Information, Modeling, and Analysis – Project 17 Year 3 Annual Report

Epidemic Models of FMD Introduction and Spread in the High Plains

DHS Priority Areas Addressed	☐ Prevention ☐ Detection ☒ Response ☐ Recovery ☐ Education/Risk Communication
Proposal Section Addressed	Sections: NA
Investigators	TAMU: Michael Ward, Bo Norby, Bruce McCarl, R. Srinivasan

Objectives	**Deliverables**	**Progress Toward Deliverables**	**Percent Complete**
Develop and apply a decision support system that assists policy formulation to efficiently detect and respond to incursions of FMD virus within the high plains region of Texas.	Realistic, regional FMD epidemic model	The AusSpread model has been adapted and extended for the High Plains region as follows: 1) The number of herd types in the model was increased from 7 to 13, including 6 feedlot categories, based on discussions with the Texas Cattle Feeders Association (TCFA) officials and collaborators at WTAMU and TAMU. 2) Survey responses obtained by Dr. Norby's team were used to update direct and indirect contacts between herd types and the probability of contact between herd types. 3) Spatial datasets necessary for modeling FMD spread were updated to reflect the new herd types based on available data and expert opinion where necessary. 4) The option of including order buyers has been added to the model. 5) Typical latent, infectious and immune periods for FMD for all herd types were derived using expert opinion and used to update the model. 6) Weather station locations and appropriate data (wind direction, humidity) were obtained from the National Weather Service and used for modeling windborne spread of FMD. 7) The model was adapted to keep track of each simulation by herd identification number and to track herds under quarantine for all simulation runs to facilitate economic analysis, mapping, and statistical analysis. 8) The model was adapted to more realistically reflect slaughter capacity for each herd type by using a "teams" approach. Each team is dedicated to a herd until depopulation, disposal and decontamination are completed. Time to completion was estimated based on expert opinion (TCFA official and other industry members) for each herd type. Order of depopulation is based on risk category and time since infection to more accurately reflect decision making with limited resources. Model code was adapted as needed to allow for the above changes.	100%
	Decision support system for FMD incursion assessment	The AusSpread model has been converted to Java and is being integrated into the Risk Analyst Workbench decision support tool project. We are actively collaborating with Mike Orosz and the development team to ensure that the model is ready for use in the DSS. Initial comparisons between the AusSpread MapBasic and Java versions have been made.	75%

	Evaluation of a range of potential mitigation strategies that might be used in the event of an incursion of FMD in the High Plains region of Texas	A total of 64 outbreak scenarios are being evaluated. The predicted magnitude of an FMD outbreak, based on the type of introduction (large feedlot, small feedlot, large beef or backyard index herd), is being determined. Mitigations simulated include: slaughter of infected herds and dangerous contacts, ring slaughter, ring vaccination and targeted vaccination. Each mitigation strategy is being simulated with early versus late detection in the index herd, regular versus enhanced surveillance and adequate versus inadequate vaccine availability. Results from each set of scenarios have been provided to the TAMU economics group (McCarl, Elbakidze) for economic analysis. Results from each set of simulations are being analyzed using an Analysis of Variance (ANOVA) approach to ascertain which mitigations provide the best results with respect to the two primary outcomes of interest, epidemic length and the number of herds slaughtered, for each index herd type scenario.	75%

Highlight for Research Briefs

- AusSpread has been extended and adapted to create a realistic, regional FMD epidemic model for the High Plains region
- AusSpread has been adapted to facilitate economic analysis, statistical analysis and spatial mapping of results
- The AusSpread modeling team attended an FMD exercise (*Operation Palo Duro*), led by USDA-APHIS and the Texas Animal Health Commission (TAHC), in Amarillo, Texas between February 21st and 23rd, 2007
- Insights on slaughter procedures gained from *Operation Palo Duro* were used to update the AusSpread model to better reflect real response efforts in the face of an outbreak
- 64 scenarios for the High Plains region have been developed in collaboration with TCFA and modeled using AusSpread
- A meeting was held with TCFA in Amarillo, Texas on July 25th, 2007 to present initial results and to discuss future development of the AusSpread model
- Detailed analysis and a full report are currently being generated for TCFA

