EA	EA10	5.00E-05	0.00E+00	0.00E+00	1.00E-03																
Aerosol	EA	EA11	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA2	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA3	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA4	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA5	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA6	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA7	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA8	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA9	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	NA	NA10	5.00E-05	0.00E+00	0.00E+00	1.00E-03																
Aerosol	NA	NA11	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	OA	OA1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Aerosol	OA	OA2	2.00E-04	0.00E+00	0.00E+00	4.00E-03																
Aerosol	OA	OA3	2.00E-04	0.00E+00	0.00E+00	4.00E-03																
Liquid Waste	AL	AL1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	AL	AL2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	AL	AL3	6.87E-01				0.00E+00	3.66E-01	9.02E-01	0.00E+00	5.10E-01	7.83E-01	0.00E+00	3.83E-05	2.69E-02	0.00E+00	0.00E+00	0.00E+00	3.75E-01	4.98E-01	1.35E-03	0.00E+00
Liquid Waste	AL	AL4	8.63E-01				0.00E+00	6.46E-01	9.78E-01	0.00E+00	6.40E-01	8.68E-01	0.00E+00	1.09E-03	1.50E-01	0.00E+00	0.00E+00	3.58E-01	6.31E-01	6.19E-01	7.49E-03	1.79E-02
Liquid Waste	AL	AL5	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	AL	AL6	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	AL	AL7	7.43E-01				0.00E+00	4.45E-01	9.32E-01	0.00E+00	5.48E-01	8.10E-01	0.00E+00	1.07E-04	4.69E-02	0.00E+00	0.00E+00	0.00E+00	4.47E-01	5.33E-01	2.34E-03	0.00E+00
Liquid Waste	AL	AL8	8.97E-01				0.00E+00	7.19E-01	9.86E-01	0.00E+00	6.75E-01	8.87E-01	0.00E+00	2.46E-03	2.16E-01	0.00E+00	0.00E+00	3.94E-01	6.96E-01	6.51E-01	1.08E-02	1.97E-02
Liquid Waste	EL	EL1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	EL	EL2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	EL	EL3	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	EL	EL4	4.36E-01				0.00E+00	0.00E+00	9.86E-01	0.00E+00	3.82E-01	8.87E-01	0.00E+00	0.00E+00	2.16E-01	0.00E+00	0.00E+00	3.93E-01	4.93E-02	3.88E-01	1.08E-02	1.97E-02
Liquid Waste	EL	EL5	7.14E-01				0.00E+00	3.72E-01	9.98E-01	0.00E+00	5.13E-01	9.39E-01	0.00E+00	4.18E-05	5.41E-01	0.00E+00	0.00E+00	5.25E-01	3.85E-01	5.09E-01	2.71E-02	2.62E-02
Liquid Waste	NL	NL1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	NL	NL2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	NL	NL3	7.77E-02				0.00E+00	0.00E+00	8.37E-01	0.00E+00	0.00E+00	7.39E-01	0.00E+00	0.00E+00	1.05E-02	0.00E+00	0.00E+00	0.00E+00	4.19E-02	3.70E-02	5.23E-04	0.00E+00
Liquid Waste	NL	NL4	4.98E-01				0.00E+00	0.00E+00	9.55E-01	0.00E+00	4.77E-01	8.35E-01	0.00E+00	0.00E+00	7.79E-02	0.00E+00	0.00E+00	0.00E+00	4.78E-02	4.71E-01	3.90E-03	0.00E+00
