CHARACTERIZATION OF LIVESTOCK HERDS IN EXTENSIVE AGRICULTURAL SETTINGS IN SOUTHWEST TEXAS

A Thesis

by

BRANDON JAMES DOMINGUEZ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2007

Major Subject: Epidemiology

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Approved by:

Chair of Committee, Bo Norby
Committee Members, H. Morgan Scott
R. Daniel Posey
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ABSTRACT

Characterization of Livestock Herds in Extensive Agricultural Settings in Southwest Texas. (May 2007)

Brandon James Dominguez, B.S., Texas A&M University;

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Chair of Advisory Committee: Dr. Bo Norby

Because of an ever-increasing threat of foreign animal disease outbreaks in the United States, there is a desire to develop strategies to prevent the occurrence of a foreign animal disease and control an outbreak if it does occur. Infectious disease models have been developed and are being used to determine reasonable mitigation strategies. However, little information is available concerning premises characteristics and movement of animals in extensively managed livestock areas. Hence adaptation of these models to areas where there is low livestock density is not easy. We collected empirical data, via mail out surveys, from an extensively managed livestock area. This will aid in improving the results of infectious disease models in these areas.

In contrast to the intensively managed livestock that have previously been modeled, this study has shown that in areas of low livestock density, multiple livestock types often are managed on the same premises. Direct contacts, facilitated through the planned movement of animals, appear to have a greater seasonality in extensively managed areas as compared to intensively managed areas. Furthermore, wildlife contacts are likely and of potential importance.

The results of this study add to the knowledge base used to model the spread of infectious disease in extensively managed livestock populations. Seasonal changes in animal densities and contact rates may impact the results of the models. Additionally, the effect of multiple livestock types on premises should be considered when the expected spread of disease is modeled in extensive livestock areas.

DEDICATION

To my parents and grandparents

ACKNOWLEDGEMENTS

It has been a great honor and privilege to work with many great researchers, teachers, and other people during my time here at Texas A&M University. It has especially been a privilege to perform this research under the guidance and direction of Dr. Bo Norby and Dr. Morgan Scott. They helped me to grow academically and personally by encouraging me to attempt various methodologies and present information in the most concise and informative manner. Dr. Dan Posey has provided insights to help me develop personally and professionally, his support has been an excellent supplement to my program.

I would also like to thank Dr. Buddy Faries for his mentoring and direction for the past eight years, he has helped me reach many of my goals. I cannot mention him with out also thanking Mrs. Angie Dement, a great friend who always seems to push me in the right direction. The clinicians in the large animal clinic and especially the food animal section have provided beneficial advice over the years. Additionally, I would like to acknowledge the numerous large animal and food animal practitioners that I have visited with, read articles by, or otherwise have heard comments from regarding the future of the profession as they have been a driving force for me to learn more and be more.

The County Extension Agents and livestock producers in our study area were essential in accomplishing this project. I am truly appreciative of their willingness to share the information that I needed. I hope that they are able to benefit from what we learned and what modelers discover about the spread of disease in their area.

Finally, I am in debt to the National Center for Foreign Animal Disease Defense for funding this research. The various researchers that I had contact with through the Center have helped me learn new techniques, new ways of thinking, and how others may perceive the livestock areas that I was involved with. They also afforded me excellent opportunities to present scientific data and travel internationally. I am sure that I benefited from everyone that I have worked with and met and though I may not have mentioned them by name, they have made this part of my education an enjoyable experience.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Animal Disease Risk Assessment, Prevention, and Control Act of 2001 states that "In today's highly mobile environment and globalized agricultural economy there is a risk of an introduction of foot-and-mouth disease".[1] The risk of a foreign animal disease (FAD), such as the foot-and-mouth disease virus (FMDv) being introduced into the United States livestock population has renewed efforts to improve and expand infectious disease simulation models for resource planning and evaluation of mitigation strategies. However, in order for these infectious disease models to produce reliable outputs and correctly represent the transmission of disease in both intensive and extensive agricultural settings, knowledge of herd characteristics (e.g. composition of various livestock types on premises) and contact rates for livestock herds in various settings are needed.

Infectious disease modeling is a tool with which decision makers can analyze strategies for the purpose of preventing the introduction of an FAD and the detection, response, and recovery efforts if an FAD is introduced into the U.S.[2] The outbreak of foot-and-mouth disease (FMD) in the United Kingdom in 2001[3] and the realized threat of terrorist attacks[4] emphasized the need for well developed strategies to investigate these measures of prevention, control and eradication for FAD outbreaks.

An FAD outbreak in the United States could have severe economic and societal consequences.[5-7] These models can be used to analyze previous epidemics, evaluate

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This thesis follows the style of the *American Journal of Veterinary Research.*

possible control strategies, prepare responders, and support decision makers.[8] Furthermore, knowledge of where livestock are located, if they have moved recently, where they have moved to and from, and distances traveled is also of primary importance in the event of other adverse situations such as natural disasters.

Decision makers need to know the impact that an FAD introduction could have on the livestock industry as well as which interventions that will be most likely to stop the spread of the epidemic. To determine how an FAD might spread, several spatially-explicit stochastic infectious disease models, with FMD as the disease of interest, are available to researchers and regulatory agencies. Common to these models is the need for information on the types of animals (domestic and wild) that are susceptible to the disease, the density of animals, spatial distribution of livestock types, the contact rates between livestock premises, domestic and wildlife species, and the distance that animals, people, and vehicles travel.[9-11]

Knowledge about livestock premises' locations, livestock movements to and from the premises, and the distances that livestock moved is of primary importance in the face of adverse events such as natural disasters or FAD outbreaks. The knowledge of livestock premises' location and recent movements of livestock will improve the delivery of aid to producers in the event of natural disasters and will be of paramount importance in the fight against an FAD incursion. In addition, this information may be utilized in infectious disease models and incorporated into decision support systems.[2]

To our knowledge, the contact rate information needed for the models has not been estimated at the farm level for extensively managed range livestock in the United

States. The number of times an animal or a fomite from one livestock premises has contact with another livestock premises is important in determining the effective contact rate for disease transmission.[9] For spatially-explicit disease models, the distance between contact points is also important.[11] The distance that livestock travel between premises may also vary more in extensive settings when compared to intensively managed settings. Other studies have found that, besides livestock owners, veterinarians and auction barns are useful sources of information concerning contacts between livestock premises.[11,12] In addition to modeling how a disease might spread, this information can facilitate livestock producers' understanding of bio-security issues related to their livestock.

Objectives

The overall goal of this project is to improve the input data for current FMD simulation models used in extensive agricultural settings. These data will be provided by characterizing herd compositions and contact rates between livestock herds in a nine county study area in southwest Texas. Such data are currently not available in the United States for extensively managed livestock premises. The specific objectives of this study are to 1) determine the density of livestock in extensively managed settings, 2) determine how livestock types are distributed among premises, 3) determine management characteristics of livestock premises in an extensively managed setting, 4) determine the contact rates between extensively managed livestock herds, 5) investigate seasonal variation in contact rates, and 6) determine the distribution of distances that animals travel between premises. These data may be used in the future to model how an

infectious disease might spread in a low density population. Ultimately, this information will assist in strategically planning for adverse events involving extensively managed livestock, thus increasing the ability of decision makers' to focus their resources for the most effective disease control and prevention strategies.

LITERATURE REVIEW

Foot-and-mouth disease (FMD) is considered by many to be the most devastating of the so-called "foreign animal diseases".[13-15] The United States has not had an outbreak of FMD since 1929,[11] and like other countries that are free of the disease, precautions are taken to insure that an outbreak does not occur and that outbreaks will be controlled quickly should they happen.[4]

In the 2001 FMD outbreak in the United Kingdom there was an estimated loss of £3.1 billion (approximately $4.4 billion at June 1, 2001 exchange rate) due to cost of indemnity compensations to the public sector, export losses, decreased market price, and other expenses to the food industry and consumers.[7] The UK slaughtered an estimated 8% (4 million head) of the cattle, swine, and sheep inventories due to the outbreak.[1] There were other economic losses involved, such as to tourism in rural areas and public perception of animal agriculture.[6]

In countries or regions in Asia, Africa, and South American foot-and-mouth disease virus (FMDv) is endemic.[9] Domestic livestock such as cattle, sheep, goats, and pigs can become infected. In addition, other cloven hoofed animals including water buffalo, camel, deer, antelope, llama, giraffe, and bush pig[16] may carry and spread FMDv. Other animal species may become infected with FMDv, but their role in the spread of disease is thought to be minimal.[16] The FMDv is highly contagious,[1,16,17] and it can be spread long distances via aerosols; however, the movement of animals is

considered the primary means of spreading the disease.[16] Furthermore, FMDv can also be spread via contact with contaminated products, objects, and people.[16]

In the face of a foreign animal disease (FAD) outbreak, one of the primary goals, will be to prevent the dissemination of sub-clinically infected animals via movement bans.[11] If FMDv were to be introduced into the United States and allowed to spread through the susceptible animal population, livestock productivity is projected to decrease 10 to 20%.[1] Infectious disease modeling performed for a three county area of California in order to evaluate a variety of control strategies estimated that 2% of dairy herds would become infected.[3] The spread of infection could not be modeled outside of the area because the data accumulated from this area could not be extrapolated to other areas.[3] Paarlburg et. al (2002) determined that the impact of an FMD outbreak in the United States would be small with <1% decline in farm income overall.[5] The economic impact of a disease outbreak is not limited to the loss of productivity and compensation for euthanizing infected animals, but also to the loss of export markets, loss of tourism, and slaughter of animals for welfare reasons.[6,7,14,18]

Foreign animal disease modeling

Models, in general, are substitutes for "real life" situations.[8] Spatially explicit infectious disease models are especially useful when studying epidemics where the costs of introducing the disease for study purposes would be far greater than developing a model to examine how the disease might spread and how mitigation strategies may be used.[9] The models serve as an aid to analyzing how epidemics may develop, evaluating control strategies, training, and decision support.[8] For example, Doran and Laffan (2005)

stated that models are fundamental to developing management strategies.[19] Models are relatively cheap[18] to create compared to a real outbreak or initiating an outbreak in a controlled study environment. Bolker, et al. (1997) described three ways that models could be used:1) understand how the disease spreads, 2) determine how it could be controlled and how much effort would be needed to reduce the incidence to a certain level and 3) understand how the disease could be eradicated.

Modeling of FMD to assist with disease control planning started as early as 1976.[8] Since then, many FMD models have been created for different parts of the world and with varying levels of complexity.[2,9,13,18-23] These models have helped improve our understanding of how FMDv spreads through populations and how it could be more easily mitigated.

For diseases such as FMD, the movement of animals from one location to another is important in the spread of the disease. Various modelers have accounted for this in different ways. Nielen et al. (1996) considered both individual animals as being a contact, as well as groups of animals transported together as contacts.[12] All contacts made within their 3 km study area were coded as moving zero km. Because the 3 km was the official quarantine zone in the European Union if there were to be an outbreak, the authors assumed that only movements out of the zone would contribute to the spread of disease. Bates et al. (2001) defined a direct contact as animals physically moving from one location to another.[11] The movement of animals within an 8 km radius of each premises was considered local spread.[11] The ability for a disease to be transmitted between herds is dependent on the probability of interaction between herds.[24] It can be

argued that the contact rate per month is the product of the number of locations that animals are moved to and the number of times per month that livestock are moved. Regardless of the time scales, the contact rate can be divided by the total number of days in the period to get an average contact rate per day, which is the measure that is used by most models.[13]

Infectious disease modeling performed for a three county area of California estimated that 2% of dairy herds would become infected if FMDv was introduced.[3] The spread of infection could not be modeled outside of the area without increasing the uncertainty of the model results.[3] Modeling efforts conducted in Australia indicated that FMD would primarily spread through sale yards, via the wind, and by direct and indirect contacts.[10] Testing these models in different settings will help identify similarities and differences between regions with different livestock management styles. This is important because an outbreak of an FAD is likely to spread outside whatever area was reasonably large enough to model, and decision makers would still have to be able to evaluate the possible control strategies in the differing situations.

Data needed to improve the models

To model the spread of disease, there has to be some measure of the transmission of disease. Because FMDv is so highly contagious between animals, typically the intra-herd transmission is disregarded for the inter-herd spread of disease; this is based on the assumption that if one animal in the herd is infected, the entire herd is infected. The transmission probability takes into account the susceptibility of each species, the number of animals, and the distance from the start of the outbreak.[17,19] The amount of travel,[11]

range of travel,[11] and contact between herds[18,25] also play a role in determining the transmission probability. Additionally, since the inter-herd disease spread is of primary importance, spatial locations are needed.[26] Several models account for animal density and distribution, habitat requirements, and/or home ranges[9,19] which helps explain the inter-herd spread of disease, but could also be useful in modeling the intra-herd spread of disease. All of these parameters may be affected by the type of livestock on the premises.[11,19,27] Typically these data were obtained through questionnaires,[11] movement diaries,[27] or government data.[10,19] To use these models in the U.S., we need to validate the models with animal density and contact rate data from various regions of the country. For example, these data may be extracted from the USDA National Agricultural Statistics Service (NASS), the National Animal Health Monitoring System (NAHMS), state departments of agriculture, livestock producers, and various other sources. However, these sources are not comprehensive or exhaustive.

Available livestock data

The USDA is the most important source for information on livestock in the United States because they collect and maintain large amounts of data on the national livestock industry. The USDA NASS census of agriculture is conducted every five years while still other surveys are conducted monthly, quarterly, and annually.[28] The information obtained in the NASS surveys includes quantification of livestock, demographic information concerning farm owners and employees, animals and products sold, and acres farmed. However, the USDA NASS only compiles lists of agriculturalists that produce and sell more that $1,000 in agricultural products.[29] Extensive survey

follow-up is performed to gain responses from large operations that could significantly affect the results and to increase the response rate to greater than 75% in all counties.[29] The census is an in-depth publication on agricultural facts, with an economic focus at the county, state, and national level.[30] However, premises and animal densities on those premises can be disaggregated by county from NASS Census data for modeling purposes (with some caveats). This is especially useful for areas in the United States where exact information on the location of livestock premises and contact rates among them is not known. Regardless, spatial data on livestock premises are not available, thus for spatially-explicit infectious disease simulation models,[9,10,19] the livestock premises reported in NASS publications must currently be allocated at random or according to pre-specified algorithms (e.g. precluding livestock premises from being in lakes or restricting the size of premises in proximity to city limits). In addition, the NASS census data are only aggregated by individual livestock type (e.g. beef cow-calf, sheep, dairy, swine etc.), however, several livestock types may be managed on one premises.[31] Therefore, the contact rates may be underestimated for individual premises and lead to erroneous results and interpretation in modeling exercises. Additionally, the number of premises in a county may be overestimated.

While the NASS Census of Agriculture provides information concerning livestock numbers, the USDA NAHMS provides information regarding several animal health and management issues.[32] Data for NAHMS reports are collected through NASS.[33] To be used in infectious disease simulation models, the NAHMS data have to be extrapolated to the farm level from a regional level. Instead of being included in the

full Census of Agriculture, NAHMS focuses on regions of the United States which include the highest concentration of the livestock commodity of interest.[33] The data collected for NAHMS reports of interest to disease modelers includes the proportion of premises with multiple livestock types, movements of animals, quarantine practices, people and vehicles coming onto and leaving the premises, and biosecurity measures that producers implement.

In order to specifically monitor livestock in the face of a disease outbreak, the USDA Animal and Plant Health Inspection Service initiated the National Animal Identification System (NAIS).[34] Through the NAIS, the number and type of animals on the premises, along with the geo-coded spatial location would be determined, and animal movements between premises would be recorded. While animals have been identified for disease eradication purposes in the past, it has yet to be implemented on a scale that would allow for 48-hour trace-back in the face of an outbreak.[34] At the introduction of the NAIS program, mandatory participation of all livestock producers was planned.[34] However, the program has since been reduced to a voluntary program driven by individual State and industry needs.[35] The primary need for information on herd locations, sizes, and movements between herds is for government animal health officials to trace all the animals that were exposed to infected animals or herds during a disease outbreak. Infectious disease modelers can also use the same information to aid in determining the most effective mitigation strategies. Unfortunately, the voluntary character of the NAIS will likely prohibit these intended objectives for the program.

Currently, all animals involved in interstate movements are required to have health certificates from the state of origin. Copious amounts of information can be found on health certificates including: the origin and destination, date of shipment, species, number of head, and health related information.[25] This information could be beneficial to modeling the long distance spread of disease. However, there are several drawbacks, such as the large amount of variability between States. Only 18 out of the 50 states keep record of import and export information, and livestock classifications are not consistent between States.[25] Often, age and sex of animals is not specified and the addresses listed on the health certificate may not represent the actual location that the animals are kept.[25] Health certificates could be a valuable source of interstate movement information if they were consistently applied across states.

Besides the aforementioned sources on movement of animals, there are numerous other sources from which information concerning livestock locations and their movements could be captured. Veterinarians, County Extension Agents, auction barn managers, and producers[36] can serve as sources of information about animal movements. However, there is often disagreement among data from the national census of agriculture, state level agricultural censuses, and County Extension Agent reports.[30] Likely, this is due to slight differences in calculations and classifications of agricultural products and their values.[30] For accurate modeling purposes, validation will always show that there is not complete agreement between all of the data sources;[37] hence, the sole use of census data may result in inaccurate model results.[37]

Livestock management

Previous modeling efforts in the United States have primarily focused on intensive, high-density livestock operations. Intensive livestock management includes operations such as dairies, feedlots, and those swine farms with high densities of animals on a relatively small acreage. In contrast, extensive livestock management relies on a relatively large area of land for each animal unit with relatively low labor needs, resources, and capital.[38] In 2005, 982,510 farms in the United States had cattle or calves. Of those, only 78,295 were dairies and 88,199 were feedlots.[28] In the U.S., the majority of cattle (78.4%) were managed under what could be considered extensive settings.[28] One of the goals of livestock management is to maximize the efficiency[11] of meat production. Domestic ruminant livestock have the unique ability to convert forages to protein for human consumption, and extensive beef production makes use of land resources that cannot be effectively used for crops.[39]

In addition to variable livestock management intensity it is possible that seasonal differences in animal densities and movements may have an effect on the rate of spread of an FAD. For example, it has been suggested that the spread of disease in extensively managed livestock would most likely occur in the dry season.[16] This is because animals would gather around watering holes, riparian areas, and feeding areas, changing the distribution of animals[40] and subsequently affecting disease spread. Some also believe that infection would be less likely to be maintained in an endemic state in low density populations,[16] an assumption that is dependent on the disease and its infectiveness.

Modeling the spread of disease in extensively-managed, low-density populations can aid in testing these hypotheses.

FMD is a highly contagious FAD that would have detrimental effects on the U.S. livestock market. Fortunately, there are models available to assist in evaluating the best strategies to prevent the incursion of the disease, detection of and response to an outbreak, control the spread of disease, and assist in recovery from an outbreak. There is information available on the livestock industry at the county and region levels that could be modified for the models, but there are few data available at the premises and individual animal levels. While models have been validated for the areas they were developed in, there may be other parameters in different areas that could substantially affect the model outcomes. There could be parameters, such as seasonality, that could affect the outcome of models as data is acquired from other areas to improve and broaden the scope of infectious disease models.

