Parameterization of the multi-scale epidemic/economic simulation and analysis (MESA) model for classical swine fever virus

Lindsey Holmstrom[1], Pam Hullinger[2], Carl Melius[2], Alix Robertson[2]
1 Texas A&M University, College of Veterinary Medicine, College Station, TX 77843
2 Biodefense Knowledge Center, Lawrence Livermore National Laboratory, Livermore, CA 94550

I. Introduction

Classical swine fever (CSF) is a highly contagious viral disease of swine. CSF was first recognized in the U.S. in 1833 and eradicated in 1978 after an intensive 16 year campaign, which cost $140 million (Dahle and Liess, 1992; USAHA, 1998). Previous outbreaks of the disease were characterized by high mortalities, but strains circulating today in the Caribbean and Mexico may be much less virulent. Decreased virulence of the virus may delay the detection of CSF introduction in the U.S. due to an inability to distinguish CSF from other clinically similar diseases of swine. CSF remains endemic in many regions around the world, including the Caribbean basin and areas of Mexico. The ease of access to the virus represents a constant threat to the U.S. swine industry.

The U.S. commercial swine industry has changed dramatically since CSF was eradicated. The industry has become significantly more vertically integrated with increased national and international movement of swine. To assess the potential impact of an outbreak of CSF in the U.S., the DHS Foreign Animal Disease Decision Support System MESA (Multi-scale Epidemiologic/Economic Simulation and Analysis) at Lawrence Livermore National Laboratory was parameterized for CSF and used to simulate and evaluate national scale outbreaks.

II. Methods

To adapt the MESA model to CSF, only swine facility types were included in the model. A literature review was performed to determine the latent, subclinical and clinical disease state transition periods for CSF. The model uses the lengths of these transition periods to calculate the number of animals in each disease state within an individual facility type based on specified probability distributions (see Figure 1).

The swine facility types included in the model are farrow to wean, nursery, farrow to feed, finisher, and farrow to finisher. Disease can be spread between these facility types by direct and indirect contacts. Various commercial swine operations were contacted to obtain information on the type and frequency of contacts between swine. This information was applied to the 2002 U.S. swine census data provided by the National Agricultural Statistical Service (NASS) to calculate contact rates between facility types. Disease outbreak scenarios have been simulated and are currently being evaluated for different geographic locations within the US.

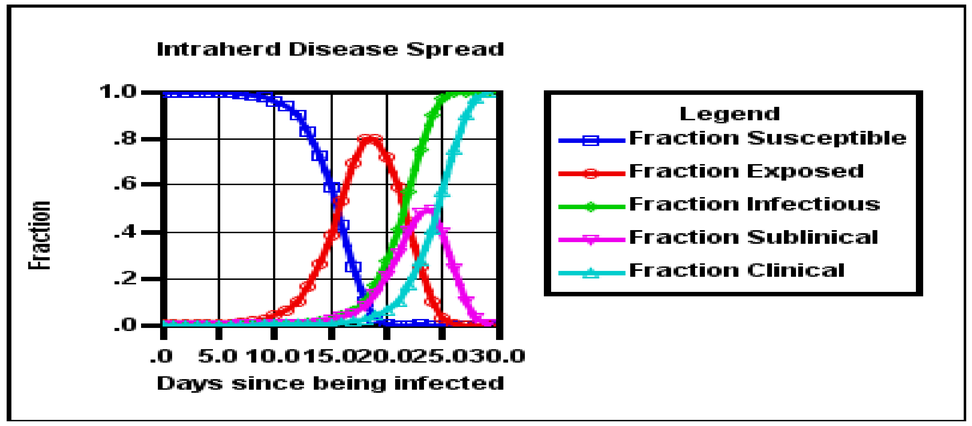

Fig. 1: Fraction of animals in each disease state within a facility

III. Results

Duplin County, North Carolina was chosen as the geographic location to initiate this simulated outbreak. The model used stochastic sampling techniques over four hundred iterations to determine how the disease would spread. The facility type of the index case was chosen at random from all available facilities. Figure 2 shows a heat map illustrating how in this simulation large farrow-to-wean operations and large nurseries were primarily infected. Due to the high degree of vertical integration within the industry, infection was spread from large farrow-to-wean operations to large nurseries and then subsequently to large finishing operations. The average duration of the outbreak was 101 days, in which 18 facilities consisting of 78,812 animals were infected. Figure 3 is an example of the disease spread in one realization of the outbreak scenario 31 days after an outbreak was initialized.