Liquid Waste	NL	NL5	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Waste	NL	NL6	2.25E-02				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-02	0.00E+00	0.00E+00
Liquid Waste	NL	NL7	9.29E-01				4.17E-01	7.57E-01	9.98E-01	5.35E-01	6.94E-01	9.38E-01	7.56E-05	3.86E-03	5.38E-01	0.00E+00	0.00E+00	5.24E-01	7.52E-01	6.98E-01	2.69E-02	2.62E-02
Liquid Waste	NL	NL8	9.84E-01				6.95E-01	9.21E-01	1.00E+00	6.63E-01	8.00E-01	9.69E-01	1.88E-03	3.81E-02	8.38E-01	0.00E+00	0.00E+00	6.53E-01	9.14E-01	8.01E-01	4.20E-02	3.26E-02
Solid Waste	AS	AS1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	AS	AS2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		

Table A8-2: Pi Calculations by Event

Pathway	Tree	Event	P_i	Estimated P_i values (by Q term) for All but Solid and Liquid			Estimated P_i values (by Q term and location) for Solid and Liquid Waste Events												Overall P_i values by location for Solid and Liquid Waste Events			
				P_i- Low	P_i- Med	P_i- High	Site 1 (Transfer Station)/ Premises A			Site 2 (Landfill)/Premises B			Premises C			Premises D			Overall Pi for Site 1/ Premises A	Overall Pi for Site 2/ Premises B	Overall Pi for Premises C	Overall Pi for Premises D
							P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	Pi.1	Pi.2	Pi.3	Pi.4
Solid Waste	AS	AS3	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	AS	AS4	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	AS	AS5	6.73E-02				0.00E+00	0.00E+00	6.85E-01	0.00E+00	0.00E+00	6.85E-01							3.42E-02	3.42E-02		
Solid Waste	AS	AS6	9.99E-01				4.87E-01	9.99E-01	1.00E+00	4.87E-01	9.99E-01	1.00E+00							9.74E-01	9.74E-01		
Solid Waste	ES	ES1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	ES	ES2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	ES	ES3	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	ES	ES4	3.76E-02				0.00E+00	0.00E+00	3.80E-01	0.00E+00	0.00E+00	3.80E-01							1.90E-02	1.90E-02		
Solid Waste	ES	ES5	9.44E-02				0.00E+00	0.00E+00	9.68E-01	0.00E+00	0.00E+00	9.68E-01							4.84E-02	4.84E-02		
Solid Waste	ES	ES6	9.99E-01				3.62E-01	9.98E-01	1.00E+00	3.62E-01	9.98E-01	1.00E+00							9.66E-01	9.66E-01		
Solid Waste	NSW	NSW1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	NSW	NSW2	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	NSW	NSW3	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste	NSW	NSW4	7.55E-02				0.00E+00	0.00E+00	7.69E-01	0.00E+00	0.00E+00	7.69E-01							3.85E-02	3.85E-02		
Solid Waste	NSW	NSW5	9.73E-02				0.00E+00	0.00E+00	9.98E-01	0.00E+00	0.00E+00	9.98E-01							4.99E-02	4.99E-02		
Solid Waste	NSW	NSW6	1.00E+00				9.03E-01	1.00E+00	1.00E+00	9.03E-01	1.00E+00	1.00E+00							9.95E-01	9.95E-01		
Solid Waste (Carcasses/Tissue)	NST	NST1	0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00							0.00E+00	0.00E+00		
Solid Waste (Carcasses/Tissue)	NST	NST2	6.77E-01				0.00E+00	4.24E-01	1.00E+00	0.00E+00	4.24E-01	1.00E+00							4.32E-01	4.32E-01		
Solid Waste (Carcasses/Tissue)	NST	NST3	8.59E-02				0.00E+00	0.00E+00	8.79E-01	0.00E+00	0.00E+00	8.79E-01							4.39E-02	4.39E-02		