MATERIALS AND METHODS

Study area

The study area in southwest Texas consisted of nine counties: Bandera, Edwards, Frio, Kinney, Maverick, Medina, Real, Uvalde, and Zavala Counties. These nine counties cover 30,000 km^2 between the 7th largest city in the United States, San Antonio, Texas,[41] and the international border with Mexico (see Figure 1). It represents an extensive agricultural setting with an average farm or ranch size of 750 hectares.[42] In 2002, there were an estimated 104,830 beef cows, 330 dairy cows, 8,600 cattle on feed, 95,000 sheep, 180,800 goats, 1,400 hogs, and 25,600 farmed deer on 2,830, 54, 91, 486, 1,020, 112, and 163 premises, respectively.[42] There were an estimated 5,223 farms in the study area with livestock or crops according to the 2002 NASS census of agriculture.[42]

The land cover in the area is primarily native prairie grasses with low lying shrubs and a small number of improved pastures and cultivated lands.[43] The topography of the area is flat in the southeastern and northwestern regions of the study area with large canyons in the north. Elevations range from 400 feet on the Rio Grande plain in the south to 2,410 feet above sea level on the Edward's Plateau in the north.[43]

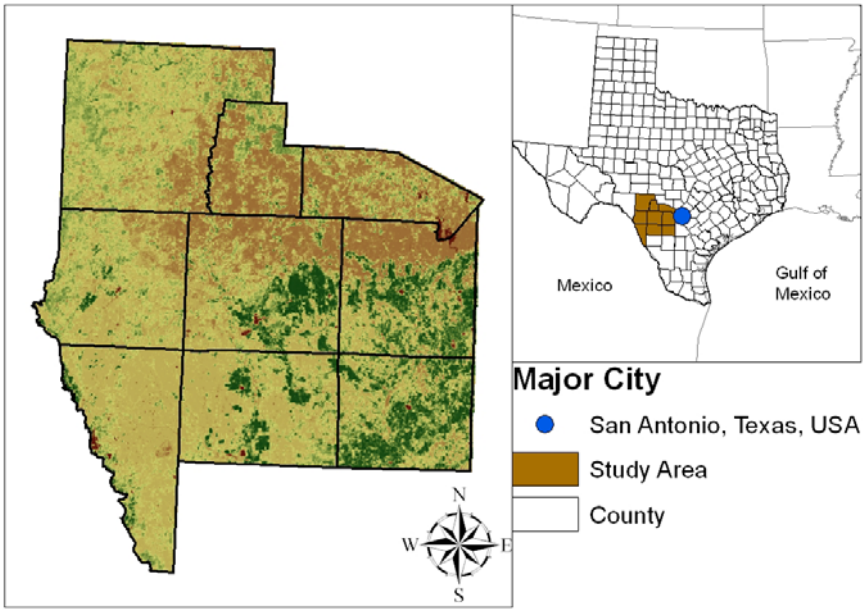

Figure 1. Land cover map of the Southwest Texas study area.

Study design

A descriptive study (survey) was conducted to accomplish the objectives for this study. The target population for this study was all livestock producers in the nine-county study area. The sampling frame consisted of producers that had participated in at least one producer meeting arranged by county-level agents and enrolled in the agents' mailing lists in the nine county study area. All livestock producers on these mailing lists were included in the survey, and hence comprised our study population.

Survey

The exact type(s) of livestock that they each raised was not known prior to mailing out surveys. To avoid mailing surveys to each rancher requesting information on all possible livestock types in the study area, we took a two-stage approach which allowed us to first determine the type(s) of livestock raised on each premises and general

management practices used, and to secondly determine movements of specific livestock types. First, a 4-page general survey was developed to collect information on animal density and distribution, premises components, and indirect contacts (see APPENDIX I). Second, 2- to 4-page livestock-type-specific surveys were developed to gather data on seasonal changes in animal density and direct contacts based on the various livestock types that producers owned (see Appendices II-VIII). Based on the predominant herd types reported by the 2002 USDA NASS agricultural census, the livestock types chosen were beef cow-calf, stocker cattle, cattle on feed, dairy cattle, sheep and goats, domestic swine, and high-fenced deer and exotics.

Administration of the surveys followed the outlines published by Dillman,[44] and surveys were first mailed in October 2005 to all livestock producers on the lists. The first mailing included a cover letter and information sheet explaining the rationale and goals of the project, the general survey, and a pre-paid postage return envelope. A reminder postcard was sent one week after the first mailing, and non-respondents received a replacement survey five weeks after the first mailing. With the help of a journalist with the regional Texas Cooperative Extension office, newspaper articles were distributed through the local media at the time the general survey was first mailed out and again at the time of the replacement survey mailing. The articles explained the project, how data from the surveys would be used, and encouraged participation. Broadcasts on local farm radio shows explained more about the project and further encouraged participation.

Respondents to the general survey were mailed a livestock-type-specific survey for each livestock type(s) they owned as indicated on the general survey. Non-

respondents to the livestock-type-specific survey were contacted with a follow up mailing four weeks after sending the initial livestock-type-specific survey. The last survey was received in late March, 2006. Surveys were pre-tested with Cooperative Extension Service personnel from the nine counties. The project and all survey mailings and instruments were exempted from review by the Texas A&M University Institutional Review Board (IRB exempt protocol: 2005-0352).

Livestock numbers

On the general survey, producers reported the type(s) of livestock they owned. For beef cow-calf, dairy cattle, sheep and goats, and swine, the number of breeding females was determined. The total number of animals, for the respective livestock type, was determined for stocker cattle, cattle on feed, and high-fenced deer and exotics. From this information, we determined which livestock-type-specific survey(s) to send each producer. From the livestock-type-specific survey, the numbers of male, female, and offspring animals were ascertained for each month of the year. The monthly variation in animal numbers was also determined for the stocker cattle, cattle on feed, and high-fenced deer. Because there were a large number of beef cow-calf premises, they were divided into small and large premises based on the NASS category closest to the median cow-calf herd size.

Livestock density

Livestock numbers for each month, obtained from the livestock type specific survey, were divided by the total acreage for each premises to obtain an estimate of the livestock density on the premises.

Premises information

The total number of acres, owned and leased, included in the premises was determined. Furthermore, the subtotal number of acres of each of native rangeland, improved pastures, and cultivated land was ascertained for each premises. The number of locations more than a 1.6 km apart under each producer's management was established. Roads separating locations and premises borders were also determined. Watering locations and supplemental feeding practices were obtained for premises. Producers were asked about the kind and quantity of supplemental feeding that they did each month of the year.

The number of employees that each premises employed and the number of those employees that had livestock of their own was assessed. The number of hunters that used each premises and the number of hunters that had livestock of their own was determined since hunting is a large ancillary income for many ranches in the area. Because extensive management may necessitate horses and dogs being used to work livestock, their numbers were assessed in the survey as well.

Producers were asked, on the livestock type specific survey, to provide the distance and direction "as a crow flies" from their premises to the nearest town. A layer file with cities in the study area was created in an analytical mapping program (ESRI ArcMap^{TM} 9.0, ESRI, Inc. Redlands, California, USA) and the producers' spatial location was added using the direction-distance tool to plot premises locations as points with respect to named cities or towns. Coordinates (X and Y) were calculated for the premises using the standard Visual Basic script available. A database containing

information on the total number of animals, acreage, and herd type for each producer was joined to the layer file.

Herd-aggregate determination

Several producers had multiple livestock-types on their premises. For analytical purposes and because the sample sizes for some livestock type combinations were very low, herd-aggregates were constructed (see Figure 2). Multivariate analysis techniques were attempted to group the various livestock type combinations into herd aggregates of similar livestock type combinations. Other studies guided our approach to assign premises to herd aggregates based on the livestock types they had.[10-12,27] Factor analysis was unsuccessfully attempted followed by cluster analysis. An *ad hoc* definition of herd-aggregates was made based on the livestock-type, herd size, and contact rate.

Livestock numbers, density, and contact rates were calculated both by livestock type--regardless of other livestock types that were on the premises--and by herd aggregates, which accounted for multiple livestock types being managed on the same premises.

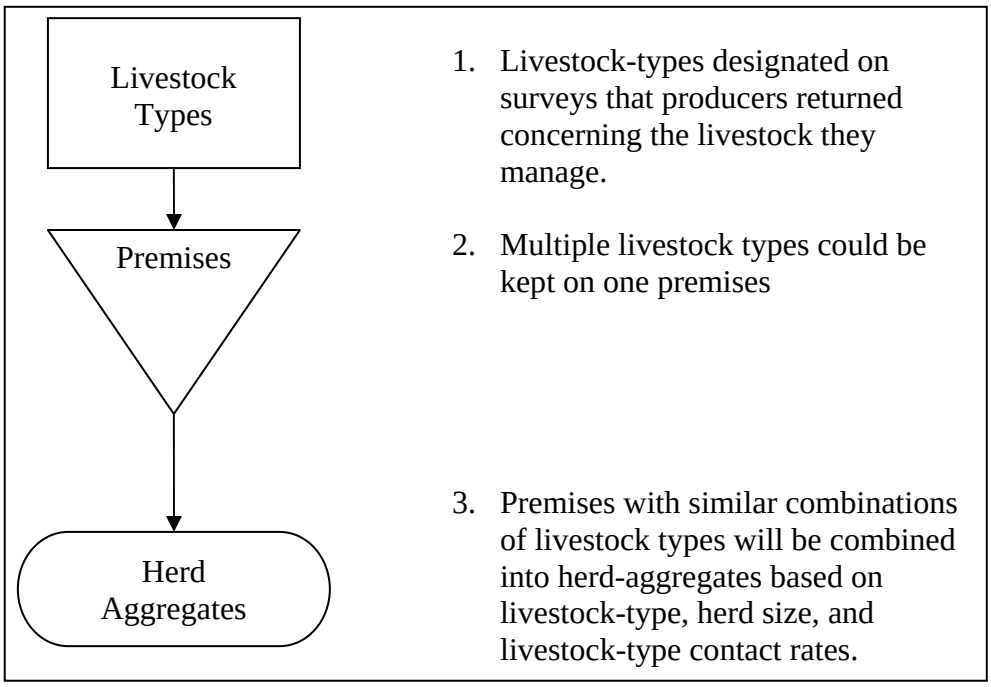

Figure 2. Flow of livestock groupings.

Determination of contacts

Each month, where each of the livestock types were shipped to when leaving the premises was determined, as well as where they came from when arriving at the premises. Direct contacts, the movement of animals from one location to another, and indirect contacts, the movement of people and vehicles to the livestock premises was determined. Contacts were divided into categories based on whether the contact was a direct contact on to the premises, a direct contact off of the premises to another premises, a direct contact to slaughter, an indirect contact to the premises that included contact with animals (high risk), or an indirect contact to the premises that did not include contact with animals (low risk). Direct contacts were classified into categories based on

whether the contact was coming to the premises, leaving the premises, or going to slaughter. Indirect contacts were divided into high risk and low risk categories similar to a study done by Bates, et al (2001) where indirect contacts that involved contact with animals were considered high risk and those that just came to the premises were low risk.[11]

The number of animals moved each month was determined for each livestock type and each contact category. Each movement of animals indicated by producers in a month was counted as one direct contact regardless of the number of animals moved. A follow-up telephone interview was performed with producers to verify this assumption (see APPENDIX IX). Producers were asked the number of premises of each type that they would take animals to and receive animals from. The number of days each month that animals were shipped or received was determined for the months which animals were moved. Indirect contacts were summed for each premises by month according to the risk category. Direct contacts were summed for each livestock type by month based on whether the contact was coming to the premises, leaving the premises, or going to slaughter. These summed monthly contact rates were then divided by 30 to obtain an average contact rate per day for each livestock type for premises.

A surrogate measure for contacts between livestock and wildlife was estimated by the number of times livestock producers observed wildlife susceptible to foot and mouth disease within 150 m of their livestock on per day, per week, per month, and per year basis. Wildlife types of interest were whitetail deer, feral swine, javelina, and exotic hoof stock. An ‘other’ category was included, and those responses to this category that

fit the exotic livestock category were re-coded as such. Responses were standardized to the number of observations per day. The number of each type of wildlife was approximated as the minimum seen, most common number seen, and the maximum number seen to define a triangular distribution.

Distance moved by direct contacts

Producers were asked to report the minimum, most common, and maximum distances that animals traveled to and from their premises. The shortest distance, most common distance, and longest distance were summarized for each livestock type. Distances were further divided according to whether animals were leaving the premises or coming on to the premises.

County agents

County Agriculture and Natural Resources Agents with the Texas Cooperative Extension Service in the study area (n=9) were asked questions similar to those on the general and livestock-type specific surveys in September, 2005 (see APPENDIX X). Participation was encouraged by regional directors, and all county agents participated in the study. Livestock numbers and the percentage of cow-calf operations with other livestock types were determined at the county level, and ownership and employee trends were ascertained. Livestock marketing practices in each county were determined. The percentage of producers, by livestock type, that perform certain production practices (e.g. weaning, culling) each month was ascertained.

Auction barns

To estimate the distances that animals traveled to and from auction barns and the volume of animals that pass through auction barns, auction barn managers in the general area were interviewed (see APPENDIX XI). There were three auction barns in the study area and another four within 50 km of the study area. All seven were considered potential transfer points for producers in the study area, based on preliminary discussions with Cooperative Extension Service personnel. All seven auction barns were asked to participate in the study.

Veterinarians

Veterinarians in the study area were surveyed similarly to livestock producers (see APPENDIX XII). The goal in surveying veterinarians was to determine the number of contacts they had with multiple livestock premises, as an example of high risk indirect contact. The number of farm calls made, the distance traveled on calls, the number of in-clinic livestock appointments, and the distance that clients traveled for appointments were estimated. Veterinarians within the study area were identified through the Texas Veterinary Medical Association as working in a large animal or mixed animal practice. All large animal or mixed animal practitioners were sent a survey with a letter of support from the current association president.

Statistical analysis

Data were entered and stored in a commercially available relational database (Microsoft Access 2003®, Microsoft Corporation. Redwood, Washington, USA). Descriptive statistics for livestock numbers, livestock densities, and contact rates were

reported as the mean, standard deviation, median, and range for each variable of interest using a commercially available statistical program (STATA/SE 9.1 ®, Stata Corp., College Station, Texas, USA).

The mean center of the spatial location of the surveyed premises and a directional ellipse with a 95% confidence interval was determined using analytical mapping software (ESRI ArcMap™ 9.0, ESRI, Inc. Redlands, California, USA). The mean center is simply an average of the X and Y coordinates.[45] This information can be used to observe changes in the distribution of various parameters. The directional ellipse is the most common way to evaluate the trend over points.[45] The mean center was then weighted based on the total number of animals in the herd, total acreage of the premises, and density of livestock. The density of livestock was calculated as the total number of acres divided by the total number of animals per acre.

The Spatial Autocorrelation tool (Moran's I) was used to determine if there was significant clustering based on herd type, total number of animals, total acreage, and density. A Moran's Index of zero indicates random dispersion, while values approaching (+) 1 or (-) 1 indicate clustering or dispersion, respectively.[45]

Factor analysis using a principle factor analysis method and Eigen cut-off value of 1 was used to attempt to group livestock type combinations into similar factors. Additionally, cluster analysis was attempted to group livestock types based on natural groupings in the data. The average direct contact on to and off of premises for each livestock type combination was used as the cluster variable, and an indicator variable for each livestock type were added as constraints to the clustering variable to keep livestock

types as close together as possible. Single linkage, complete linkage and Ward's linkage hierarchical clustering was performed using both the Calinski-Harabasz pseudo-F and the Duda-Hart Je(2)/Je(1) index as indicators of when to establish the clusters.[46] Both methods could give the same or different cut points, so both were evaluated. The correlation coefficient was used as the similarity measure.[46] Some combinations of livestock types could not be evaluated because of a lack of information.

The Kruskal-Wallis statistic was used to determine significant differences in contact rates between months for each livestock type and the number of animals on the premises each month because the data was not normally distributed.

RESULTS

Survey response

Of 528 livestock producers available on the mailing lists from the 9 county-level agents, 23 (4.4%) had addresses which were no longer valid, 35 (6.6%) no longer had livestock and 51 (9.7%) responded that they declined to participate. The remainder of producers did not respond. A total of 156 (33.2%) producers completed the general survey. (We were unable to contact one producer for the livestock-type-specific survey.) Overall, 125 different completed livestock-type-specific surveys were received from 87 of 155 (56.1%) producers. Each producer returned between one and four livestock-type-specific surveys. Seventy (55.1%) beef cow-calf producers, 20 (40.8%) stocker cattle producers, 4 (28.6%) cattle on feed producers, 27 (39.1%) small ruminant producers, and 4 (26.7%) high-fenced deer and exotics producers responded out of 155 producers contacted.

Livestock numbers

The number of animals on each premises was determined for each month of a typical year (see Table 1). Deer and exotics had the highest number of animals per premises (745 head). The distribution of the number of animals was heavily right skewed for each livestock type. Because there were numerous beef cow-calf premises, for analytical purposes concerning livestock numbers and contact rates, we divided them into large and small premises based on herd size cut point of 100, which was the most reasonable break point in the NASS Agricultural Census data.

Table 1. Mean and median number of animals by livestock type (n=125) per month. Numbers represent all premises reporting a particular livestock type regardless of other livestock types on the premises.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
		Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Small Cow-calf†	45	43.9 ±41.3 29.5 (0;152)	47.7 ±39.9 35.5 (0;152)	49.3 ±40.9 38 (0;172)	49.1 ±40.2 38 (0;155)	50.2 ±40.2 40 (0;155)	50.6 ±40.8 40 (0;155)	49.0 ±38.8 40 (0;143)	49.1 ±38.6 41.5 (0;143)	46.9 ±36.5 41.5 (0;133)	47.0 ±36.5 42 (0;133)	48.2 ±36.8 42.5 (0;133)	46.1 ±36.8 40.5 (0;133)	48.1 ±38.6 40 (0;172)
Large Cow-calf‡	25	389.6 ±630.2 240 (0;3051)	405.0 ±625.1 232 (0;3051)	439.9 ±665.9 240 (0;2651)	459.4 ±707.8 240 (0;2931)	459.4 ±726.3 240 (0;3071)	471.2 ±724.9 250 (48;3101)	451.2 ±710.4 240 (0;2966)	454.2 ±712.7 240 (0;2991)	449.7 ±23.7 240 (0;3051)	435.0 ±706.5 240 (0;2941)	433.0 ±707.4 240 (0;2941)	392.0 ±603.4 240 (0;2941)	436.6 ±676.0 240 (0;3101)
All Cow-calf	70	150.8 ±266.5 66.5 (0,1526)	158.6 ±267.5 70.5 (0,1526)	175.0 ±345.5 76 (0,2535)	179.8 ±356.2 72.5 (0,2535)	179.5 ±356.6 71.5 (5,2535)	179.8 ±356.7 75 (0,2535)	176.5 ±352.6 72.5 (0,2535)	177.5 ±352.8 72.5 (5,2535)	174.0 ±354.3 71.5 (0,2535)	170.0 ±348.0 68.5 (0,2535)	167.7 ±347.4 68.5 (0,2535)	151.7 ±258.4 68.5 (0,1515)	170.0 ±332.3 72 (0,2535)
Stocker Cattle	20	420.4 ±1,046 18.5 (0;5000)	623.7 ±1,968 39 (0;10000)	264.0 ±482.8 24 (0;1900)	289.4 ±491.3 39 (0;1900)	274.1 ±494.7 23.5 (0;1900)	566.5 ±1,958 38 (0;10000)	224.2 ±436.9 25 (0;1500)	178.0 ±390.6 22 (0;1500)	189.6 ±391.1 22 (0;1500)	253.5 ±422.6 80 (0;1500)	257.3 ±434.7 65 (0;1500)	253.6 ±474.0 37 (0;1900)	316.2 ±933.9 26 (0;10000)

Table 1. continued.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
		Mean ±SD Median (Range	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Cattle on Feed	4	148.5 ±20.5 8 (0;800)	148.5 ±20.5 8 (0;800)	148.5 ±20.5 8 (0;800)	161. 7 ±319.0 5 (0;800)	275.0 ±356.6 105 (0;800)	275.0 ±356.6 105 (0;800)	275.0 ±356.6 105 (0;800)	275.0 ±356.6 105 (0;800)	276.0 ±355.8 108 (0;800)	151.8 ±319.7 8 (0;800)	151.8 ±319.7 8 (0;800)	151.8 ±319.7 8 (0;800)	203.2 ±314.6 13 (0;800)
Small Rum-inant	27	513.0 ±1087.7 124 (0;5585)	556.9 ±1153.2 201 (0;5585)	567.0 ±1152.5 181.5 (0;5585)	583.2 ±1150.6 224 (0;5585)	474.2 ±792.3 224 (0;3435)	439.9 ±668.1 224 (0;3085)	423.1 ±661.2 191 (0;3085)	417.5 ±663.9 129.5 (0;3085)	417.1 ±664.1 129.5 (0;3085)	414.2 ±664.6 129.5 (0;3085)	411.6 ±663.5 129.5 (0;3085)	408.9 ±661.0 129.5 (0;3085)	468.9 ±849.3 184 (0;5585)
Deer & Exotics	4	724.3 ±1417.2 23 (1;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	746.8 ±1402.5 61 (15;2850)	744.9 ±1228.5 31 (1;2850)

*N represents the number of premises which completed the appropriate species-specific survey concerning the number of total animals by species each month. †Small Cow-calf represents premises with less than 100 head of breeding cows/heifers. ‡Large Cow-calf represents premises with more than 100 head of breeding cows/heifers.