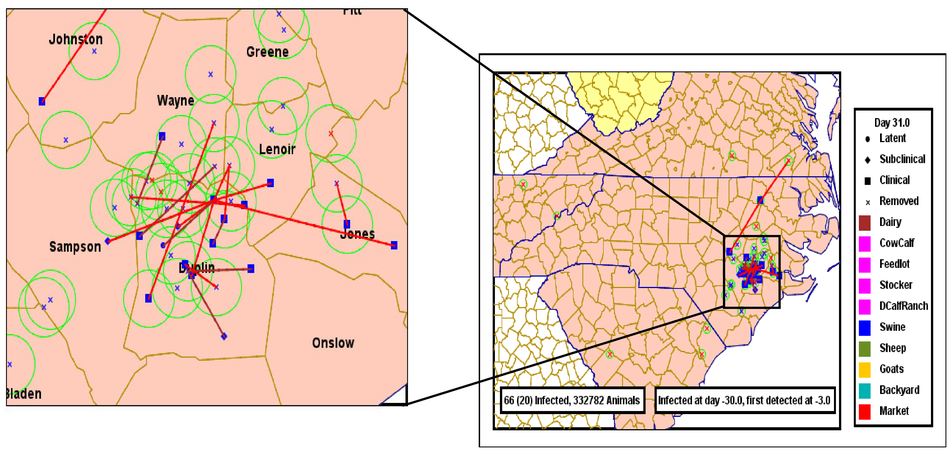

Fig. 3: Disease spread from one realization of the model scenario

IV. Discussion

The high degree of vertical integration of the US swine industry is not reflected in the NASS data and leads to an overestimation of disease spread. Future work will attempt to better represent this characteristic of commercial industry by compartmentalizing facility types through the creation of synthetic companies. The outbreak simulated here assumed the CSF strain was highly virulent and therefore detected relatively early in the course of the outbreak. This may explain why on average only 18 facilities were infected. Additional simulations will be performed with reduced detection parameters to approximate the behavior of low virulence CSF strains.

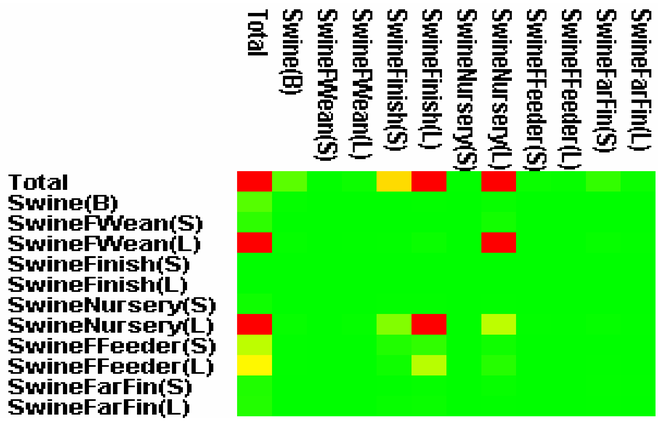

Fig. 2: Interactions between infected and susceptible facilities

V. References

Dahle J. and B. Liess. 1992. A review on classical swine fever infections in pigs: epizootiology, clinical disease and pathology. *Comp. Immun. Microbiol. Infect. Dis.* 15:3, 203-211

United States Animal Health Association (USAHA). 1998. Hog Cholera In: *Foreign Animal Diseases*. Pat Campbell & Associates and Carter Printing Co. Richmond, VA. p. 273-282.

VI. Acknowledgements

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