Interpretive Summary

The AusSpread model has been updated and adapted to create a realistic, regional FMD epidemic model for the High Plains of Texas. This was facilitated by collaboration with FAZD researchers, the Texas Cattle Feeders Association (TCFA) and WTAMU. Based on discussions, 64 scenarios of interest were developed. These scenarios include single site introductions to each of four index herd types: 1) large feedlot, 2) small feedlot, 3) large beef and 4) backyard. For each index herd type a range of mitigations were simulated, including: ring and targeted vaccination with adequate (at detection) or inadequate (7 days post detection) vaccine supply, slaughter of infected herds and dangerous contacts, ring slaughter, enhanced surveillance and timeliness of detection (early, late). Early detection was defined as detection of FMD in the index herd at 7 days post introduction. Late detection was defined as detection of FMD in the index herd at 14 days post detection. Results from each set of simulations were analyzed using descriptive statistics (epidemic length, epidemic control, number of herds slaughtered and vaccinated) and using an analysis-of-variance (ANOVA) design to determine which mitigation strategies produced the shortest epidemic lengths and the fewest number of herds slaughtered. Results from each set of simulations from the epidemic model were provided to the TAMU economic group for evaluation of the economic impacts of the various mitigation strategies simulated.

In addition to the current work on model refinement and simulation of mitigation strategies, we are actively working with other areas of IMA to aid development of a stand alone decision support tool which would allow potential customers to access the AusSpread model through the Decision Support Tools project led by Mike Orosz. The AusSpread model has been converted to Java programming language under this project and we have conducted an initial comparison of the epidemic predictions between the two versions of the model as a first step toward validation of the Java platform prior to implementation.

Results and Interpretations

Initial results indicate that early detection of FMD in the index herd has a strong influence ($p<0.0001$) on the overall epidemic length, regardless of index herd type (large feedlot, small feedlot, large beef and backyard). Early detection (day 7) results in epidemics of significantly shorter duration that detection at day 14. All scenarios that were simulated with early detection were found to be the "best" mitigations for epidemic length for all herd types. Adequate vaccine availability has a slight beneficial impact ($p< 0.1$) outbreaks with large feedlot or backyard herd typed as the index herd, while enhanced surveillance provides no benefit regardless of the index herd type, except for small feedlot ($p< 0.05$). For all index herd types the best mitigations predicted from the ANOVA are summarized in Table 1.

Table 1. Predicted "best" mitigation strategies from ANOVA comparison for epidemic length.

Mitigation	**Lrg. Feedlot**	**Sm. Feedlot**	**Lrg. Beef**	**Backyard**
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc's, early detection	1	2	3	4
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, early detection	17	18	19	20
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, late detection	21	22	23	24
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, late detection, targeted vaccination, adequate vaccine	N/A	26	N/A	N/A
Slaughter of infecteds, slaughter of dc's, regular surveillance, ring vaccination, early detection, inadequate vaccine	33	34	35	36
Slaughter of infecteds, slaughter of dc's, regular surveillance, early detection	37	38	39	40
Slaughter of infecteds, slaughter of dc's, regular surveillance, early detection, targeted vaccination, adequate vaccine	49	50	51	52

N/A indicates that the mitigation was not significant for that particular index herd type.

Initial results indicate that early detection of FMD in the index herd also has a strong influence ($p<0.0001$) on the total number of herds slaughtered, regardless of index herd type (large feedlot, small feedlot, large beef and backyard), resulting in significantly fewer slaughtered herds. Similarly, adequate vaccine availability significantly ($p< 0.0001$) reduces the number of herds slaughtered regardless of index herd types, except in the case of a large feedlot index herd in which there is only a slight ($p< 0.1$) reduction. Enhanced surveillance resulted in no significant ($p< 0.1$) reduction in the number of herds slaughtered regardless of index herd type, except for small feedlot index herd type ($p< 0.0001$). More variability in the "best" mitigation strategies for each index herd type was observed for the number of herds slaughtered, compared to predicted epidemic length, particularly for small feedlot as the index herd (Table 2).