Livestock densities

The density of animals per acre was determined for each month of the year. Small ruminants had the highest density of animals per acre followed by stocker cattle when averaged among premises (see Table 2). Cattle on feed, while typically an intensively managed livestock type with high-densities, had the lowest density in this study area.

Premises information

Eighty-four of the 156 premises (53.8%) only had one livestock type. The distribution of livestock types was such that 81.4% of premises were cow-calf operations, 31.5% had stocker cattle, 9.0% had cattle on feed, 32.7% had small ruminants, and 7.7% had deer and exotics. Of the cow-calf premises, 29.9% also had stocker cattle, 7.1% had cattle on feed, 26.0% had sheep, 24.4% had goats, and 7.9% had deer. A majority of stocker premises (77.6%) were involved with cow-calf production, 22.4% had cattle on feed, 14.3% had sheep, 20.4% had goats, and 21.4% had deer. Premises with cattle on feed were likely to also have cow-calf production (64.3%) and stocker cattle production (78.6%). They also had sheep (14.3%), goats (14.3%), and deer or exotics (21.4%). Likewise premises with sheep or goats were apt to also have beef cattle (78.6%, 67.4% respectively). Three quarters of the sheep premises also had goats while 48.8% of goat premises had sheep. A majority of high-fenced deer and exotic premises had beef cattle (90.9%), stocker cattle (45.5%), cattle on feed (27.3%), sheep (18.2%), and goats (18.2%).

Table 2. Mean and median density of animals by livestock type per month. Numbers represent all premises reporting a particular livestock type regardless of other livestock types on the premises.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
		Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Small Cow-calf†	45	0.08 ±0.09 0.05 (0,.4)	0.09 ±0.10 0.06 (0,0.4)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.10 0.06 (0,0.5)	0.10 ±0.11 0.60 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)	0.09 ±0.11 0.06 (0,0.5)	0.10 ±0.11 0.06 (0,0.5)
Large Cow-calf‡	25	0.08± 0.08 0.05 (0,0.3)	0.08 ±0.08 0.05 (0,0.3)	0.08 ±0.08 0.05 (0,0.3)	0.09 ±0.08 0.06 (0,0.3)	0.09 ±0.08 0.05 (0,0.3)	0.09 ±0.08 0.06 (0,0.3)	0.09 ±0.08 0.05 (0,0.3)	0.09 ±0.08 0.05 (0,0.3)	0.09 ±0.08 0.05 (0,0.3)	0.09 ±0.09 0.05 (0,0.3)	0.08 ±0.08 0.05 (0,0.3)	0.08 ±0.08 0.05 (0,0.3)	0.09 ±0.08 0.05 (0,0.3)
All Cow-calf	70	0.09 ±0.09 0.05 (0,0.4)	0.09 ±0.09 0.05 (0,0.4)	0.10 ±0.10 0.05 (0,0.5)	0.10 ±0.10 0.06 (0,0.5)	0.10 ±0.10 0.05 (0,0.5)	0.10 ±0.10 0.05 (0,0.5)	0.10 ±0.10 0.5 (0,0.5)	0.10 ±0.10 0.06 (0,0.5)	0.09 ±0.10 0.06 (0,0.5)	0.10 ±0.10 0.06 (0,0.5)	0.09 ±0.10 0.06 (0,0.5)	0.09 ±0.10 0.05 (0,0.5)	0.09 ±0.10 0.06 (0,0.5)
Stocker Cattle	20	0.23 ±0.72 0.20 (0,3.6)	0.38 ±1.40 0.02 (0,7.1)	0.12 ±0.23 0.02 (0,1)	0.13 ±0..25 0.02 (0,1)	0.13 ±0.25 0.02 (0,1)	0.37 ±1.40 0.02 (0,7.1)	0.12 ±0.27 0.02 (0,1)	0.12 ±0.27 0.02 (0,1)	0.13 ±0.27 0.02 (0,1)	0.15 ±0.30 0.02 (0,1)	0.13 ±0.25 0.02 (0,1)	0.12 ±0.23 0.02 (0,1)	0.18 ±0.64 0.02 (0,7.1)

Table 2. continued.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
		Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Cattle on Feed	4	0.022 ±0.044 0.005 (0,0.1)	0.022 ±0.044 0.005 (0,0.1)	0.022 ±0.044 0.005 (0,0.1)	0.018 ±0.028 0.005 (0,0.1)	0.046 ±0.050 0.040 (0,0.1)	0.046 ±0.050 0.040 (0,0.1)	0.046 ±0.050 0.040 (0,0.1)	0.046 ±0.050 0.040 (0,0.1)	0.053 ±0.056 0.046 (0,0.1)	0.023 ±0.044 0.005 (0,0.1)	0.023 ±0.044 0.005 (0,0.1)	0.023 ±0.044 0.005 (0,0.1)	0.033 ±0.044 0.010 (0,0.1)
Small Rum-inant	27	0.507 ±0.913 0.132 (0,3.8)	0.561 ±0.985 0.143 (0,3.8)	0.610 ±1.09 0.141 (0,3.8)	0.693 ±1.30 0.154 (0,4.8)	0.616 ±1.17 0.141 (0,4.2)	0.600 ±1.14 0.133 (0,4.2)	0.501 ±0.934 0.133 (0,3.8)	0.487 ±0.926 0.133 (0,3.8)	0.461 ±0.892 0.127 (0,3.8)	0.485 ±0.912 0.127 (0,3.8)	0.484 ±0.912 0.127 (0,3.8)	0.483 ±0.912 0.127 (0,3.8)	0.541 ±1.00 0.129 (0,4.8)
Deer & Exotics	4	0.103 ±0.195 0.009 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)	0.111 ±0.190 0.023 (0,0.4)

*N represents the number of premises which completed the appropriate species-specific survey concerning the number of total animals by species each month. †Small Cow-calf represents premises with less than 100 head of breeding cows/heifers. ‡Large Cow-calf represents premises with more than 100 head of breeding cows/heifers

Operations with cattle on feed reported the highest number of average hectares (4,661 hectares) whereas cow calf producers with less than 100 head had 486.7 hectares , on average (Table 3). Overall the average premises size in the study was 1,954 hectares. The distribution was heavily right skewed.

Table 3. Mean and median hectares reported by livestock type.

	N*	Mean ±SD	Median (Range) †
Small Cow-calf‡	61	486.7 ± 804.9	192.2 (12.3,4111.6)
Large Cow-calf§	64	2880.2 ± 5349.9	1396.2 (192.2,38445.1)
All Cow-calf	125	1849.9 ± 4985.7	607.0 (12.3,38445.1)
Stocker Cattle	49	3405.8 ± 8088.8	689.0 (3.6,38445.1)
Cattle on Feed	14	4661.1 ± 9970.2	996.3 (58.3,31970.2)
Small Ruminants	49	2547.3 ± 5478.2	809.4 (9.7,31940.2)
Deer & Exotics	12	2161.4 ± 1427.0	2023.4 (809.4,3035.1)
Total¶	156	1953.9 ± 4985.7	445.2 (3.6,38445.1)

*N is the number of premises that completed a species-specific questionnaire and reported acreage.
† The range is the minimum value reported to the maximum value reported. The maximum value is the same for some livestock types due to multiple livestock types on one premises.
‡ Small Cow-calf represents premises with less than 100 head of breeding cows/heifers.
§ Large Cow-calf represents premises with more than 100 head of breeding cows/heifers.
¶The total is for all producers reporting acreage.

Approximately 46.5% of the land (122,215/263,045 hectares) used for grazing was leased. The majority of extensively managed grazing land was considered native rangeland (87.3%). A small percentage (8.1%) of the reported land types were improved pasture and a smaller percentage was considered cultivated land (4.6%).

Roads that separated livestock premises into more than one location were determined for 133 producers. Two-lane highways comprised the highest response

(46.6%), followed by county maintained dirt or rock roads (42.1%), private ranch roads (37.6%), county maintained asphalt roads (26.3%), and four-lane highways (4.5%).

Borders of livestock premises were defined by what adjoined them. The majority (90.8%) of livestock premises were bordered by other livestock premises. County maintained roads (64.5%), highways (44.7%), rivers or streams (30.9%), and housing developments (7.9%) comprised most of the remainder of responses. Few producers (3.3%) indicated that crop land or state managed land was on at least one border of their premises.

Water troughs, either in pens (78.2%) and/or in the pasture (70.0%), and stock ponds (66.6%) were the most common watering locations. Streams, creeks, or rivers were used as a water source on 43.6% of premises and individual waterers on 8.3%. Several premises utilized multiple watering methods. The number of times supplemental feed (e.g. hay, range cubes, mineral blocks) were distributed each month was determined for each premises. For all types of supplemental feeding, there was a significant ($p<0.05$) increase in the winter months (October to February) (see Table 4). The data were not normally distributed so Kruskal-Wallis ($p<0.0001$) was used to evaluate differences in between months.

There was an average of 3 (median of 2 and range of 1 to 22) employees working on each livestock premises including the owner completing the survey. On average,0.5 employees per premises had livestock of their own with a range of 0 to 5 employees per premises owning livestock.

Table 4. Mean and median number of times that supplemental feeding was done each month of the year under extensive management for all premises (n=156) regardless of livestock type.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Automatic feeders	91	4.10 ±8.91 0 (0,45)	2.41 ±6.41 0 (0,45)	1.80 ±5.87 0 (0,45)	1.56 ±5.77 0 (0,45)	1.55 ±5.78 0 (0,45)	1.54 ±5.78 0 (0,45)	1.60 ±5.78 0 (0,45)	2.12 ±6.68 0 (0,45)	2.34 ±6.78 0 (0,45)	3.82 ±8.88 0 (0,45)	3.97 ±8.85 0 (0,45)	3.94 ±8.88 0 (0,45)
Sack feed† on ground	98	9.46 ±12.29 6 (0,60)	8.87 ±10.90 6.5 (0,60)	7.05 ±9.57 4 (0,52)	5.00 ±9.30 1 (0,52)	3.73 ±8.63 0 (0,52)	3.61 ±8.29 0 (0,52)	3.77 ±8.33 0 (0,52)	3.88 ±8.37 0 (0,52)	4.33 ±8.56 1 (0,52)	5.04 ±8.87 2 (0,52)	7.55 ±10.97 4 (0,52)	8.39 ±11.70 4 (0,60)
Sack feed in troughs	102	6.40 ±10.79 1 (0,31)	6.19 ±10.45 1 (0,30)	5.48 ±10.22 0 (0,31)	4.49 ±9.48 0 (0,30)	3.88 ±8.87 0 (0,31)	3.60 ±8.26 0 (0,30)	3.71 ±8.49 0 (0,31)	3.81 ±8.73 0 (0,31)	4.29 ±9.21 0 (0,31)	4.93 ±9.91 0 (0,31)	5.64 ±10.12 0.5 (0,30)	6.50 ±11.37 0.5 (0,30)
Round bales with hay rings	118	8.84 ±16.26 4 (0,100)	8.89 ±16.69 4 (0,100)	3.76 ±10.80 0 (0,100)	1.25 ±5.29 0 (0,50)	0.67 ±4.74 0 (0,50)	0.64 ±4.72 0 (0,50)	1.09 ±6.56 0 (0,50)	1.25 ±6.62 0 (0,50)	2.05 ±14.13 0 (0,150)	3.05 ±18.65 0 (0,200)	5.31 ±19.03 1 (0,200)	8.68 ±21.05 4 (0,200)

Table 4. continued.

	N*	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)	Mean ±SD Median (Range)
Round bales unrolled	83	0.87 ±1.30 0 (0,4)	0.87 ±1.30 0 (0,4)	0.67 ±0.98 0 (0,3)	0.80 ±1.26 0 (0,4)	0.73 ±1.10 0 (0,3)	0..73 ±1.28 0 (0,4)	0.67 ±0.98 0 (0,3)	0.87 ±1.30 0 (0,4)	0.73 ±1.03 0 (0,3)	0.87 ±1.30 0 (0,4)	0.87 ±1.30 0 (0,4)	0.87 ±1.30 0 (0,4)
Square bales	103	18.74 ±60.05 0 (0,500)	20.68 ±65.32 2 (0,500)	14.57 ±53.13 0 (0,500)	11.24 ±51.09 0 (0,500)	8.72 ±50.42 0 (0,500)	7.84 ±50.33 0 (0,500)	7.89 ±50.33 0 (0,500)	8.00 ±50.34 0 (0,500)	9.22 ±51.17 0 (0,500)	9.16 ±50.43 0 (0,500)	16.32 ±59.54 0 (0,500)	19.67 ±65.19 0 (0,500)
Self feeders	84	1.54 ±5.73 0 (0,40)	1.65 ±5.99 0 (0,40)	1.68 ±6.13 0 (0,40)	1.61 ±6.05 0 (0,40)	1.50 ±6.00 0 (0,40)	1.53 ±5.94 0 (0,40)	1.44 ±5.99 0 (0,40)	1.37 ±5.98 0 (0,40)	1.64 ±6.13 0 (0,40)	1.42 ±5.81 0 (0,40)	1.50 ±5.76 0 (0,40)	1.37 ±5.71 0 (0,40)

*N is the number of premises reporting that the indicated feeding methods were used. †Sack feed includes range cubes, grain, and/or mineral (other than mineral blocks) that could be fed to livestock

One hundred twenty-eight premises reported hunters using their premises to hunt wildlife or exotics. There was an average of 2.7 hunters (median of 6, and range of 1 to 650) hunters per premises per year. On average, 3.8 hunters per premises (on 30 premises) also raised livestock of their own.

On 78 premises reporting that they had horses, there was an average of 8 horses (median number of horses was 3 with a range of 1 to 60) per premises. Thirty-four premises reported that their horses went to other ranches, shows, and rodeos at least once a year, or they had horses come onto their premises at least once a year. On average, 7.1 (median was 3 and range from 1 to 100) horses per premises were in contact with other premises. Fifty-three producers used dogs to work livestock, with an average of 2.3 dogs (median was 2 and range from 1 to 10).

The mean center, based on the approximated X,Y coordinates, for the premises in the data set was found to be approximately 20.4 km East of the mean center of the study area. The 95% confidence interval directional ellipse for the study area was oriented in the Northwest to Southeast direction. This allows observations on the change in parameters such as land size and animal density change over the study area.

Weighted mean centers were calculated using acreage and livestock density (acres/animal) (see Figures 3 and 4). For acreage, the mean center shifted approximately 38.7 km to the Southwest of the mean center for the data set. The 95% confidence interval directional ellipse weighted by acreage was slightly increased in length in the East to West direction. The mean center weighted by density of animals per premises shifted approximately 18.2 km North-Northwest of the mean center for the data. The

directional ellipse weighted by number of animals was largely stretched in the Northwest to Southwest direction.

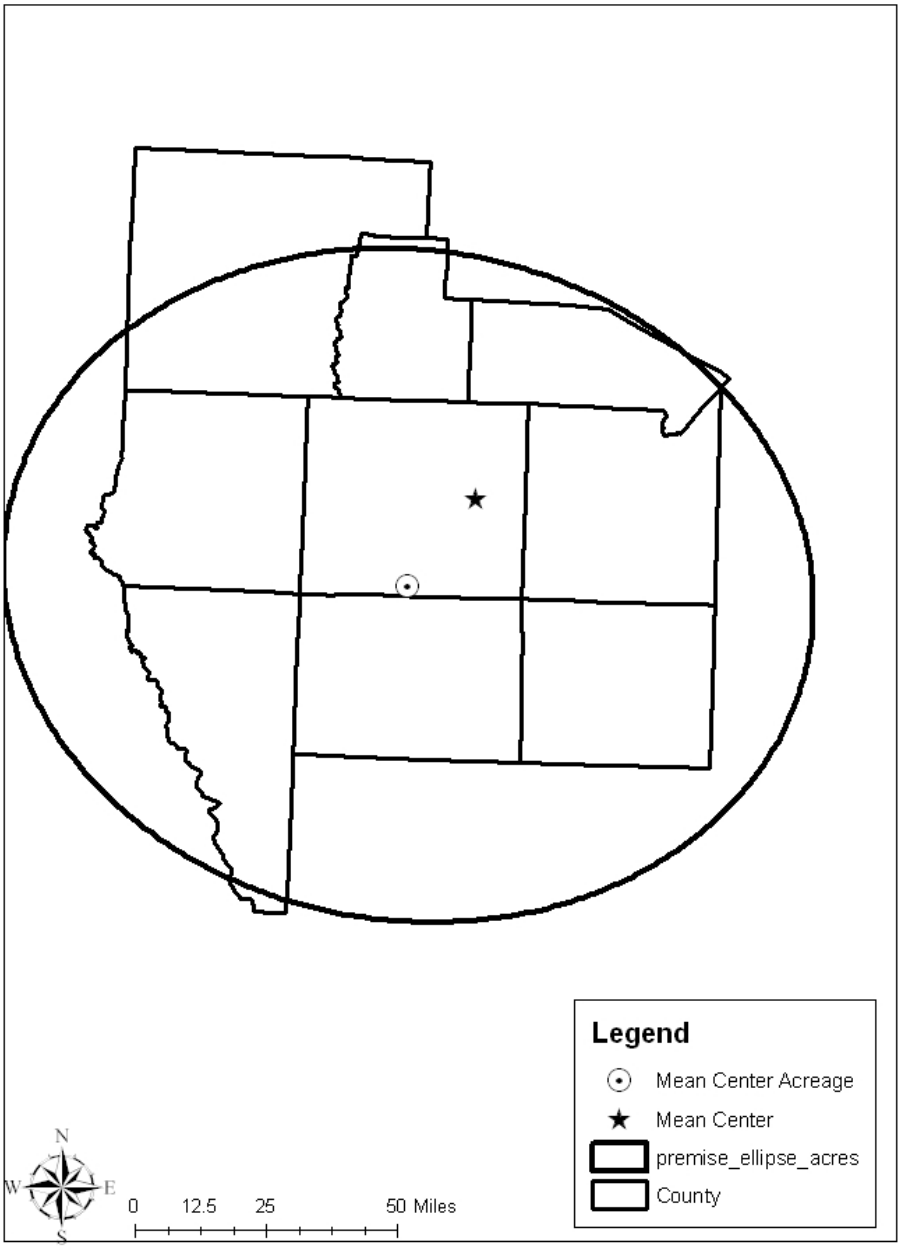

Figure 3. Weighted mean center for acreage in relation to the mean center for the data.