Solid Waste (Carcasses/Tissue)	NST	NST4	1.00E+00				9.58E-01	1.00E+00	1.00E+00	9.58E-01	1.00E+00	1.00E+00							9.98E-01	9.98E-01		
Transference (Body)	ETB	ETB0	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Body)	ETB	ETB1	3.92E-12	0.00E+00	0.00E+00	7.85E-11																
Transference (Body)	ETB	ETB2	1.15E-08	0.00E+00	9.28E-13	2.31E-07																
Transference (Body)	ETB	ETB3	1.66E-10	0.00E+00	0.00E+00	3.32E-09																
Transference (Body)	ETB	ETB4	2.88E-07	0.00E+00	2.83E-12	5.77E-06																
Transference (Body)	ETB	ETB5	1.98E-09	0.00E+00	2.57E-15	3.97E-08																
Transference (Body)	ETB	ETB6	6.36E-07	0.00E+00	3.51E-10	1.27E-05																
Transference (Body)	NTB	NTB1	1.24E-12	0.00E+00	0.00E+00	2.49E-11																
Transference (Body)	NTB	NTB2	3.01E-09	0.00E+00	9.35E-13	6.01E-08																
Transference (Body)	NTB	NTB3	5.62E-12	0.00E+00	0.00E+00	1.12E-10																
Transference (Body)	NTB	NTB4	3.14E-08	0.00E+00	1.58E-11	6.27E-07																
Transference (Body)	NTB	NTB5	8.22E-11	0.00E+00	8.90E-15	1.64E-09																
Transference (Body)	NTB	NTB6	7.37E-08	0.00E+00	2.05E-10	1.47E-06																
Transference (Body)	OTB	OTB1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Body)	OTB	OTB2	5.39E-04	0.00E+00	0.00E+00	1.08E-02																
Transference (Body)	OTB	OTB3	5.58E-04	0.00E+00	0.00E+00	1.12E-02																
Transference (Body)	OTB	OTB4	1.38E-02	0.00E+00	1.26E-02	4.85E-02																
Transference (Body)	OTB	OTB5	1.37E-02	0.00E+00	1.26E-02	4.75E-02																

Table A8-2: Pi Calculations by Event

Pathway	Tree	Event	P_i	Estimated P_i values (by Q term) for All but Solid and Liquid			Estimated P_i values (by Q term and location) for Solid and Liquid Waste Events												Overall P_i values by location for Solid and Liquid Waste Events			
				P_i- Low	P_i- Med	P_i- High	Site 1 (Transfer Station)/ Premises A			Site 2 (Landfill)/Premises B			Premises C			Premises D			Overall Pi for Site 1/ Premises A	Overall Pi for Site 2/ Premises B	Overall Pi for Premises C	Overall Pi for Premises D
							P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	Pi.1	Pi.2	Pi.3	Pi.4
Transference (Fomite)	ATF	ATF1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Fomite)	ATF	ATF2	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Fomite)	ATF	ATF3	1.76E-05	0.00E+00	8.38E-06	2.01E-04																
Transference (Fomite)	OTFom	OTFom1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Foot)	OTF	OTF1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Foot)	OTF	OTF2	3.12E-02	0.00E+00	3.00E-02	8.42E-02																
Transference (Foot)	OTF	OTF3	3.00E-02	0.00E+00	2.87E-02	8.28E-02																
Transference (Hand)	ETP-1	ETP0	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Hand)	ETP-1	ETP1	2.25E-14	0.00E+00	0.00E+00	4.50E-13																
Transference (Hand)	ETP-1	ETP2	4.54E-10	0.00E+00	0.00E+00	9.08E-09																