Table 2. Predicted “best” mitigation strategies from ANOVA comparison for number of herds slaughtered.

Mitigation	**Lrg. Feedlot**	**Sm. Feedlot**	**Lrg. Beef**	**Backyard**
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc’s, early detection	N/A	2	N/A	4
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc’s, late detection	N/A	6	N/A	N/A
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc’s, late detection, targeted vaccination, adequate vaccine	N/A	10	N/A	N/A
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc’s, late detection, targeted vaccination, inadequate vaccine	N/A	14	N/A	N/A
Enhanced surveillance, slaughter of infecteds, slaughter of dc’s, early detection	17	N/A	N/A	20
Enhanced surveillance, slaughter of infecteds, slaughter of dc’s, late detection	N/A	22	N/A	N/A
Enhanced surveillance, slaughter of infecteds, slaughter of dc’s, late detection, targeted vaccination, inadequate vaccine	N/A	30	N/A	N/A
Slaughter of infecteds, slaughter of dc’s, regular surveillance, ring vaccination, early detection, inadequate vaccine	33	N/A	35	36
Slaughter of infecteds, slaughter of dc’s, regular surveillance, early detection	37	N/A	N/A	40
Slaughter of infecteds, slaughter of dc’s, regular surveillance, late detection, ring vaccination, adequate vaccine	N/A	42	43	44
Slaughter of infecteds, slaughter of dc’s, regular surveillance, late detection, ring vaccination, inadequate vaccine	N/A	46	N/A	N/A
Slaughter of infecteds, slaughter of dc’s, regular surveillance, early detection, targeted vaccination, adequate vaccine	49	N/A	N/A	52
Slaughter of infecteds, slaughter of dc’s, regular surveillance, late detection	N/A	54	N/A	N/A
Slaughter of infecteds, slaughter of dc’s, regular surveillance, late detection, targeted vaccination, adequate vaccine	N/A	58	N/A	N/A

N/A indicates that the mitigation was not significant for that particular index herd type.

Initial results from the comparison of the MapInfo based version of AusSpread and the Java version of AusSpread indicate variability in the predicted epidemic length. Additional analysis is being conducted to identify why the differences occur, to verify the transition of the model from MapInfo to Java, and to ensure that the predictions are similar between models.

Technology Transition

We are actively engaged with the Texas Cattle Feeders Association on model refinement and simulation of scenarios of interest to the feedlot industry. Meetings were held with TCFA and industry personnel, in Amarillo, Texas, on November 16, 2006 and April 30, 2007 to develop the system framework for simulation and simulation scenarios. A meeting was held with TCFA in Amarillo, Texas on July 25th, 2007 to present initial results and to discuss future development of the AusSpread model. A comprehensive report is currently being developed and will be provided to TCFA (due date, September 30, 2007). We will also simulate the Palo Duro Exercise scenario, using AusSpread, in collaboration with TCFA. Results may be incorporated into overall recommendations regarding response strategies and policy.

Simulation of the outbreak scenario used within the Palo Duro Exercise will demonstrate the utility of developing decision-support systems for response training. Secondarily, it can be seen as a service to a very wide range of client groups, ranging from industry through to local responders (including police, city and county government, state and national agencies).

Additional engagement with USDA-APHIS has been discussed, although no formal meetings have been held.

Dr. Michael Ward will travel to Canberra, Australia in September 2007 to meet with the model developer, Dr. Graeme Garner. He will present a report on the Java version of AusSpread and discuss further model refinements, model development and the use of the decision support system.

Status of Funding

Within agreed budget. Additional funds have been requested (but not received) to support a student worker for the period 1 October to 31 December, 2007.