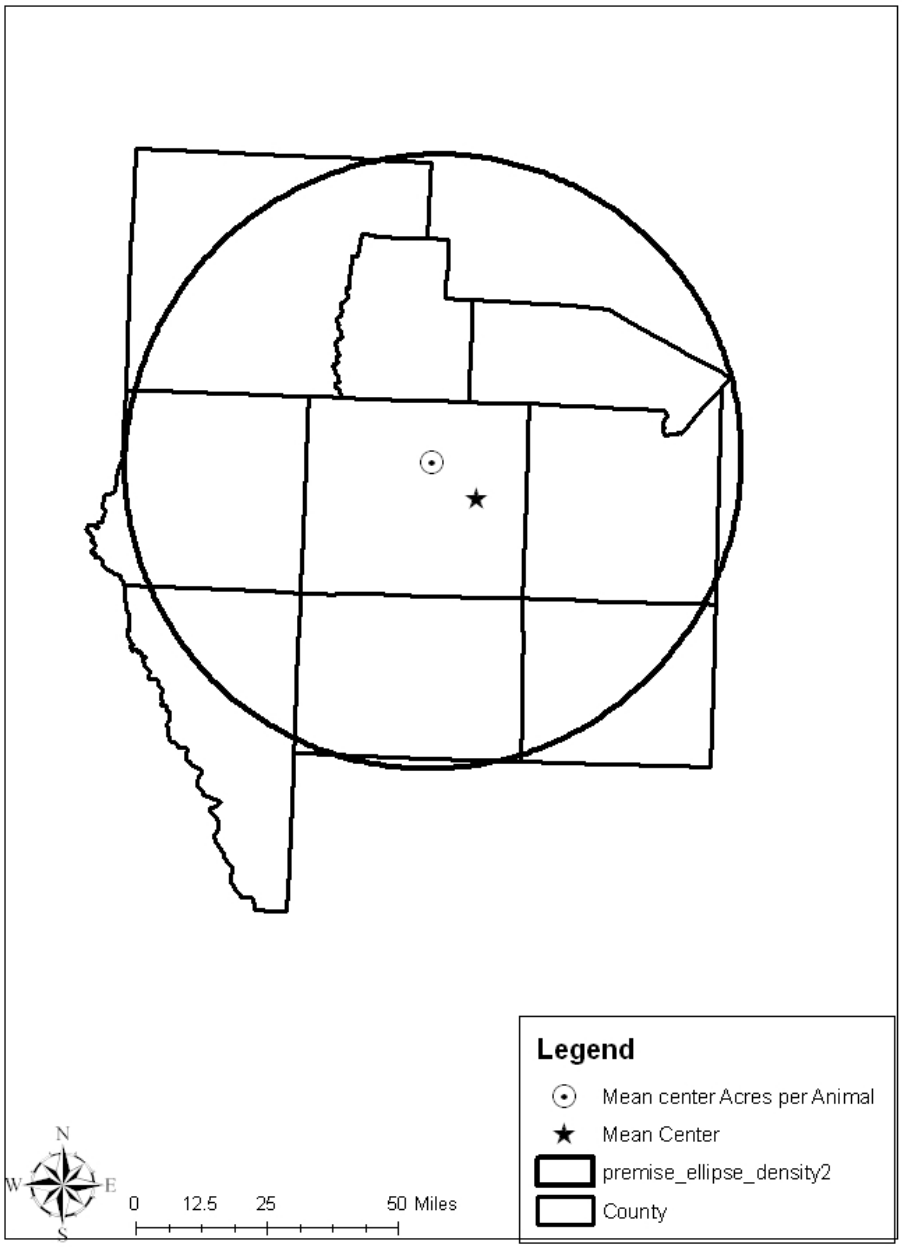

Figure 4. Weighted mean center for density of animals in relation to the mean center of the data.

Herd-aggregates

There were 22 different combinations of livestock types found on the premises in our study. An average of 1.7 livestock types per premises (median=1 and range of 1 to 4)

was indicated on the general questionnaire. There was an average of 1.4 livestock types per premises with a median of 1 and a (range of 1 to 4) of the premises that returned livestock type specific surveys. Approximately 57.5% of producers had one livestock type, but 33.3% had two livestock types, 8.1% had three, and 1.1% had four livestock types.

Factor analysis was attempted, but resulted in the loading of all livestock type combinations into one factor. Using the Calinski-Harabasz pseudo-F to determine the number of clusters, two clusters were formed by the single linkage method (see Figure 5), five clusters were formed by complete linkage (see Figure 6), and four clusters were formed by Ward's linkage (see Figure 7). Single linkage removed the combination of stocker cattle and cattle on feed to a group by itself. The complete linkage method grouped stocker cattle and cattle on feed into one group, high fenced deer into a group of its own, beef cow-calf alone and with high fenced deer in a group, and small ruminants alone, with beef cow-calf, and with beef cow-calf and high fenced deer in a fourth group. The remainder constituted the fifth group. Ward's linkage method divided groups similarly except high fenced deer only were included with beef cow-calf (alone and with high fenced deer) group so that there were only four total groups.

The Duda-Hart Je(2)/Je(1) index indicated that there should be five clusters using the single linkage method and two using the complete linkage method (see Figures 5 and 6). There were no distinct clusters using Ward's linkage (see Figure 7). Single linkage, using the Duda-Hart index to determine the number of clusters, created four clusters with one combination of livestock types per combination with the remaining

combinations in one large combination. The complete linkage method produced one group that included high fenced deer and the combination of stocker cattle and cattle on feed with the remainder of livestock type combinations in the second cluster.

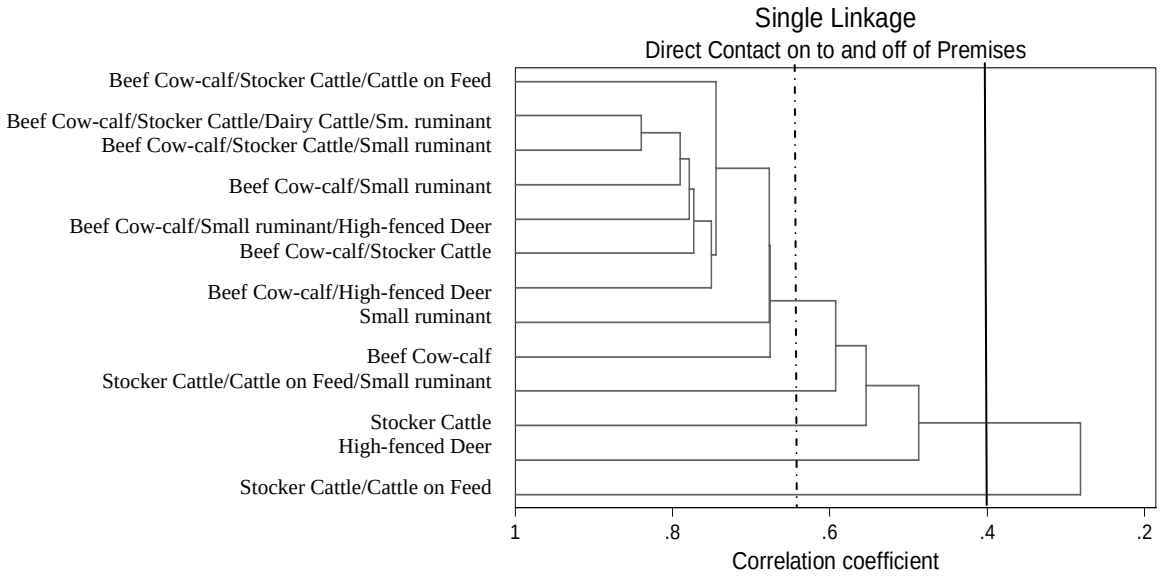

Figure 5. Single linkage clustering of livestock type combinations based on total direct contacts onto and off of the premises. The solid line indicates the cut point determined by the Calinski-Harabasz pseudo-F rule, and the dotted line indicates the cut point determined by Duda-Hart Je(2)/Je(1) index.

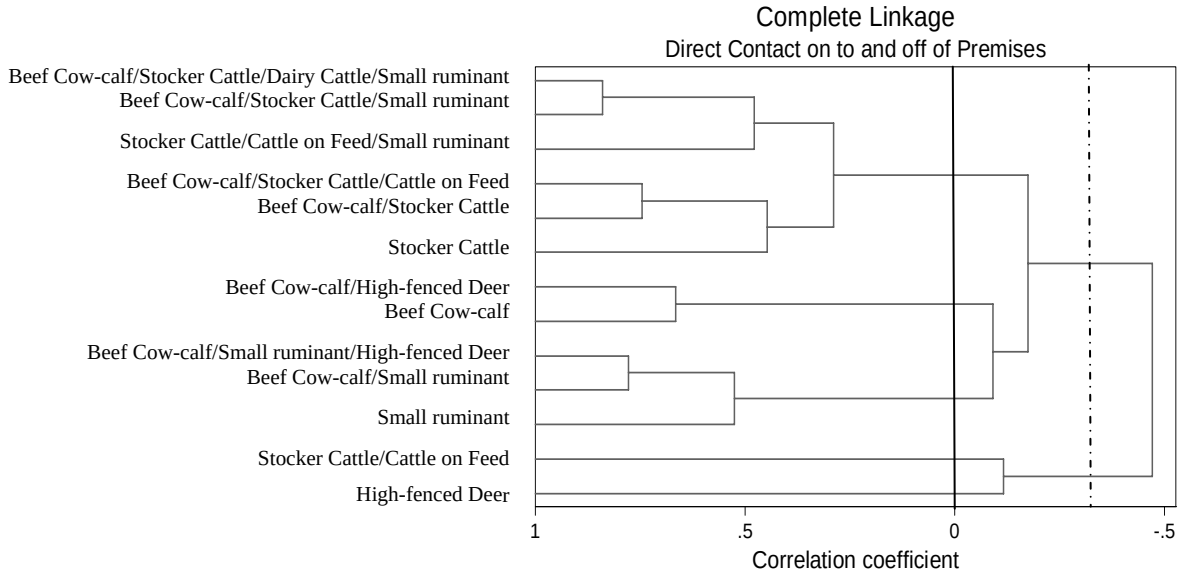

Figure 6. Complete linkage clustering of livestock type combinations based on total direct contacts onto and off of the premises. The solid line indicates the cut point determined by the Calinski-Harabasz pseudo-F rule, and the dotted line indicates the cut point determined by Duda-Hart Je(2)/Je(1) index.

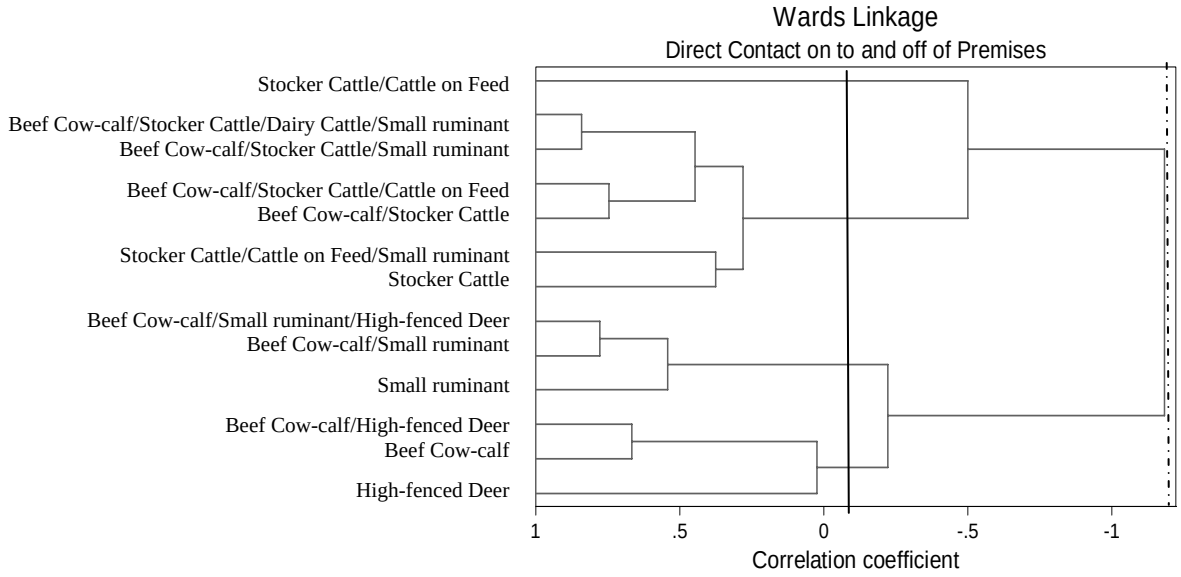

Figure 7. Ward's linkage clustering of livestock type combinations based on total direct contacts onto and off of the premises. The solid line indicates the cut point determined by the Calinski-Harabasz pseudo-F rule, and the dotted line indicates the cut point determined by Duda-Hart Je(2)/Je(1) index.

Since the clustering methods did not produced consistent results that could reasonable explain all combinations of livestock types, an *ad hoc* approach was employed using the following steps (see Figure 8).

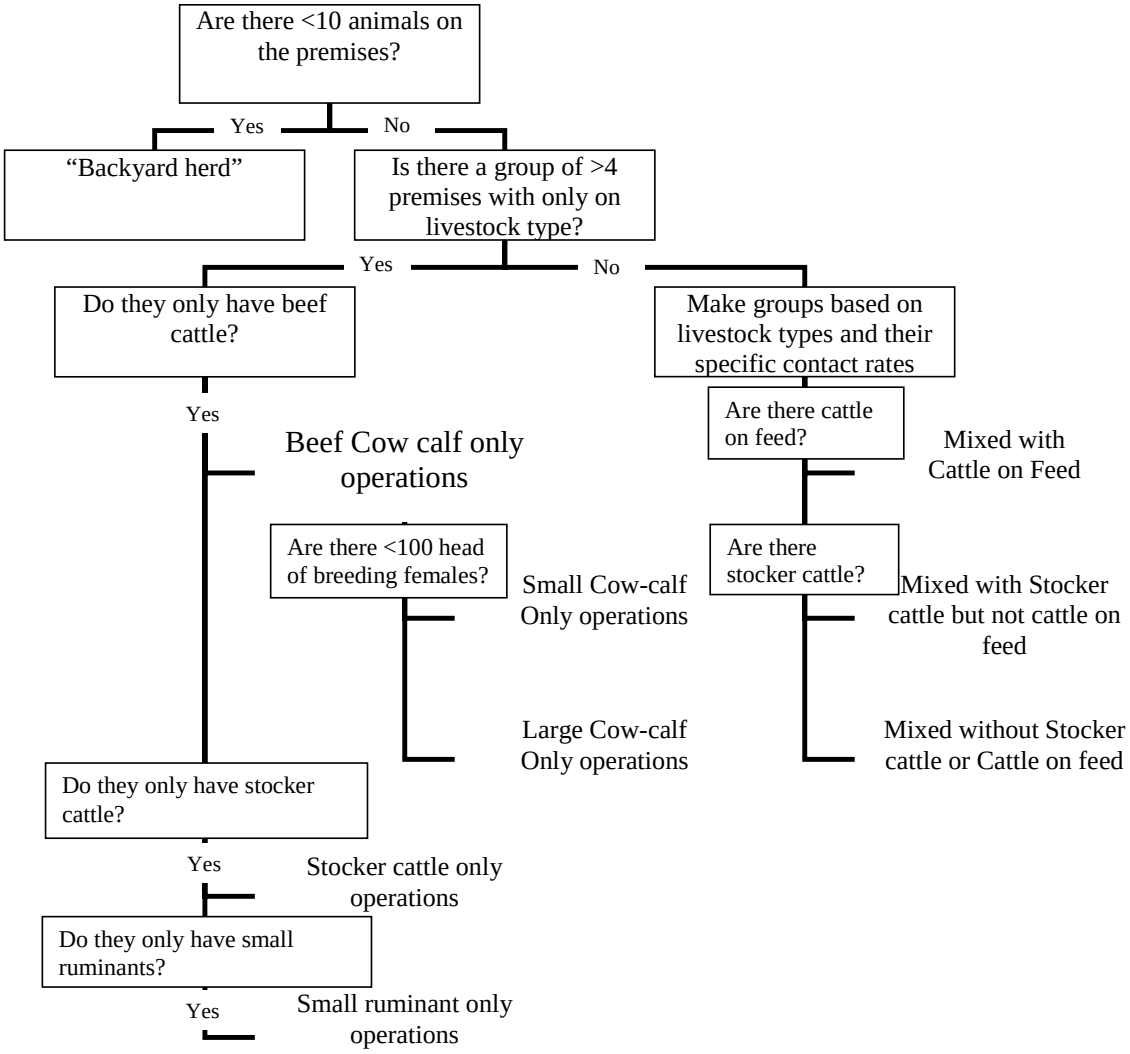

Figure 8. Decision tree on determining herd aggregates.

Determination of contacts

All producers (n=156) responded that at least one high risk contact came on to their premises at some time during the year. On average, there were 0.3 (standard deviation=1.7) high risk, those that included contact with animals, indirect contacts per month on the premises in the study. Ninety producers also reported low risk indirect contacts, those that just contacted the premises not animals on the premises, occurring approximately 0.2 (standard deviation=0.8) times per month. For all premises in the study, there were insignificant differences ($p>0.05$, by Kruskal-Wallis) in the average indirect contact rate across months for both high risk and low risk indirect contacts.

There was a statistically significant seasonal variability to animals leaving premises between months for cow-calf and high fenced deer/exotics premises ($p<0.05$) (see Table 5). Cattle and small ruminants were shipped off of premises to other locations besides slaughter every month of the year (see Table 5). There were peaks in months that corresponded with observed weaning times. Of the livestock types with non-slaughter movements off of the premises, stocker cattle had the highest monthly contact rate. Many of the contacts for the high-fenced deer and exotics livestock type in our study were influenced by Texas Parks and Wildlife Department (TPWD) regulations as most movements were during the hunting season between October and February--this also coincides with the regulated trap and transfer period for deer breeders. The TPWD regulates all native species (e.g. whitetail deer) even if they are managed by a private land owner[47]. Additionally, most movements involved hides or meat (animal products) as opposed to live animals. There was always a level of movements of animal products

(0.74 contacts/month) for high-fenced deer and exotics during the remainder of the year, largely due to the hunting of non-regulated wildlife such as feral swine.

Ten beef cow-calf, small ruminant, and/or stocker cattle producers were interviewed by telephone to validate the assumption that the movement of animals in one month was generally performed on one day to one location. The median number of locations per day that animals were received from or shipped to was one (1) (range: one to seven). The median number of days per month that animals were shipped off of the premises, if animals were moved from the premises, was one (1) (range: one to four). The median number of days per month that animals were received on premises was four (4) (range: one to seven). The interviewees were equally divided in their opinion of whether or not they were representative of other livestock producers in the area. The responses as to why they were not representative ranged from not having many cattle to having mainly stocker cattle in an area they felt was primarily comprised of cow-calf operations.

Table 5. Mean[*] number of direct contacts each month in an average year by livestock type.