Transference (Hand)	ETP-1	ETP3	1.82E-12	0.00E+00	0.00E+00	3.64E-11																
Transference (Hand)	ETP-1	ETP4	6.00E-09	0.00E+00	7.42E-15	1.20E-07																
Transference (Hand)	ETP-1	ETP5	4.24E-12	0.00E+00	0.00E+00	8.47E-11																
Transference (Hand)	ETP-1	ETP6	6.54E-08	0.00E+00	8.06E-13	1.31E-06																
Transference (Hand)	ETP-2	ETP7	3.82E-15	0.00E+00	0.00E+00	7.64E-14																
Transference (Hand)	ETP-2	ETP8	4.75E-12	0.00E+00	0.00E+00	9.51E-11																
Transference (Hand)	ETP-2	ETP9	3.50E-12	0.00E+00	0.00E+00	6.99E-11																
Transference (Hand)	ETP-2	ETP10	3.06E-08	0.00E+00	1.08E-13	6.12E-07																
Transference (Hand)	ETP-2	ETP11	1.77E-07	0.00E+00	9.11E-12	3.53E-06																
Transference (Hand)	ETP-2	ETP12	1.05E-06	0.00E+00	6.46E-10	2.10E-05																
Transference (Hand)	NTH-1	NTH1	4.45E-16	0.00E+00	0.00E+00	8.89E-15																
Transference (Hand)	NTH-1	NTH2	6.32E-11	0.00E+00	0.00E+00	1.26E-09																
Transference (Hand)	NTH-1	NTH3	3.33E-14	0.00E+00	0.00E+00	6.66E-13																
Transference (Hand)	NTH-1	NTH4	7.39E-10	0.00E+00	8.75E-14	1.48E-08																
Transference (Hand)	NTH-1	NTH5	2.38E-12	0.00E+00	0.00E+00	4.77E-11																
Transference (Hand)	NTH-1	NTH6	4.96E-09	0.00E+00	3.70E-12	9.92E-08																
Transference (Hand)	NTH-2	NTH7	4.45E-16	0.00E+00	0.00E+00	8.90E-15																
Transference (Hand)	NTH-2	NTH8	6.93E-15	0.00E+00	0.00E+00	1.39E-13																
Transference (Hand)	NTH-2	NTH9	7.45E-13	0.00E+00	0.00E+00	1.49E-11																
Transference (Hand)	NTH-2	NTH10	4.62E-09	0.00E+00	9.12E-13	9.24E-08																

Table A8-2: Pi Calculations by Event

Pathway	Tree	Event	P_i	Estimated P_i values (by Q term) for All but Solid and Liquid			Estimated P_i values (by Q term and location) for Solid and Liquid Waste Events												Overall P_i values by location for Solid and Liquid Waste Events			
				P_i- Low	P_i- Med	P_i- High	Site 1 (Transfer Station)/ Premises A			Site 2 (Landfill)/Premises B			Premises C			Premises D			Overall Pi for Site 1/ Premises A	Overall Pi for Site 2/ Premises B	Overall Pi for Premises C	Overall Pi for Premises D
							P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	P_i- Low	P_i- Med	P_i- High	Pi.1	Pi.2	Pi.3	Pi.4
Transference (Hand)	NTH-2	NTH11	2.95E-08	0.00E+00	1.11E-10	5.87E-07																
Transference (Hand)	NTH-2	NTH12	6.16E-07	0.00E+00	4.23E-09	1.22E-05																
Transference (Hand)	OTP	OTP1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Hand)	OTP	OTP2	1.20E-04	0.00E+00	0.00E+00	2.40E-03																
Transference (Hand)	OTP	OTP3	1.33E-04	0.00E+00	0.00E+00	2.66E-03																
Transference (Hand)	OTP	OTP4	1.14E-02	0.00E+00	1.01E-02	4.61E-02																
Transference (Hand)	OTP	OTP5	1.21E-02	0.00E+00	1.09E-02	4.69E-02																