		N	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Year
Small Cow-calf[†,a]	To premises	45	0.04± 0.21	0.02± 0.15	0.04± 0.21	0± 0	0± 0	0± 0	0± 0	0± 0	0.02± 0.15	0.02± 0.15	0.06± 0.25	0.02± 0.15	0.02± 0.14
	From premises	45	0.18± 0.49	0.04± 0.21	0.04± 0.21	0.09± 0.29	0.09± 0.29	0.20± 0.59	0.22± 0.52	0.29± 0.55	0.40± 0.62	0.44± 0.72	0.18± 0.39	0.24± 0.53	0.20± 0.49
	To slaughter	45	0.2± 0.15	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.02± 0.15	0.02± 0.15	0.04± 0.21	0.02± 0.15	0± 0	0.01± 0.10
Large Cow-calf[‡,a]	To premises	25	0.08± 0.28	008± 0.28	0.12± 0.33	0.12± 0.33	0.04± 0.20	0.04± 0.20	0.04± 0.20	0± 0	0± 0	0.04± 0.20	0.08± 0.28	0± 0	0.5± 0.23
	From premises	25	0.24± 0.52	0.20± 0.50	0.24± 0.60	0.40± 0.71	0.28± 0.61	0.16± 0.47	0.20± 0.41	0.16± 0.37	0.48± 0.65	0.68± 0.85	0.52± 0.65	0.28± 0.61	0.32± 0.60
	To slaughter	25	0.04± 0.20	0± 0	0± 0	0.04± 0.20	0± 0	0± 0	0± 0	0.04± 0.20	0.04± 0.20	0± 0	0.04± 0.20	0.08± 0.28	0.20± 0.15
Stocker cattle	To premises	20	0.10± 0.31	0.10± 0.31	0.10± 0.31	0.10± 0.31	0.10± 0.31	0.20± 0.41	0.10± 0.31	0.10± 0.31	0.25± 0.44	0.40± 0.60	0.25± 0.55	0.25± 0.44	0.17± 0.40
	From premises	20	0.10± 0.31	0.10± 0.31	0.20± 0.41	0.25± 0.55	0.20± 0.41	0.20± 0.41	0.15± 0.37	0.25± 0.55	0.10± 0.31	0.30± 0.57	0.30± 0.47	0.40± 0.50	0.21± 0.44
	To slaughter	20	0± 0	0± 0	0± 0	0± 0	0± 0	0.05± 0.22	0± 0	0± 0	0.05± 0.22	0± 0	0± 0	0± 0	0.01± 0.09

Table 5. continued.

		N	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Year
Cattle on Feed	To premises	4	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0
	From premises	4	0± 0	0± 0	0.25± 0.50	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0
	To slaughter	4	0.50± 0.58	0± 0	0.25± 0.50	0.25± 0.50	0± 0	0± 0	0± 0	0± 0	0.50± 0.58	0± 0	0.25± 0.50	0.25± 0.50	0.17± 0.38
Small ruminants	To premises	27	0± 0	0± 0	0.40± 0.19	0± 0	0.07± 0.27	0.40± 0.19	0.40± 0.19	0.70± 0.27	0.11± 0.32	0± 0	0± 0	0± 0	0.03± 0.17
	From premises	27	0.22± 0.51	0.15± 0.36	0.15± 0.36	0.15± 0.46	0.37± 0.74	0.44± 0.75	0.37± 0.69	0.33± 0.73	0.44± 0.80	0.15± 0.36	0.15± 0.53	0.15± 0.46	0.26± 0.59
	To slaughter	27	0.40± 0.19	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.04± 0.19	0.04± 0.19	0.04± 0.19	0± 0	0.04± 0.19	0.02± 0.12
High-fenced Deer/Exo.[a]	To premises	4	0.25± 0.50	0.25± 0.50	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.10± 0.31
	From premises	4	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0
	To slaughter	4	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.25± 0.50

[*] ± values represent the standard deviation [†]Small cow-calf premises have less than 100 head of breeding females [‡]Large cow-calf premises have 100 head or more of breeding females [a] Significant differences in contact rates between months from the premises.

Table 6. Distances traveled in kilometers coming on to the farm, leaving the farm, and going to slaughter for each livestock type.

	N*	Minimum	Mean	Median	Maximum
Direct contact onto farm					
Small Cow-calf†	0	.	.	.	.
Large Cow-calf‡	4	6.0	55.2	70.4	80.5
Stocker cattle	4	20.1	275.8	281.6	402.3
Cattle on Feed	1	160.9	426.7	563.3	563.3
Small ruminants	2	5.4	54.5	53.6	107.3
High-fenced Deer/Exotics	0	.	.	.	.
Direct contact off of farm					
Small Cow-calf	17	4.3	46.3	25.8	152.9
Large Cow-calf	11	4.8	132.0	32.2	804.7
Stocker cattle	6	13.4	324.1	375.5	804.7
Cattle on Feed	1	12.9	31.1	40.23	40.23
Small ruminants	6	2.7	45.7	29.0	128.8
High-fenced Deer/Exotics	0	.	.	.	.
Terminal contact					
Small Cow-calf	0	.	.	.	.
Large Cow-calf	2	64.4	86.5	86.5	108.6
Stocker cattle	0	.	.	.	.
Cattle on Feed	1	402.3	1448.4	402.3	1448.4
Small ruminants	0	.	.	.	.
High-fenced Deer/Exotics	0	.	.	.	.

*'N' is equal to the number of producers that responded completely to the relevant question†Small cow-calf premises are those with less than 100 head of breeding females‡Large cow-calf premises are those with more than 100 head.

The distance that animals traveled between contacts ranged from nearly 4.8 km for direct contacts from small cow calf operations to1, 448.4 km for cattle on feed going to slaughter (see Table 6). Many producers responded with an incomplete set of minimum, maximum, and most common distances and were not included in the summary.

While cattle on feed, as a livestock type had virtually zero contacts off-of premises other than to slaughter, as a herd aggregate with other livestock types, there were more direct contacts off of the premises. When stocker cattle only premises are evaluated as a herd aggregate, there were more months with zero contacts as opposed to the consistent monthly contact seen with all stocker cattle operations (see Table 7).

Because the contact rate data were not normally distributed and residual distribution from ANOVA did not have constant variance, the Kruskal-Wallis statistic was used for comparison between months for each herd aggregate. Cow-calf operations and high-fenced deer and exotic producers had the only significant differences between months for direct contact off of the premises (see Table 7).

Table 7. Mean[*] number of direct contacts each month in an average year by herd-aggregate.

		N	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Large Cow-calf[†]	To premises	10	0.10± 0.32	0± 0	0± 0	0.10± 0.32	0± 0	0.10± 0.32	0± 0	0± 0	0± 0	0± 0	0.20± 0.42	0± 0	0.04± 0.20
	From premises	10	0.50± 0.71	0.30± 0.67	0.30± 0.67	0.30± 0.48	0.50± 0.85	0.50± 0.85	0.50± 0.71	0.30± 0.48	0.50± 0.85	0.70± 0.95	0.60± 0.52	0.20± 0.42	0.43± 0.06
	To slaughter	10	0.10± 0.32	0± 0	0± 0	0.10± 0.32	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.10± 0.32	0.03± 0.16
Small Cow-calf[‡,a]	To premises	22	0.04± 0.21	0.04± 0.21	0.04± 0.21	0± 0	0± 0	0± 0	0± 0	0± 0	0.04± 0.21	0.04± 0.21	0.04± 0.21	0.04± 0.21	0.03± 0.17
	From premises	22	0.17± 0.49	0.09± 0.29	0.09± 0.29	0.17± 0.39	0.13± 0.34	0.17± 0.58	0.26± 0.54	0.17± 0.39	0.48± 0.73	0.61± 0.78	0.17± 0.39	0.17± 0.39	0.22± 0.50
	To slaughter	22	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.04± 0.21	0.04± 0.21	0.04± 0.21	0.04± 0.21	0± 0	0.01± 0.12
Stocker Cattle	To premises	4	0.25± 0.50	0.25± 0.50	0± 0	0± 0	0± 0	0.25± 0.50	0± 0	0± 0	0± 0	0.50± 0.58	0.25± 0.50	0.25± 0.50	0.15± 0.36
	From premises	4	0± 0	0± 0	0± 0	0.25± 0.50	0.25± 0.50	0.25± 0.50	0± 0	0.50± 1.00	0± 0	0.25± 0.50	0.25± 0.50	0.25± 0.50	0.17± 0.43
	To slaughter	4	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0
Small Ruminant	To premises	7	0± 0	0± 0	0± 0	0± 0	0.14± 0.38	0.17± 0.38	0± 0	0± 0	0.14± 0.38	0± 0	0± 0	0± 0	0.04± 0.19
	From premises	7	0.14± 0.38	0.14± 0.38	0.29± 0.49	0.14± 0.38	0.71± 0.76	0.43± 0.79	0.57± 0.98	0.29± 0.76	0.43± 0.79	0± 0	0.29± 0.76	0± 0	0.29± 0.61
	To slaughter	7	0.14± 0.38	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.14± 0.38	0.02± 0.15
Mixed with Cattle on Feed[¶]	To premises	6	0.08± 0.28	0.15± 0.38	0.08± 0.28	0.15± 0.38	0.08± 0.28	0.08± 0.28	0.08± 0.28	0.08± 0.28	0.31± 0.48	0.31± 0.63	0.23± 0.60	0.15± 0.38	0.15± 0.39
	From premises	6	0.31± 0.63	0.15± 0.38	0.31± 0.48	0.46± 0.97	0.23± 0.44	0.08± 0.28	0.08± 0.28	0.08± 0.28	0.23± 0.44	0.08± 0.28	0.08± 0.28	0.38± 0.65	0.21± 0.49
	To slaughter	6	0.15± 0.38	0± 0	0.08± 0.28	0.08± 0.28	0± 0	0.08± 0.28	0± 0	0± 0	0.23± 0.44	0± 0	0.08± 0.28	0.08± 0.28	0.06± 0.25

Table 7. continued.

		N	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mixed with Stocker cattle[**,a]	To premises	16	0.04± 0.19	0.04± 0.19	0.11± 0.31	0.04± 0.19	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.08± 0.26	0.07± 0.25
	From premises	16	0.18± 0.39	0.08± 0.26	0.14± 0.45	0.14± 0.36	0.08± 0.26	0.21± 0.50	0.15± 0.35	0.25± 0.59	0.25± 0.44	0.54± 0.79	0.25± 0.44	0.46± 0.69	0.23± 0.50
	To slaughter	16	0.0± 40.19	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0.04± 0.19	0.04± 0.19	0.04± 0.19	0.01± 0.11
Mixed [§,a]	To premises	18	0.06± 0.24	0.03± 0.17	0.09± 0.28	0.03± 0.17	0.03± 0.17	0± 0	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.06± 0.24	0.03± 0.17	0.03± 0.17	0.04± 0.19
	From premises	18	0.09± 0.37	0.09± 0.28	0.03± 0.17	0.11± 0.40	0.17± 0.47	0.26± 0.61	0.23± 0.49	0.31± 0.63	0.43± 0.70	0.26± 0.51	0.26± 0.61	0.14± 0.43	0.20± 0.51
	To slaughter	18	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.03± 0.17	0.09± 0.28	0.09± 0.28	0.06± 0.24	0.03± 0.17	0.03± 0.17	0.04± 0.20
Backyard [††]	To premises	4	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0
	From premises	4	0± 0	0± 0	0.20± 0.45	0± 0	0± 0	0± 0	0± 0	0.20± 0.45	0± 0	0± 0	0.20± 0.45	0± 0	0.05± 0.22
	To slaughter	4	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0	0± 0

[*] ± values represent the standard deviation [†]Large cow-calf aggregates have 100 or more head of breeding females [‡]Small cow-calf aggregates have less than 100 head of breeding females [§]The mixed herd aggregate with cattle on feed includes all premises with cattle on feed [¶]The mixed with stocker cattle herd aggregate includes all premises that have stocker cattle and another livestock aggregate besides cattle on feed. [**]The mixed herd aggregate includes combinations of beef cow-calf, small ruminant, and/or deer livestock types [††]The backyard herd aggregate is all premises with less than 10 head of livestock [a] Significant differences in contact rates between months from the premises.

The results for distances traveled by herd aggregates had the same range as the livestock type analysis. The small cow-calf only herd aggregate moved animals off of the premises a minimum distance of 4.83 km, while the mixed herd aggregate with cattle on feed sent animals to slaughter up to 1,48.41 km away (see Table 8).

Table 8. Distances traveled in kilometers coming on to the farm, leaving the farm, and going to slaughter for each herd-aggregate.

Direct contact onto farm	N	Minimum	Mean	Mode	Maximum
Cow-calf only >=100	1	16.1	16.1	16.1	16.1
Cow-calf only <100	0	.	.	.	.
Stocker cattle only	0	.	.	.	.
Small ruminant only	2	5.3	54.6	53.6	107.3
Mixed with Cattle on Feed	1	20.1	368.9	402.3	563.3
Mixed with Stocker cattle, not Fed cattle	4	52.3	154.2	148.9	241.4
Mixed without Stocker or Fed cattle	1	6.1	46.8	60.4	60.4
Backyard	0	.	.	.	.
Direct contact off of farm					
Cow-calf only >=100	5	14.5	100.6	32.2	278.9
Cow-calf only <100	9	4.8	21.9	24.1	48.3
Stocker cattle only	1	22.5	501.0	740.3	740.3
Small ruminant only	3	2.7	52.8	53.6	90.1
Mixed with Cattle on Feed	2	6.4	58.4	40.3	321.9
Mixed with Stocker cattle, not Fed cattle	13	4.83	172.2	88.5	804.7
Mixed without Stocker or Fed cattle	5	10.8	65.0	32.2	152.9
Backyard	1	4.4	4.4	4.4	4.4
Terminal contact					
Cow-calf only >=100	0	.	.	.	.
Cow-calf only <100	0	.	.	.	.
Stocker cattle only	0	.	.	.	.
Small ruminant only	0	.	.	.	.
Mixed with Cattle on Feed	1	402.4	1448.4	402.4	1448.4
Mixed with Stocker cattle, not Fed cattle	2	64.4	86.9	65.5	108.6
Mixed without Stocker or Fed cattle	0	.	.	.	.
Backyard	0	.	.	.	.

Livestock producers reported seeing wildlife from twice a day for white tailed deer to once every three days for exotic wildlife and javelina. Feral hogs were seen

approximately once a day. Group sizes seen were reported up to 200 large, but most commonly ranged from 2 to 6 animals for all wildlife species.

County agents

All County Extension Agents returned completed surveys. Cow-calf and small ruminants were estimated to be the most represented livestock types in the study area, according to County Extension Agents, with approximately 260,000 head of beef cows, 258,000 goats, and 18,500 sheep reported. Eight of the counties reported an estimated total of 162,000 stocker cattle and 54,000 cattle on feed. A small number of swine (350 head) and virtually no dairy cattle were believed to be in the study area.

Approximately 30.7% of cow-calf operations in the study area estimated to have deer or exotic hoof stock. Sheep or goats were estimated to be present on almost 12.5% of the cow-calf operations. Thirteen percent of cow-calf operations were estimated to also have stocker cattle and six percent had cattle on feed.

Approximately 40% of premises were likely to have owners who lived in town. It was estimated that 15.4% of the premises in the area employed additional workers and 51% of those employees had livestock of their own.

County Extension Agents reported that approximately 30.5% of livestock coming into their county came from an adjacent county and another 55.3% came from other counties in Texas. Animals coming from other states and countries constituted 8.0% and 6.2%, respectively. For counties that did not have a sales barn (n=6) in the study area, County Extension Agents reported that 60.7% of livestock went to sales barns outside of the county with the remainder going to other herds, feedlots, or slaughter facilities

outside of the county, 12.8%, 10.5%, 16.0%, respectively. Three counties had a sales barn, and approximately 37.7% of the livestock from those counties were marketed there. Livestock from counties with sales barns were marketed outside of the county to sales barns 33.4% of the time, other herds (5.2%), feedlots (10.9%), and slaughter facilities (12.8%); 28% of livestock were marketed within these counties.

County agents reported that, generally, beef cow-calf producers (23.1%) weaned calves in October, which coincided with the time there was the most shipments to stocker operations (35.0%). Most hunting of deer and exotics occurred during the November to January regulated deer hunting season although there was some during other months due to special hunting seasons and the lack of hunting seasons on exotic hoof stock. Most of the sheep and goat premises weaned lambs or kids between March and September. For both beef cattle and sheep and goats, most movements to livestock shows occurred in January (see Table 9).

Table 9. County agent estimates of percentage of premises going through each production phase per month.

Beef	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Tot**
Receive Breeding	0.8	25.2	21.8	9.2	5.0	1.7	1.7	1.7	10.1	5.0	16.8	0.8	100
Weaning	0.1	0.1	2.0	11.9	15.0	15.6	5.0	6.9	11.3	23.1	8.9	0.1	100
Ship to stocker	12.5	0.0	5.0	2.5	3.8	0.0	5.0	2.5	8.8	35.0	12.5	12.5	100
Ship to feed yard	2.8	10.6	20.6	7.8	22.7	0.0	0.0	0.0	12.8	17.0	2.8	2.8	100
Livestock Show	82.5	8.3	5.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	1.7	100
Cull breeding	0.0	15.7	1.4	1.4	22.9	7.1	7.1	0.0	10.7	26.4	7.1	0.0	100
Deer & Exotics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Tot**
Hunting	24.1	1.9	0.4	0.3	0.3	0.1	0.1	0.1	0.6	2.5	29.1	40.5	100
Ship to Auction	2.5	2.5	12.5	27.5	27.5	2.5	2.5	2.5	2.5	12.5	2.5	2.5	100
Ship to other herds	9.0	9.0	9.0	21.0	1.0	1.0	1.0	11.0	11.0	25.0	1.0	1.0	100
Commercial Slaughter	12.5	0.0	0.0	12.5	37.5	0.0	0.0	0.0	0.0	12.5	12.5	12.5	100
Sheep & Goats	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Tot**
Receive breeding	0.0	1.7	12.5	6.7	0.0	3.3	4.2	24.2	22.5	15.0	5.0	5.0	100
Weaning	1.1	1.1	11.6	9.7	10.7	26.4	7.6	15.7	11.1	2.6	1.1	1.1	100
Ship to feed yard	20.0	0.0	6.6	8.0	13.0	17.0	2.0	33.4	0.0	0.0	0.0	0.0	100
Livestock show	67.4	11.6	9.1	0.6	0.0	0.0	0.0	1.3	3.8	2.5	2.5	1.3	100
Cull breeding	0.0	0.0	15.8	15.0	3.3	28.3	8.3	4.2	25.0	0.0	0.0	0.0	100

Auction barns

Three of the seven auction barns (42.9%) within 50 km of the study area participated in a face-to-face interview. Combined, the three sold an approximate 358,000 head of animals in an average year, with numbers reportedly consistent from month to month. All auction barns sold cattle to feedlots, stocker operations, cow-calf

ranches, and slaughter facilities. Two of the barns sold slaughter goats and one of those also sold sheep and goats to producers as replacements. One facility also sold a small number of exotic hoof stock and some swine. Sales were held once a week except for one facility that had twice weekly sales and one special sale per month. Approximately 69% of animals (standard deviation was 12.6, range of 60 to 78%) came from within a 72.4 km distance of each sale barn (standard deviation was 17.1, range of 56.3 to 80.5) and would be transported from 1.6 to more than 965.6 km from each barn. A majority (73.3% (standard deviation was 46.2, range of 20 to 100%)) of livestock sold through the auction barns came directly from farms and ranches in the area, with the remainder (26.7% (standard deviation was 46.2%, range of 0 to 80%)) coming from stocker operations. Approximately 57.3% (standard deviation was 39.1, range of 23 to 100%) of the livestock sold went back to farms and ranches with the remainder going equally to feedlots or slaughter facilities and a small percentage (<1%) going to other auction barns.

Veterinarians

Three veterinarians that were mailed surveys responded that they were no longer involved in livestock medicine, five (45.5%) completed questionnaires, and the remainder did not respond. The respondents indicated that beef cow-calf work made up the greatest amount of their livestock practice both in terms of appointments in the clinic (average 12.1 visits per month, standard deviation 8.3, range 1 to 40) and calls to the farm (average 8.5 visits per month, standard deviation 5.3, range 0 to 40). Sheep, goats, and exotics constituted most of the remainder of in clinic appointments. Beef cattle calls

on the farm were divided between cow-calf premises (average 9.0 calls per month, 5 veterinarians), stocker operations (average 2.0 calls per month, 2 veterinarians) and feedlots (average 19 calls per month, 1 veterinarian). Swine comprised a small number of calls and appointments generally between October and March (less than 8 per month for one veterinarian). Approximately 80% of clients brought animals in from a 56.3 km radius, but they did come from as far as 0.8 km to 177 km. The radii for farm calls extended from 0.8 km to 643.7 km for some practices, but the average farm call was within 48.3 km.

DISCUSSION AND CONCLUSIONS

The nine-county study area in Southwest Texas was selected as a representative extensive livestock management area. There are at least three ecological areas from the fertile Rio Grande plains through what is known as the Hill Country to the drier Edwards Plateau.[43] It borders an international border with Mexico and is in close proximity to a large metropolitan area. This allows observations to be made concerning cross-border movements[12] of animals and the effect that cities have on premises and potentially the spread of disease. Animal movements from Mexico, as indicated by County Extension Agents, may not be as apparent for other areas. Additionally, the area had notable populations of beef cattle and small ruminants,[48] the two primary extensively managed livestock types. It is unlikely that this study area is representative of all extensive livestock areas in the United States, but some of the aspects that differ between extensive and intensive livestock management, such as multiple livestock types on a premises and seasonal changes in density and contact rates, could be applicable and should be studied in other low-density livestock areas. Spatial modeling of disease spread or animal movements in an extensive setting is benefited by knowledge of what borders a premises along with the management factors on the premises itself. Important information concerning seasonal changes in livestock densities and the number of livestock types on premises may be expected to impact the results of FMD models.

The target population for this study was all the livestock producers in each of the nine counties in the study area. In order to obtain a random sample, or a stratified

random sample, from the target population, the total number of livestock producers in the study area and their mailing addresses would be needed. However, such a list was not available. The most complete lists of the number of livestock producers in the study area would likely be the ones provided by the USDA National Agricultural Statistics Service (NASS) 2002 Census of Agriculture. Although sampling from the list of livestock producers included in the NASS 2002 Census of Agriculture likely would have provided us with the most representative sample from the target population, the NASS mailing lists were not available for this study. Instead, a list of producers that had attended county agent meetings was used as the sampling frame. As surveys were mailed to all the livestock producers on the county agent lists, livestock producers on these lists comprised the study population. The county agent lists included all the different types of livestock producers included in the study. However, the lists only included approximately 9% of the number of livestock producers in the study area as compared to the NASS 2002 Census of Agriculture. Furthermore, it was unknown how representative the county agent lists were of the different livestock producers in the study area. For example, the proportions of cow-calf producers sampled could be larger than the proportion of small ruminants producers sampled. Furthermore, and perhaps more importantly, within the population of different livestock producers, the county agent lists could over-represent or under-represent large or small herds. In other words, the internal validity of the study could be affected, and the study population is a potentially biased sample of our target population. In addition, the response rate to our surveys was lower than 70%,[49] and selection bias could have been introduced as well.

The reasons why some producers did not respond to the survey were not ascertained. Because different surveys were used for each livestock type an information bias could be present in comparisons between livestock types, however procedures used to survey each producer was consistent among all livestock types.

Since selection of a stratified sample of all producers in the target population was not possible, all available producers in the study population received a survey. Although not done, post-stratification could be performed by livestock type or by livestock type within county in order to obtain more precise point estimates of contact rates. Livestock type alone could be used as a post-stratification variable, but there would have been too few observations if the data were stratified by livestock type within county. If post-stratification were to be done, the total number of producers with each livestock type in the study area would have to be ascertained. The NASS census data is the best approximation of the total livestock numbers in the area, but that also is just an estimate of the true number.[29] Furthermore, the total number of premises in the county is less than the sum of the number of farms with each livestock type reported in the census.[42]

We assumed, for this study area, that the movement of animals occurred on one day to or from one other premises and contacts were made with only one other premises at each movement. We believe that this is a reasonable estimate of animal movement in a month since in extensive settings; animals would have to be gathered from pastures which take time and man power. For this reason, many producers would try to maximize their efficiency by gathering livestock as few times as possible and moving them in groups. Furthermore, with a few animals (<50 head) typically being moved each month

from each premises and most of the contacts occurring at sale barns, it is unlikely that a producer would take cattle to multiple sale barns on the same day. The absolute maximum number of potential contacts per month would be equivalent to the number of animals moved each month each going to separate premises on different days, which could be modeled as a cumulative incidence of contact.[12] This was likely not the case in our study area because most livestock are managed and moved in groups to maintain some level of consistency in production. It is probable that in low density livestock areas, when animals are moved between premises, that movement occurs on one day for most livestock premises.

Extensively managed settings may be characterized by seasonal changes in livestock densities and contact rates. Other studies have attempted to capture seasonal variation by taking measurements during a "busy" period and during a "slow" period.[27] As opposed to intensively managed livestock, especially dairies and feedlots, where producers may strive for constant production over the year, extensively managed livestock is managed to; theoretically, make the best use of forage. The availability of forage may vary from month to month. Because of the variability in forage, the number of animals that one premise can support may vary by month or year. In addition to forage availability, birthing seasons and weaning seasons add to the seasonal variation in livestock numbers. Livestock are naturally seasonal breeders in that they have evolved to conceive and give birth to offspring at times when the chance for their survival is the highest and when forage most abundant. While there may be some fluctuation from the natural breeding season in order to take advantage of market prices, densities and

movements at the very start of the ruminant livestock production chain (which is typically extensively managed) can be seasonal.

Movements of animals in extensive settings are associated with various production practices that dictate when animals can be moved. Movement of animals off of the premises peaked in the fall months (September to November) for beef cow-calf premises and in the summer months (May to August) for small ruminants, but there were movements during other months as well. When we looked specifically at large cow-calf premises, three peaks could be identified in March, June, and November, which could coincide with often used deworming schedules.[50] Direct contacts off of premises from cow-calf or small ruminant operations peak at weaning time when the offspring are old enough to remove from their mothers.[33] Breeding stock also moves off of the premises for production reasons (i.e. they did not get bred), lack of forage, illness, injury, or age.[33] Movements of stocker cattle and cattle on feed occur when they are large enough or in good enough body condition to move to the feedlot or abattoir. Stocker cattle are usually moved onto premises when grass is available which could vary from premises to premises, and there is an expected peak for summer pastures and another peak for winter pastures. With the seasonal trend in supplemental feeding, there may be times of the year when susceptible animals are clustered closer together on premises. This seasonal change in feeding practices may indicate periods of the year when disease transmission is more likely.[51]

In extensively managed agricultural settings, different variables affect the density and distribution of livestock within premises when compared to intensively managed

agricultural systems. Producers in extensive agricultural settings manage livestock based on forage type and availability, terrain, climate, and economic factors. For example, multiple livestock types may be managed on single premises to optimize forage utilization and the economic return. This is in sharp contrast to primarily intensively managed operations, such as dairies and feedlots, in which only one livestock type is typically present. Where only one livestock type is involved, animal density and contact rates can be approximated for premises based on that one livestock type. When there are multiple livestock types on premises, they may be managed as separate herds in which the contacts between one livestock type are completely independent of the other livestock types on the premises. The alternative would be for contacts to be defined on the premises level where contact made by one livestock type is a contact for all other livestock types on the premises. The dilemma of how to define premises arises because premises could be defined by all of the livestock types present, the predominant livestock type, or the presence of important livestock type combinations. As the number of possible livestock types increases, the number of combinations can increase exponentially, however if just the predominant livestock type or important livestock type combinations are used, data could be lost and there could be uncertainty concerning what constitutes an important livestock type. It is not known whether the effect of having more than one livestock type on animal density and contact rates is additive or if there is interaction between the livestock types that influences the management on the premises. Because of the sample size, sampling methods in this study and the numerous

combinations of livestock types found, we were unable to accurately determine this effect.

Multivariate analysis methods (factor and cluster analyses) may be used to combine the possible livestock type combinations into similar categories for modeling and decision support purposes so that any effect of having more than one livestock type on a premises can be taken into account. Factor analysis is a statistical technique for data reduction while cluster analysis is an exploratory data analysis technique to determine natural groupings of observations.[46] Meigs (2000) found factor analysis to be a useful method for understanding patterns in the co-occurrence of risk factors, but the subjective nature of the approach was recognized.[52] Factor analysis was used in another study to show that a risk assessment instrument could be reduced in length without loss of information.[53] Basically, factor analysis is a method where by similar variables can be grouped into factors based on their communality. Cluster analysis, on the other hand, has been used to group similar individuals in genomics,[54,55] microbiologic, and marketing research.[56] We attempted to use these methods to group the various combinations of livestock types into a manageable number of groups to evaluate the effect that multiple livestock types on a premises has on the animal density, but no definitive groupings could be established.

The idea of multiple livestock types on premises extends beyond our study area. The USDA National Animal Health Monitoring System (NAHMS) reported that 85.1% of cow-calf premises had some other animal species on the premises.[31] Dogs, cats, and horses were the largest groups represented. Swine were present on approximately 9.3%

of cow-calf premises, sheep on 4.5%, and goats on 5.1%.[31] Though the number of premises with horses is approximately the same between our study and the NAHMS 1997 Beef Report,[31] we found a smaller percentage of dogs kept on the premises which is possibly due to the proportion of absentee owners as reported by County Extension Agents, but absentee ownership was not ascertained on the producer surveys. In our study area, 52.8% of the beef cow-calf premises had another livestock type. According to the 1997 NAHMS Beef Management Practices Report, approximately 25% of beef cattle premises had some other livestock type present on the premises.[31] There were a larger number of premises in our study area that had beef cattle as well as sheep and goats compared to the NAHMS study which could be explained by the amount of brush land in our study area which sheep and goats could browse. Because our study area is substantially smaller and contained a more homogenous land cover than the NAHMS survey, we may have a concentration of beef cattle premises with sheep and goats or other livestock types. Additionally, our sample estimates of beef cow calf premises also having other livestock types were higher than expected by County Extension Agents. This could indicate a biased sample due to producers who have multiple livestock types being more willing to participate in studies such as ours.

In a previous study in a primarily intensive setting, the spatial location of livestock premises was available.[11] These data are available for most premises that can be defined by barns or pens; however, they are not widely available in extensive settings where premises are defined by pastures and are not required to disclose their location for environmental quality purposes. The information reported here concerning the borders of

premises and roads separating premises can help to spatially allocate premises when the actual location is not known. The observed shift in the mean center of the premises when weighted by acreage further south and west, away from San Antonio, supports the hypothesis that larger premises tend to be farther from cities or metropolitan areas. The shift in the density-weighted mean center indicates that drier areas, with less topsoil thus lower forage production require more land per animal compared to areas with more fertile soils. The information reported here concerning the borders of premises and roads separating premises can help to spatially allocate premises when the actual location is not known. Knowing how premises are distributed in an area based on acreage, animal numbers, and livestock type could also serve to develop algorithms that then could be used to allocate premises when their location is unknown. Furthermore, land cover, borders, and proximity to roads and cities may be used to develop such algorithms. This ability might be more useful to extensively managed premises than it would for large dairies or cattle feedlots.

The average acreage by livestock type was highest for cattle on feed, but cattle on feed were also managed together with other livestock types in the study area. Since cattle are typically fed in pens and more intensively managed, our data suggests that larger premises are more likely to have cattle feeding components to their operation as opposed to cattle on feed actually being managed on that many hectares. The actual density of each livestock type could be improved if the amount of land dedicated to each was determined. Additionally, because 5 to 7 sheep, goats, or deer consume as much

forage as a single cow-calf pair,[57] their density on pastures could be expected to be higher than cattle.

Aside from the intentional movement of livestock between premises, susceptible wildlife species may carry FADs between premises within their home range. While, Bates et al. (2001) determined that the number of wildlife contacts were not significant in their intensively managed study area,[11] all premises in our study area reported observed wildlife very frequently within 150 m of their livestock. The most commonly seen wildlife was whitetail deer (average of twice per day) with feral swine seen (approximately every day). Producer reported frequencies for seeing wildlife within 150 m of livestock was used as an indirect measure of how often wildlife was in contact with livestock. The exact distance that is important for disease transmission is not known and varies with the disease. In determining watering locations and supplemental feeding practices, potential livestock-wildlife interfaces were discovered. In the NAHMS Beef Management Practices Report, deer were most commonly seen near livestock.[58] Approximately 80% of beef cow-calf premises in the NAHMS survey reported that deer were in contact with livestock, feed, or water sources.[58] In low density livestock areas where there is a higher density of wildlife, the interaction between livestock and wildlife may be significant in spreading FADs and other diseases from premises to premises. Where infectious diseases of livestock are of concern, wildlife (e.g. deer and feral hogs) could become important[40] because wildlife may become infected with some of the same diseases as domestic livestock. In the face of a foreign animal disease introduction, wildlife may become an important reservoir for disease.

Deer and exotics are a special definition of livestock type in our study area. Wildlife enclosed by high fences supplemented many ranch incomes because of their value for hunting. Native wildlife species (e.g. white- tailed deer) are regulated by the Texas Parks and Wildlife Department.[47] Many of the contacts for the high-fenced deer and exotics livestock type were influenced by these regulations as most movements were during the hunting season between October and February. Additionally, most movements involved hides or meat as opposed to live animals. There was a low level of direct contacts during the remainder of the year due to hunting of non-regulated wildlife.

Cattle on feed, in this study area, were associated with co-production of beef cow-calf production, stocker production, or both. The lack of direct contacts coming to this livestock type may indicate that calves are born on the premises, moved through a stocker cattle pasture, and then into the feedlot all under the same owner's management. Conversely, the cattle to be fed can all be bought at one time, fed out, or sold at one time with no additions to the feedlot for the time with no additions to the feedlot for the time where there are animals present.

To further improve the information available in the area, alternative sources of information on movements of animals were explored. Veterinarians and County Extension Agents were the most important sources of information for livestock producers, and most beef cow-calf producers sold animals through auction barns.[33] They can serve as comparisons to producer data, USDA reports, and other studies.

Questioning the County Extension Agents in the study area created a link between the USDA NASS census of agriculture and livestock producers since the census

was agglomerated to the county level and county agents have a relationship with producers in their county. Some discrepancy existed between the 2002 census of agriculture and our study. This may be explained by the fact that conditions in the area changed over the three years between our survey and the census. Climate changes, forage availability, and market prices during the intervening period may have lead to producers buying or selling animals. Furthermore, the NASS census is based on livestock numbers on the first of December, while our study looked at animal numbers over a typical year. County agents may know of more animals that are not reported on the census as it only includes farms with greater than $1,000 in expected sales.[48] The census also reports statistics on individual livestock types, which may differ from data collected on premises with multiple livestock types. The average size of farms sampled in this study (4,828 hectares) is greater than the average of 750 hectares reported for the study area by the USDA Census. The median for our sample was 445 hectares which does suggest that there may have been a few large premises that increased the average acreage. This could indicate that smaller producers were more likely to respond to our surveys or were over-represented on the compiled mailing lists that we used. However, larger and possibly more progressive producers also participated. County Extension Agents reported that the highest percentage of cattle producers weaned calves in October and the most shipments to stocker operations occurred from October to January. These two production phases coincided with the months that beef cow-calf producers reported the highest number of movements off of their premises and stocker cattle producers reported the highest number of movements on to their premises. County Extension

Agents and small ruminant producers both reported that weaning and movements off of the premises occurred from May to September. County Extension Agents could be a valuable source for determining seasonal variations in livestock movements, since the data obtained from surveying them agreed well with surveys of livestock producers. For examples, County Extension Agents indicated that a large proportion of beef cow-calf producers would wean cattle in October and ship cattle to stocker operations, and many producers did actually ship most of their weaned calves in October. Auction barns reported that most cattle came from and returned to farms and ranches, and veterinarians were able to report how often they were in contact with livestock premises. While this kind of data may be biased by the agent's, veterinarian's, or auction barn manager's perceptions compared to information obtained directly from producers, it can help to approximate contact rates when they are unknown.

Veterinarians and County Extension Agents were the most important sources of information for livestock producers, and most beef cow-calf producers sold animals through auction barns.[33] County Extension Agents with the Cooperative Extension Service were able to describe season of animal movements close to what was reported by producers. Auction barns reported that most cattle came from and returned to farms and ranches.

Study limitations

Some discrepancy between the numbers obtained from the 2002 census of agriculture and our study may be explained by the fact that conditions in the area changed over the three years between our survey and the Census. The census also reports

statistics on individual livestock types, which may differ from data collected on premises with multiple livestock types. Differences between different groups in our study (i.e. livestock producers, County Extension Agents, veterinarians, and auction barn managers) may indicate some underlying biases.

The response to the general survey (33.1%) and the livestock type specific surveys (26.7-55.1%) was comparable to similar studies,[11] but below the 75% coverage rate that is obtained by the NASS Census of Agriculture.[29] However, a survey response less than 70 to 80% is suspect of bias due to self-selection of the participants who might have different management than those who did not participate.[49] The sampling frame for this study included attendees of county-level agricultural meetings which could be viewed as more progressive and willing to participate in such a study compared to other livestock producers in the area. Because a low response rate was anticipated and mailing addresses for all livestock producers in the nine-county area was un-obtainable, all livestock producers on our mailing lists were contacted in lieu of a sample being taken. We informed county agents with the Texas Cooperative Extension Service of the research we were doing and it's potential for impact on preventing and controlling FAD outbreaks. Because they are a common source of information for livestock producers, they served as local liaisons that could further educate producers to the benefits of participating in the study. Additionally, newspaper articles and an interview on local farm radio served to get information about the project distributed. We speculate that our response rate was positively influenced by the fact that participants were aware of the study prior to receiving a survey. Although the survey was conducted under the

condition of anonymity, recipients may have perceived an invasion of privacy. Because of the quantity of information, some producers may have decided to not complete the survey forms.[11] Additionally, because farmers and ranchers receive many surveys during the year, they may have taken the stance to only complete those surveys which they are required to by law.[11] However, given the rationale for gathering this data was to improve the protection of livestock in the face of an FAD outbreak; some producers may have been persuaded to respond when they otherwise would not have. As in previous studies,[11] the extent and nature of the bias due to non-responders is unknown. Even though NASS statistics and county agent estimates are available, without a full enumeration of the livestock producers in the area, the degree to which the sample represents the population can only be estimated.

Recommendations for future studies

While this study yielded several results similar to previous studies, it clarifies several particular aspects of extensive livestock management that have not previously been reported. Further studies may be used to investigate the effect other livestock types may have on the contact rate for various combinations of livestock types. Because of the number of combinations of livestock types in our study area, there were insufficient numbers of premises to model the contact rate for each combination. A larger study or a study that is more specifically targeted at certain livestock producers would allow these estimates to be obtained. Additionally, with a larger study, some of the seasonal variations in livestock movements observed in our study may exhibit statistical significance.

It is also possible to use the information from this study to help livestock producers understand bio-security issues that they may have on their premises. Given the livestock type, animal density, number of direct and indirect contacts, season of contacts, and other parameters, a biosecurity grading scale could be created to illustrate where improvements to biosecurity could be made.

Summary/Conclusion

Knowledge of the livestock density and distribution in the study area will aid in responding to natural disasters or foreign animal disease outbreaks by allowing decision makers to plan responses. Our data will improve infectious disease modeling that is currently being conducted for the study area. It is unlikely that this study area is representative of all extensive livestock areas in the United States, but some of the aspects that differ between extensive and intensive livestock management, such as multiple livestock types on a premises and seasonal changes in density, could be applicable and should be studied in other low-density livestock areas. The fact that multiple livestock types are managed on one premises could impact the interpretation of future studies and infectious disease modeling efforts. Additionally, the apparent seasonal movement of animals may have an impact on future models and the disease spread in general. Spatial modeling of disease spread or animal movements in an extensive setting is benefited by a knowledge of what borders a premises along with the management factors on the premises itself. This study provides foundation for further studies into biosecurity and infectious disease modeling for decision support systems to help protect livestock in extensively managed settings.