Transference (Hand)	OTPalm	OTPalm1	0.00E+00	0.00E+00	0.00E+00	0.00E+00																
Transference (Respiratory)	ATR	ATR1	2.79E-17	0.00E+00	4.32E-22	5.58E-16																
Transference (Respiratory)	ATR	ATR2	3.35E-16	0.00E+00	1.28E-18	6.69E-15																
Transference (Respiratory)	ATR	ATR3	1.01E-18	0.00E+00	1.78E-21	2.02E-17																
Transference (Respiratory)	ATR	ATR4	1.28E-15	4.89E-22	1.11E-17	2.54E-14																
Catastrophic	Earthquake	Earthquake	5.00E-02	0.00E+00	0.00E+00	1.00E+00																
Catastrophic	Tornado	Tornado	9.61E-01	0.00E+00	9.59E-01	1.00E+00																

Table A8-3: Calculations by Event Tree

Pathway	Tree Name	P_{tree}	Sigma - P_{tree}	F_{tree}	Sigma - F_{tree}	R_o	C_{tree} ($M)	Sigma - C_{tree} ($M)	$Risk_{Tree}$ ($M)	Sigma - $Risk_{Tree}$ ($M)
Aerosol	OA	3.98E-10	1.99E-05	1.99E-07	1.42E-04	5.00E+02	1.08E+05	2.99E+04	2.15E-02	1.53E+01
Liquid Waste	AL	6.89E-11	8.30E-06	7.82E-09	7.82E-04	1.13E+02	1.07E+05	3.03E+04	8.41E-04	8.41E+01
Liquid Waste	EL	4.36E-15	6.60E-08	2.29E-10	2.29E-03	5.25E+04	1.08E+05	3.19E+04	2.47E-05	2.47E+02
Liquid Waste	NL	2.25E-09	4.75E-05	9.52E-08	3.05E-04	4.23E+01	1.08E+05	3.26E+04	1.03E-02	3.28E+01
Solid Waste	AS	1.35E-16	1.16E-08	1.53E-14	3.42E-07	1.13E+02	2.47E+04	3.02E+04	3.77E-10	8.43E-03
Solid Waste	ES	3.76E-12	1.94E-06	9.40E-10	9.40E-05	2.50E+02	2.46E+04	3.02E+04	2.32E-05	2.32E+00
Solid Waste	NSW	7.55E-12	2.75E-06	3.19E-10	3.19E-05	4.23E+01	2.47E+04	3.02E+04	7.87E-06	7.87E-01
Solid Waste (Carcasses/Tissue)	NST	7.63E-11	8.74E-06	3.22E-09	2.88E-04	4.23E+01	2.55E+04	2.79E+04	8.21E-05	7.37E+00
Transference (Body)	ETB	2.97E-13	5.45E-07	6.24E-09	9.32E-05	2.10E+04	8.20E+04	1.77E+04	5.12E-04	7.64E+00
Transference (Body)	NTB	3.42E-11	5.85E-06	5.78E-09	2.06E-04	1.69E+02	8.20E+04	1.96E+04	4.74E-04	1.69E+01
Transference (Body)	OTB	1.20E-09	3.47E-05	6.02E-07	7.86E-04	5.00E+02	8.20E+04	1.99E+04	4.94E-02	6.44E+01
Transference (Fomite)	ATF	4.40E-10	2.10E-05	2.50E-07	7.77E-05	5.67E+02	8.20E+04	2.23E+04	2.05E-02	6.37E+00
Transference (Foot)	OTF	3.10E-10	1.76E-05	1.55E-07	1.56E-03	5.00E+02	8.20E+04	2.23E+04	1.27E-02	1.28E+02
Transference (Hand)	ETP-1	7.84E-14	2.80E-07	1.65E-09	6.82E-05	2.10E+04	8.20E+04	1.98E+04	1.35E-04	5.60E+00
Transference (Hand)	ETP-2	8.03E-13	8.96E-07	1.69E-08	9.13E-05	2.10E+04	8.20E+04	2.11E+04	1.38E-03	7.49E+00
Transference (Hand)	NTH-1	5.37E-12	2.32E-06	9.08E-10	1.02E-04	1.69E+02	8.20E+04	2.01E+04	7.45E-05	8.38E+00
Transference (Hand)	NTH-2	1.22E-13	3.49E-07	2.06E-11	2.85E-07	1.69E+02	8.20E+04	2.10E+04	1.69E-06	2.34E-02
Transference (Hand)	OTP	3.51E-10	1.87E-05	1.76E-07	5.75E-04	5.00E+02	8.20E+04	1.67E+04	1.44E-02	4.72E+01
Transference (Respiratory)	ATR	3.56E-17	5.96E-09	2.02E-14	2.92E-06	5.67E+02	8.20E+04	1.78E+04	1.66E-09	2.39E-01
Catastrophic	Earthquake	2.00E-05	4.47E-03	2.00E-05	1.00E-03	1.00E+00	2.82E+04	3.35E+04	5.64E-01	2.83E+01
Catastrophic	Tornado	6.78E-08	2.60E-04	6.78E-08	2.55E-04	1.00E+00	3.01E+04	3.38E+04	2.04E-03	7.69E+00