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APPENDIX I

GENERAL PRODUCER SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS-General Questions

Responses will remain strictly anonymous (See the introductory letter for details).

The purpose of this survey is to gather general information about your operation. Species specific questions will be sent to you upon receipt of this survey.

1. Did you within the past 12 months own or raise:

a.	beef cattle?	❑ No	❑ Yes, number of heifers and cows?	_____
b.	stocker cattle?	❑ No	❑ Yes, number of calves?	_____
c.	cattle on feed?	❑ No	❑ Yes, number of head?	_____
d.	sheep?	❑ No	❑ Yes, number of ewes?	_____
e.	goats?	❑ No	❑ Yes, number of does?	_____
f.	high-fenced deer or exotics?	❑ No	❑ Yes, number of head/acre?	_____
g.	dairy cattle?	❑ No	❑ Yes, number of heifers and cows?	_____
h.	domestic swine?	❑ No	❑ Yes, number of gilts and sows?	_____

2. How many acres do you own? _____;lease? _____

3. How many acres that you own or lease are improved pasture? _____; native rangeland?_____; cultivated land? _____

4. How many different locations separated by a public road do you have animals on? (Please include both properties that you own and lease).

❑ 0 ❑ 2 ❑ 3 ❑ 4 ❑ 5 or more

5. What kind of road(s) separate(s) your property? (Please check all that apply).

❑Private ranch road ❑County maintained dirt/rock road ❑County maintained asphalt road
❑Two lane highway ❑Four lane highway ❑Other_____

6. How many of the properties on which you run livestock are more than one (1) mile apart? (Please include both properties that you own and lease)?

❑ 0 ❑ 2 ❑ 3 ❑ 4 ❑ 5 or more

7. What borders your premises? (Please check all that apply)

❑Other livestock premises ❑ River/Stream ❑ Housing Development
❑County maintained road ❑Highway ❑Other_____

8. How many employees, including yourself and family members, (full-time and part-time) work on your premises regularly?

(Please fill in the space) _____ Total employees

9. <u>What is the greatest number of employees</u>, including yourself and family members, that work on your premises?

(Please fill in the spaces or check box)_____ Total employees _____ Season/dates
❑ Does not apply

10. How many employees who work on your premises <u>also raise cloven-hoofed livestock (cattle, sheep, goats, pigs, llamas, bison, etc.) of their own</u>?

(Fill in space or check box)_____Number of employees ❑ Don't know

11. How many horses are kept at your premises?

(Please fill in the space or check box) _____ Total horses ❑ Does not apply

12. What is the maximum number of horses brought to your premises? ❑ Does not apply

(Please fill in the spaces or check box)_____ Total horses_____ Season/dates

13. How many horses that have been on your premises, go to <u>shows, rodeos, or other ranches</u>?

(Please fill in the space or check box) _____ Total horses ❑ Does not apply

14. How many herding dogs do you have?_____; **guarding dogs?**_____;

dogs to track game? _____ ❑ Does not apply

15. What is the maximum number of dogs used to track livestock? ❑ Does not apply (Please fill in the spaces or check box)_____ Total dogs_____ Season/dates

16. How often is your livestock seen within 500 feet of the following wildlife? (Fill in the number of times each type of animal is seen in the most appropriate space per row)

Type of Animals	Never	Times seen per DAY	Times seen per WEEK	Times seen per MONTH	Times seen per YEAR
Example: Javelina	❑		*3*		
Whitetail deer	❑				
Javelina	❑				
Feral swine	❑				
Exotics	❑				
Other_____	❑				

17. What is the minimum, most common, and maximum group size for each species of wildlife seen within 500 feet of your livestock? (Fill in the number of times each type of animal is seen in the most appropriate space per row)

	N/A	Minimum group size	Most Common group size	Maximum group size
EXAMPLE - Javelina	❑	*10*	*25*	*50*
Whitetail deer	❑			
Javelina	❑			
Feral swine	❑			
Exotics	❑			
Other_____	❑			

18. How many hunters, including yourself and family members, hunt on your premises?
(Please fill in the space) _____ Total hunters

19. How many hunters who hunt on your premises <u>raise cloven-hoofed livestock (cattle, sheep, goats, pigs, llamas, bison, etc.) of their own</u>? (Fill in space or check box)_____Hunters ❑ Don't know

20. How many of the following species are removed from your property through hunting? (Please fill in the number of times an animal is taken in each month of an average year) ❑ Does not apply

Month / Animal	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE – Whitetail deer	❑	*3*										*1*	*4*
Whitetail deer	❑												
Feral hogs	❑												
Javelina	❑												
Exotic hoof stock	❑												
Other, specify_____	❑												

21. How often do live animals leave your ranch to an out of state location? (Fill in the most appropriate space with the number of head)

	Never	Per day	Per week	Per month	Per year
Number of head	❑				

22. How often do you receive animals from another state or country? (Fill in the most appropriate space with the number of head)

	Never	Per day	Per week	Per month	Per year
Number of head	❑				

23. Which months of the year do the following visit your farm? (Please fill in the number of times a person visits in each month of an average year)

Person \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE – A.I. breeder	❑		*25*	*30*	*20*	*10*							
A.I. breeder	❑												
Veterinarian	❑												
Farrier/Hoof trimmer	❑												
Agency Personnel (i.e. Extension, NRCS)	❑												
Other, specify:_____	❑												

24. If artificial insemination is performed, where do you receive semen from? (Please fill in the number of doses per source used each month) ❑ Does not apply

Location \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Out of state	❑		*26*	*36*	*20*	*18*								*100*
Out of state	❑													
Internationally	❑													
Texas	❑													
Own sires	❑													
Other, specify:_____	❑													

25. Which months in a year do the following visit your farm? (Please fill in the number of times an activity occurs in each month of an average year).

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE – Feed/hay truck	❑	*4*	*2*									*5*	*3*
Feed/hay truck	❑												
Animal hauler	❑												
Drugs/sales reps	❑												
Manure hauler/spreader	❑												
Dead animal pickup	❑												
Door-to-door delivery (e.g. UPS)	❑												
Milk Truck	❑												
Other, specify:_____	❑												

26. Which months in a year do you/your employees go to any of the following premises other than your own?
(Please fill in the number of times an activity occurs in each months of an average year)

Activity \ Month	Never	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE - Dairies	❑	2	2	3	2	5	6	6	5	3	2	2	2
Dairies	❑												
Beef ranches	❑												
Swine premises	❑												
Slaughterhouses	❑												
Livestock shows/Auctions/sale yards	❑												
Goat or sheep premises	❑												
Other, specify:_____	❑												

27. In the months marked under question 26, what are the minimum, most common, and maximum distances that you/your employees travel to the following premises other than your own? (Please check box or fill in the most appropriate non-shaded space per row)

		Minimum Distance	Most Common Distance	Maximum Distance
	N/A	Miles	Miles	Miles
EXAMPLE – Dairies	❑	10	25	50
Dairies	❑			
Beef ranches	❑			
Swine premises	❑			
Slaughterhouses	❑			
Livestock shows/Auctions/sale yards	❑			
Goat or sheep premises	❑			
Other, specify:_____	❑			

28. Do you supplement animals on pasture and/or wildlife with feed or hay? (Please fill in the number of times an activity is performed in each month of an average year, if applicable). ❑ Does not apply

Feedstuff \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE – Round bales, hay rings	❑	16	8									4	10
Round bales, hay rings	❑												
Round bales, unrolled	❑												
Square bales	❑												
Range cubes/grain/mineral/protein pellet,fed in trough	❑												
Range cubes/grain/mineral/protein pellet,fed on ground	❑												
Mineral blocks	❑												
Automatic feeder (Please give number of feeders)	❑												
Self feeder (Please give number of feeders)	❑												
Other, specify:_____	❑												

29. Where do your animals drink? (Please fill in space or check all that apply).

❑Individual waterer ❑Water trough, in pens ❑Water trough, in pasture
❑Stock tank/pond ❑Stream/creek/river ❑Other_____

APPENDIX II

BEEF CATTLE SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Beef Cow-Calf Survey
Responses will remain strictly anonymous (See the introductory letter for details).

This survey only contains questions specifically related to your beef cattle operation.

1. How would you classify your herd? (Please fill in the number of head you have in each category each month of the year).

Code No.	Category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
01	EXAMPLE – Purebred cows/heifers	❑	250												
01	Purebred cows/heifers	❑													
02	Purebred bulls	❑													
03	Commercial cows/heifers	❑													
04	Commercial bulls	❑													
05	Calves, not weaned	❑													
06	Calves, weaned	❑													
07	4-H/FFA Show cattle, for exhibition	❑													
08	Other, Specify_____	❑													

2. Which months in a year do you do the following with WEANED CALVES? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE – Ship to sale barn	❑								10	45	40	5		100
Ship to sale barn	❑													
Ship directly to feed yard	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Keep in the herd (month entered herd)	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that WEANED CALVES traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to sale barn	❑	10	10	85	25	5	50
Ship to sale barn	❑						
Ship directly to feed yard	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Other, specify:_____	❑						

4. Which months in a year do you do the following with CULL COWS AND BULLS? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sale barn	❑		20				80							100
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common and maximum distances that CULL COWS AND BULLS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to sales barn	❑	20	10	70	25	10	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Ship directly to slaughter	❑						
Other, specify:_____	❑						

6. Which months in a year do you receive BREEDING CATTLE? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑									20	20	40	20	100
From Sale barn	❑													
From Seedstock producer	❑													
From Purebred producer	❑													
From Commercial ranch	❑													
Other, specify:_____	❑													

7. In the months marked under question 6, what are the minimum, most common, and maximum distances that BREEDING CATTLE traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	20	10	60	25	20	50
From Sale barn	❑						
From Seedstock producer	❑						
From Purebred producer	❑						
From Commercial ranch	❑						
Other, specify:_____	❑						

8. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (All information you provide will remain strictly anonymous)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX III

STOCKER CATTLE SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Stocker Cattle Survey
Responses will remain strictly anonymous (See the introductory letter for details).
This survey only contains questions specifically related to your stocker cattle operation.

1. How would you classify your herd? (Please fill in the number of head you have in each category each month of the year).

Code No.	Category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
10	EXAMPLE – Stocker cattle	❑	250												
10	Stocker cattle	❑													
07	4-H/FFA Show cattle, for exhibition	❑													
08	Other, specify_____	❑													

2. Which months in a year do you do the following with STOCKER CATTLE? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sales barn	❑		50	50										100
Ship to sales barn	❑													
Ship directly to feed yard	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Keep to feed out	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that STOCKER CATTLE traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sales barn	❑	10	10	50	25	40	50
Ship to sales barn	❑						
Ship directly to feed yard	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Other, specify:_____	❑						

4. Which months in a year do you receive STOCKER CATTLE? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total.
EXAMPLE – From Sale barn	❑									*10*	*10*	*80*		*100*
From Sale barn	❑													
From Contract buyer	❑													
From Private contract/treaty	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common, and maximum distances that STOCKER CATTLE traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*10*	*10*	*80*	*25*	*10*	*50*
From Sale barn	❑						
From Contract buyer	❑						
From Private contract/treaty	❑						
Other, specify:_____	❑						

6. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (All information you provide will remain strictly anonymous)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX IV

CATTLE ON FEED SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Cattle on Feed Survey
Responses will remain strictly anonymous (See the introductory letter for details).

This survey only contains questions specifically related to your operation with cattle on feed.

1. How would you classify your herd? (Please fill in the number of head you have in each category each month of the year).

Code No.	Category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
09	EXAMPLE – Cattle on feed	❑	250												
09	Cattle on feed	❑													
07	4-H/FFA Show cattle, for exhibition	❑													
08	**Other, Specify**_____	❑													

2. Which months in a year do you do the following with CATTLE ON FEED? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sale barn	❑	50	45	40	40	35	35	30	40	45	50	50	40	500
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Exhibit at livestock show	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that CATTLE ON FEED traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to sale barn	❑	25	10	400	25	75	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Exhibit at livestock show	❑						
Other, specify:_____	❑						

4. Which months in a year do you receive CATTLE ON FEED? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑	50	45	40	40	35	35	30	40	45	50	50	40	500
From Sale barn	❑													
From Contract buyer	❑													
From Private contract/treaty	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common, and maximum distances that CATTLE ON FEED traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	25	10	400	25	75	50
From Sale barn	❑						
From Contract buyer	❑						
From Private contract/treaty	❑						
Other, specify:_____	❑						

6. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (**All information you provide will remain strictly anonymous**)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX V

DAIRY CATTLE SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Dairy Cattle Survey
Responses will remain strictly anonymous (See the introductory letter for details).

This survey only contains questions specifically related to your dairy cattle operation.

1. How would you classify your herd? (Please fill in the number of head you have in each category each month of the year).

Code No.	Cattle category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
11	EXAMPLE – Lactating cows	❑	250												
11	Lactating cows	❑													
12	Dry cows/heifers	❑													
13	Bulls	❑													
14	4-H/FFA Show cattle, for exhibition	❑													
15	Other, specify_____	❑													

2. How is your hospital milk used? **(Check all that apply)**

❑ Fed to calves on the premises ❑ Sold ❑ Dumped
❑ Fed to calves elsewhere ❑ Fed to pigs elsewhere ❑ Other, specify: _____

3. What do you do with your BULL CALVES (<500 Lbs)? (Please check one box and fill in the most appropriate non-shaded space per row) ❑ Does not apply

	Yes	Times per DAY	Times per WEEK	Times per MONTH	Never
Send to calf ranch	❑				❑
Send to slaughter	❑				❑
Keep for fattening	❑				❑
Keep for breeding	❑				❑
Raise and market for veal	❑				❑
Other, specify:_____	❑				❑

4. For question 3, what are the minimum, most common, and maximum distances that BULL CALVES traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each row).

❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Send to calf ranch	❑	20	10	160	25	20	50
Send to calf ranch	❑						
Send to slaughter	❑						
Other, specify:_____	❑						

5. What do you do with your HEIFER CALVES (<500 Lbs)? (Please check one box and fill in the most appropriate non-shaded space per row) ❑ Does not apply

	Yes	Times per DAY	Times per WEEK	Times per MONTH	Never
Send to calf ranch	❑				❑
Raise and breed for replacement	❑				❑
Other, specify:_____	❑				❑

6. For question 5, what are the minimum, most common, and maximum distances that HEIFER CALVES traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each row).

❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number of cattle	Miles	Number of cattle	Miles	Number of cattle	Miles
EXAMPLE – Send to calf ranch	❑	*20*	*10*	*160*	*25*	*20*	*50*
Send to calf ranch	❑						
Other, specify:_____	❑						

7. What are the minimum, most common and maximum distances that CULL COWS AND BULLS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row).

❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to sale barn	❑	*10*	*10*	*20*	*25*	*10*	*50*
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Ship directly to butcher or abattoir	❑						
Other, specify:_____	❑						

8. What are the minimum, most common, and maximum distances that BREEDING CATTLE traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row).

❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*15*	*10*	*30*	*25*	*5*	*50*
From Sale barn	❑						
From Seedstock producer	❑						
Other, specify:_____	❑						

9. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (<u>All information you provide will remain strictly anonymous</u>)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX VI

SMALL RUMINANT SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS-Sheep & Goat Specific Survey
Responses will remain strictly anonymous (See the introductory letter for details).

This survey only contains questions specifically related to your sheep and/or goat operation.

1. How would you classify your herd? (Please fill in the number of head you have in each category within each month of the year).

Code No.	Category / Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
20	EXAMPLE – Ewes/does	❑	250												
20	Ewes/does	❑													
21	Rams/bucks	❑													
22	Lambs/kids, not weaned	❑													
23	Lambs/kids, weaned	❑													
24	Total head on pasture	❑													
25	Dairy goats	❑													
26	Sheep/goats on feed	❑													
27	4-H/FFA Show Lambs/Goats, for exhibition	❑													
28	Other, specify_____	❑													

2. Which months in a year do you do the following with WEANED LAMBS/KIDS? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity / Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE – Ship to sale barn	❑	50	30										20	100
Ship to sale barn	❑													
Ship directly to feed yard	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Keep in the herd	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that WEANED LAMBS/KIDS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	30	10	50	25	20	50
Ship to sale barn	❑						
Ship directly to feed yard	❑						
Ship directly to other herd(s)	❑						
Ship directly to slaughter	❑						
Other, specify:_____	❑						

4. Which months in a year do you do the following with CULL BREEDING STOCK? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sale barn	❑	10	20	30	30	10								100
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common, and maximum distances that CULL BREEDING STOCK traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	20	10	60	25	20	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Ship directly to slaughter	❑						
Other, specify:_____	❑						

6. Which months in a year do you do the following with SHEEP/GOATS ON FEED? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sale barn	❑			30	30	20	40	20						140
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Exhibit at livestock show	❑													
Other, specify:_____	❑													

7. In the months marked under question 6, what are the minimum, most common and maximum distances that SHEEP/GOATS ON FEED traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to sale barn	❑	20	10	100	25	20	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Ship directly to slaughter	❑						
Exhibit at livestock show	❑						
Other, specify:_____	❑						

8. Which months in a year do you receive BREEDING STOCK? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑		*20*	*20*	*20*	*20*	*20*							*100*
From Sale barn	❑													
From Seedstock producer	❑													
From Purebred producer	❑													
From Commercial ranch	❑													
Other, specify:_____	❑													

9. In the months marked under question 8, what are the minimum, most common, and maximum distances that BREEDING STOCK traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*15*	*10*	*50*	*25*	*10*	*50*
From Sale barn	❑						
From Seedstock producer	❑						
From Purebred producer	❑						
From Commercial ranch	❑						
Other, specify:_____	❑						

10. Which months in a year do you receive SHEEP/GOATS ON FEED? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑	*15*	*15*	*50*								*10*	*10*	*100*
From Sale barn	❑													
From Contract buyer	❑													
From Private contract/treaty	❑													
Other, specify:_____	❑													

11. In the months marked under question 10, what are the minimum, most common, and maximum distances that SHEEP/GOATS ON FEED traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*20*	*10*	*50*	*25*	*30*	*50*
From Sale barn	❑						
From Contract buyer	❑						
From Private contract/treaty	❑						
Other, specify:_____	❑						

12. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (All information you provide will remain strictly anonymous)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX VII

SWINE SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Swine Survey
Responses will remain strictly anonymous (See the introductory letter for details).
This survey only contains questions specifically related to your swine operation.

1. How would you classify your herd? (Please fill in the number of head you have in each category each month of the year).

Code No.	Category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
45	EXAMPLE – Sows/gilts	❑	*100*												
45	Sows/gilts	❑													
46	Boars	❑													
47	Piglets, not weaned	❑													
48	Nursery pigs (<25 lbs)	❑													
49	Feeder pigs (25-230 lbs)	❑													
50	Market hogs (>230 lbs)	❑													
51	4-H/FFA Project, for exhibition	❑													
52	Other, specify_____	❑													

2. Which months in a year do you do the following with NURSERY PIGS (<25 lbs)? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE – Ship to sale barn	❑	*10*	*9*	*8*	*8*	*8*	*7*	*6*	*7*	*8*	*9*	*10*	*10*	*100*
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Keep in the herd	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that NURSERY PIGS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	*27*	*10*	*63*	*25*	*20*	*50*
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Other, specify:_____	❑						

4. Which months in a year do you do the following with CULL SOWS AND BOARS? (Please fill in the number of head per each month of the year) ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE – Ship to sale barn	❑	10	10	10	8	8	8	6	6	6	8	10	10	100
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common and maximum distances that CULL SOWS AND BOARS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	10	10	60	25	30	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Ship directly to slaughter	❑						
Other, specify:_____	❑						

6. Which months in a year do you do the following with FEEDER PIGS (25-230 lbs)? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Ship to sale barn	❑	10	10	8	8	8	6	6	6	8	10	10	10	100
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Keep to finish	❑													
Other, specify:_____	❑													

7. In the months marked under question 6, what are the minimum, most common, and maximum distances that FEEDER PIGS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	28	10	52	25	30	50
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Other, specify:_____	❑						

8. Which months in a year do you do the following with MARKET HOGS (230-280 lbs)? (Please fill in the number of head per activity and the percentage you do within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE – Ship to sale barn	❑	*10*	*10*	*8*	*8*	*8*	*6*	*6*	*6*	*8*	*10*	*10*	*10*	*100*
Ship to sale barn	❑													
Ship directly to other herd(s)	❑													
Ship directly to slaughter	❑													
Exhibit at livestock show	❑													
Other, specify:_____	❑													

9. In the months marked under question 8, what are the minimum, most common, and maximum distances that MARKET HOGS traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Ship to Sale barn	❑	*30*	*10*	*50*	*25*	*20*	*50*
Ship to sale barn	❑						
Ship directly to other herd(s)	❑						
Send directly to slaughter	❑						
Exhibit at livestock show	❑						
Other, specify:_____	❑						

10. Which months in a year do you receive REPLACEMENT BREEDING SWINE? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑	*6*	*8*	*8*	*8*	*8*	*12*	*10*	*10*	*12*	*6*	*6*	*6*	*100*
From Sale barn	❑													
From Seedstock producer	❑													
From Purebred producer	❑													
From Commercial producer	❑													
Other, specify:_____	❑													

11. In the months marked under question 10, what are the minimum, most common, and maximum distances that REPLACEMENT BREEDING SWINE traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*20*	*10*	*70*	*25*	*10*	*50*
From Sale barn	❑						
From Seedstock producer	❑						
From Purebred producer	❑						
From Commercial producer	❑						
Other, specify:_____	❑						

12. Which months in a year do you receive FEEDER PIGS? (Please fill in the number of head per activity and the percentage you do within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – From Sale barn	❑	*10*	*8*	*8*	*8*	*6*	*6*	*6*	*8*	*10*	*10*	*10*	*10*	*100*
From Sale barn	❑													
From Contract buyer	❑													
From Private contract/treaty	❑													
Other, specify:_____	❑													

13. In the months marked under question 12, what are the minimum, most common, and maximum distances that FEEDER PIGS traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – From Sale barn	❑	*18*	*10*	*54*	*25*	*28*	*50*
From Sale barn	❑						
From Contract buyer	❑						
From Private contract/treaty	❑						
Other, specify:_____	❑						

14. Please provide a list of locations where your livestock are kept and time of the year animals are located there. (All information you provide will remain strictly anonymous)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX VIII

HIGH-FENCED DEER AND EXOTICS SPECIFIC SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- High-fenced/Pen Raised Deer & Exotics Survey

Responses will remain strictly anonymous (See the introductory letter for details).

This survey only contains questions specifically related to your deer and/or exotics operation.

1. How would you classify your herd? (Please fill in the number of animals per acre you have in each category within each month of the year).

Code No.	Category \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
30	EXAMPLE –Whitetail Deer	❑	50												
30	Whitetail Deer	❑													
31	Other Deer	❑													
32	Exotic Goats	❑													
33	Exotic Goat Hybrids	❑													
34	Exotic Sheep	❑													
35	Exotic Sheep Hybrids	❑													
36	Antelope	❑													
37	Bison	❑													
38	Elk	❑													
39	Feral Swine	❑													
40	Other, Specify_____	❑													

2. Which months in a year do you do the following? (Please fill in the number of head per activity within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Total
EXAMPLE –Ship meat to processor	❑	10									10	30	50	100
Ship meat to processor	❑													
Ship heads/hides to taxidermist	❑													
Ship directly to other herd(s)	❑													
Ship animals to sale barn	❑													
Other, specify:_____	❑													

3. In the months marked under question 2, what are the minimum, most common, and maximum distances that animals or their products traveled after leaving your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE-Meat to processor	❑	20	25	60	75	20	200
Ship meat to processor	❑						
Ship heads/hides to taxidermist	❑						
Ship directly to other herd(s)	❑						
Ship animals to sale barn	❑						
Other, specify_____	❑						

4. Which months in a year do you receive animals? (Please fill in the number of head per activity and the percentage you do within each month of the year). ❑ Does not apply

Activity \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Tot.
EXAMPLE – Wildlife Auction	❑		60	40										100
From Wildlife Auction	❑													
From Breeder	❑													
From Trap and Transfer Ranch	❑													
Other, specify:_____	❑													

5. In the months marked under question 4, what are the minimum, most common, and maximum distances that animals traveled coming to your property in an average year? (Please check box or fill in appropriate spaces on each non-shaded row). ❑ Does not apply

		Minimum distance		Most common distance		Maximum distance	
	N/A	Number	Miles	Number	Miles	Number	Miles
EXAMPLE – Wildlife Auction	❑	20	10	60	25	20	50
From Wildlife Auction	❑						
From Breeder	❑						
From Trap and Transfer Ranch	❑						
Other, specify:_____	❑						

6. Please provide a list of locations where your wildlife are kept and time of the year animals are located there. (All information you provide will remain strictly anonymous)

Closest City	Straight line distance (miles) and direction from your primary location	All Year	Dates
EXAMPLE*EXAMPLE (PLEASE NOTE: ALL INFORMATION YOU PROVIDE US WILL REMAIN STRICTLY ANONYMOUS) EXAMPLE*EXAMPLE			
Uvalde	20 miles ("as a crow flies" from Uvalde), Northeast	❑	October to December
		❑	
		❑	
		❑	
		❑	
		❑	
		❑	

APPENDIX IX

FOLLOW UP TELEPHONE INTERVIEW

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS- Follow-up survey.
Responses will remain strictly anonymous (See the introductory letter for details).

1. What type(s) of animals are on your premises?_____

2. In the months that you RECEIVE animals, from how many locations - on a typical day - do you receive animals from each of the following sources? (Please check box or fill in the number of locations from which you receive animals on a typical day for each of the following sources) ❑ Does not apply

Source \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Year
From Sale barn	❑													
From Seed stock producer	❑													
From Purebred producer	❑													
From Commercial ranch	❑													
From Contract buyer	❑													
From private treaty	❑													
From breeder	❑													
From trap and transfer ranch	❑													
Other, specify:_____	❑													
TOTAL														

3. In the months that you RECEIVE animals, on how many days each month do you receive animals from the following sources? (Please check box or fill in the number of days each month that you receive animals from the following sources) ❑ Does not apply

Source \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Year
From Sale barn	❑													
From Seed stock producer	❑													
From Purebred producer	❑													
From Commercial ranch	❑													
From Contract buyer	❑													
From private treaty	❑													
From breeder	❑													
From trap and transfer ranch	❑													
Other, specify:_____	❑													
TOTAL														

4. What is the average number of animals per trailer load coming to your premises?

_____**Animals/trailer load**

FI 0000

5. In the months that you SHIP animals, to how many locations - on a typical day - do you ship animals for each of the following destinations? (Please check box or fill in the number of destinations to which you ship animals on a typical day for each of the following sources) ❑ Does not apply

Month / Destination	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Year
To Sale barn	❑													
To feed yard	❑													
To other herds	❑													
To slaughter	❑													
To Livestock shows	❑													
Hides to taxidermist	❑													
Meat to processor	❑													
Other, specify:_____	❑													
TOTAL														

6. In the months that you SHIP animals, on how many days each month do you SHIP animals to the following destinations? (Please check box or fill in the number of days each month that you ship animals to the following sources) ❑ Does not apply

Month / Destination	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Year
To Sale barn	❑													
To feed yard	❑													
To other herds	❑													
To slaughter	❑													
To Livestock shows	❑													
Hides to taxidermist	❑													
Meat to processor	❑													
Other, specify:_____	❑													
TOTAL														

7. What is the average number of animals per trailer load leaving your premises?

_____Animals/truck load

8. Do you believe that the numbers and sizes of truck loads moving on and off of your property are representative of other ranches in the area?

❑ Yes
❑ No

APPENDIX X

COUNTY EXTENSION AGENT SURVEY

Questionnaire for county agents
Epidemiological Model FMD
August-2005

Please write the name of your county: _____

We would like to know about the livestock practices that are generally performed within your county. Please answer questions to the best of your knowledge and ability.

1. What is the approximate percentage of the land used for animal agriculture that is absentee owned in your county (i.e. the owner does not live in the county)? ____%

2. What approximate percentage of livestock operations in your county have one of the following managers employed (full or part time)? None ☐
   - Livestock Manager _____%
   - Wildlife Biologist _____%
   - Both _____%

3. What are the approximate numbers of the following livestock in your County? (Please give number of head)
   a. Beef cattle? _____
   b. Stocker cattle? _____
   c. Cattle on feed? _____
   d. Sheep? _____
   e. Goats? _____
   f. Dairy cattle? _____
   g. Domestic swine? _____

4. Approximately what percentage of the **cow/calf operations also raise** other livestock or deer?
   a. Stocker cattle? _____%
   b. Cattle on feed? _____%
   c. Sheep? _____%
   d. Goats? _____%
   e. High-fenced/pen-raised deer or exotics? _____%
   f. Dairy cattle? _____%
   g. Domestic swine? _____%

5. What approximate percent of the land in your county is improved pasture?_____; native rangeland?_____; cultivated land?_____

6. What approximate percentage of livestock operations employ people that also work on other livestock operations? _____% livestock operations

7. What approximate percentage of livestock operations employ people that also have cattle, swine, goats or sheep of their own? _____% of employees that also own livestock

8. What is the approximate frequency of movement of employees among different livestock operations?

☐Every day ☐2-4 times a week ☐weekly ☐monthly ☐seasonally (2-3 times/year)

9. Please list the major routes (highways, major roads) of livestock movement within your county.

_____

_____

10. How often do you visit the following livestock premises? (Please fill in the number of times a type of premises is visited in each month of an average year)

Month / Livestock premises	Never	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
EXAMPLE - Dairies	❑	2	2	3	2	5	6	6	5	3	2	2	2
Dairies	❑												
Beef ranches	❑												
Domestic swine premises	❑												
Slaughterhouses	❑												
Livestock shows/Auctions/sale yards	❑												
Goat or sheep premises	❑												
Other, specify:_____	❑												

11. From where outside of your county does the livestock currently in your county originate? (Please fill in the appropriate percentage for each type of livestock)

Location / Livestock	N/A	Adjacent county*	Texas*	Another state**	Another country***
EXAMPLE – Beef cattle	☐	50%	40%	7%	3%
Beef cattle	☐				
Stocker cattle	☐				
Cattle on feed	☐				
Sheep	☐				
Goats	☐				
High-fenced/pen-raised deer or exotics	☐				
Dairy cattle	☐				
Domestic swine	☐				

*Please list counties:_____

** Please list states:_____

*** Please list countries:_____

12. Approximately what percent of the following livestock raised in your county are marketed **WITHIN** your county?
☐ No sale barn within county

Livestock	N/A	Sales barn	Direct to other herds	Direct to Feed yard	Direct to Slaughter
EXAMPLE – Cull cows	☐	*90%*			
Cull cows	☐				
Weaned calves	☐				
Stocker cattle	☐				
Cattle on feed	☐				
Sheep	☐				
Goats	☐				
High-fenced/pen-raised deer or exotics	☐				
Dairy cattle	☐				
Swine	☐				

13. Approximately what percent of the following livestock raised in your county are marketed **OUTSIDE** of your county?

Livestock	N/A	Sales barn	Direct to other herds	Direct to Feed yard	Direct to Slaughter
EXAMPLE – Cull cows	☐	*10%*			
Cull cows	☐				
Weaned calves	☐				
Stocker cattle	☐				
Cattle on feed	☐				
Sheep	☐				
Goats	☐				
High-fenced/pen-raised deer or exotics	☐				
Dairy cattle	☐				
Domestic swine	☐				

14. What months of the year are shipments of beef cattle most frequent within your county? Please fill in the approximate percentages for each activity within a year.

Activity \ Month	N/A	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Example-Weaning	☐					*50%*					*50%*			*100%*
Weaning	☐													100%
Ship to stocker operation	☐													100%
Ship to feed yard	☐													100%
Livestock shows	☐													100%
Receive breeding cattle	☐													100%
Cull breeding cattle	☐													100%

15. Which months of the year are shipments of sheep and goats most frequent within your county? Please fill in the approximate percentages for each activity within a year.

Activity \ Month	N/A	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Example-Weaning	☐	*8%*	*8%*	*8%*	*8%*	*9%*	*9%*	*8%*	*8%*	*9%*	*9%*	*8%*	*8%*	*100%*
Weaning	☐													100%
Ship to feed yard	☐													100%
Livestock shows	☐													100%
Receive breeding sheep/goats	☐													100%
Cull breeding sheep/goats	☐													100%

16. Which months of the year are shipments of any deer, exotics, and wildlife most frequent within your county? Please fill in the approximate percentages for each activity within a year.

Activity \ Month	N/A	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sep.	Oct.	Nov	Dec.	Total
Example-Hunting	☐	*40%*										*30%*	*30%*	*100%*
Hunting (carcasses)	☐													100%
Ship to other herds	☐													100%
Commercial slaughter	☐													100%
Ship to auction	☐													100%

APPENDIX XI

AUCTION BARN INTERVIEW

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS-Auction Barn Survey
Responses will remain strictly confidential (See the introductory letter for details).

The purpose of this survey is to determine potential contacts between livestock through your auction facility in an average year.

1. Which animal species are sold through your facility?

a. ❑ Slaughter cattle
b. ❑ Replacement cattle
c. ❑ Stocker cattle
d. ❑ Feeder cattle
e. ❑ Dairy cattle
f. ❑ Replacement Sheep
g. ❑ Slaughter Sheep
h. ❑ Replacement Goats
i. ❑ Slaughter Goats
j. ❑ Exotics
k. ❑ Swine
l. ❑ Other cloven hoofed livestock, please specify_____

2. How many head do you sell in January?

Slaughter cattle	
Replacement cattle	
Stocker cattle	
Feeder cattle	
Dairy cattle	
Replacement Sheep	
Slaughter Sheep	
Replacement Goats	
Slaughter Goats	
Exotics	
Swine	
Other livestock	

February?

Slaughter cattle	
Replacement cattle	
Stocker cattle	
Feeder cattle	
Dairy cattle	
Replacement Sheep	
Slaughter Sheep	
Replacement Goats	
Slaughter Goats	
Exotics	
Swine	
Other livestock	

March?

Slaughter cattle	
Replacement cattle	
Stocker cattle	
Feeder cattle	
Dairy cattle	
Replacement Sheep	
Slaughter Sheep	
Replacement Goats	
Slaughter Goats	
Exotics	
Swine	
Other livestock	

April?

Slaughter cattle	
Replacement cattle	
Stocker cattle	
Feeder cattle	
Dairy cattle	
Replacement Sheep	
Slaughter Sheep	
Replacement Goats	
Slaughter Goats	
Exotics	
Swine	
Other livestock	

May?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

June?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

July?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

August?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

September?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

October?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

November?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

December?
- Slaughter cattle
- Replacement cattle
- Stocker cattle
- Feeder cattle
- Dairy cattle
- Replacement Sheep
- Slaughter Sheep
- Replacement Goats
- Slaughter Goats
- Exotics
- Swine
- Other livestock

3. What day(s) do you sell on?
❑ Monday ❑ Tuesday ❑ Wednesday ❑ Thursday ❑ Friday ❑ Saturday ❑ Sunday

4. Do you have any special sales on days other than your regular sale day(s)?
❑ Yes, please continue to question 5
❑ No, please skip to question 6

5. What month or months do you have special sales?
How many special sales are in each month?

Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
Special Sales	❑												

6. How many days are animals typically held at your facility?

	N/A	Minimum (days)	Average (days)	Maximum (days)
Animals from gathering points	❑			

7. Are there designated gathering points for animals before coming to your facility?
❑ Yes, please continue to question 8
❑ No, please skip to question 12

8. How many different locations serve as gathering points for animals before coming to the sales facility?
❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 or more

9. What is the approximate minimum, maximum, and average number of animals coming from these gathering points to your facility?

	N/A	Minimum (head)	Average (head)	Maximum (head)
Animals from gathering points	❑			

10. What is the minimum distance, maximum distance, and average distance to gathering points from your sales facility?

	N/A	Minimum Distance (miles)	Average Distance (miles)	Maximum Distance (miles)
Distance to gathering points to facility	❑			

11. What is the minimum distance, maximum distance, and average distance animals come directly to your sales facility?

	N/A	Minimum Distance (miles)	Average Distance (miles)	Maximum Distance (miles)
Distance to facility	❑			

12 What is the minimum distance, maximum distance, and average distance animals travel from your sales facility?

	N/A	Minimum Distance (miles)	Average Distance (miles)	Maximum Distance (miles)
Distance from facility	❑			

13. How often do live animals leave your premises to an out-of-state location? (Fill in the most appropriate space with the number of head)

	Never	Per day	Per week	Per month	Per year
Number of head	❑				

14. How often do you receive animals from another state or country? (Fill in the most appropriate space with the number of head)

	Never	Per day	Per week	Per month	Per year
Number of head	❑				

15. Where do animals travel from your facility? (Please tell us the percentage of livestock that leave your facility to the following locations each month) ❑ Don't know

Condition \ Month	N/A	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
Feedlot	❑												
Slaughter facility	❑												
Another auction barn	❑												
Another ranch/farm	❑												
Other, specify:_____	❑												

==========

Observations by interviewer:

What borders your facility? (Please check all that apply)

❑Other livestock premises ❑ River/Stream ❑ Housing Development
❑County maintained road ❑Highway ❑Other_____

Other observations or comments not covered by questionnaire (use reverse side if needed):

APPENDIX XII

VETERINARIAN SURVEY

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STUDY OF ANIMAL MOVEMENTS AND CONTACTS-Veterinarians
Responses will remain strictly confidential (See the introductory letter for details).

The purpose of this survey is to determine potential contacts between livestock through your clinic.

1. Which of the following animals do you see in your clinic during an average year? (Please fill in the number of each species you see per month in your clinic)

Species \ Month	N/A	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Breeding Beef cattle	❑												
Stocker cattle	❑												
Cattle on feed	❑												
Dairy cattle	❑												
Sheep	❑												
Goats	❑												
High-fenced deer or exotics	❑												
Domestic swine	❑												
Other cloven-hoofed livestock, please specify_____	❑												

2. How many farm calls do you make to the following types of premises in an average year? (Please fill in the number of farm calls per month made to each premise type.)

Species \ Month	N/A	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Cow-calf	❑												
Stocker cattle	❑												
Cattle on feed													
Dairy cattle													
Sheep													
Goats													
High-fenced deer or exotics													
Domestic swine													
Other cloven-hoofed livestock, please specify_____													

3. From how far do producers bring their animals to your clinic? (Please fill in the minimum, average, and maximum distances traveled by producers.) ❑ Does not apply

	Minimum Distance (miles)	Average Distance (miles)	Maximum Distance (miles)
Distance producers travel			

4. How far do you typically travel on farm calls? (Please fill in the minimum, average, and maximum distances traveled by you)

❑ Does not apply

	Minimum Distance (miles)	Average Distance (miles)	Maximum Distance (miles)
Distance you travel			

5. How many farms do you visit per day? (Please fill in the minimum, average, and maximum number of farms visited per day.)

❑ Does not apply

	Minimum Number (farms)	Average Number (farms)	Maximum Number (farms)
Farms visited			

6. Based on you experience, how long do you think it will take an average producer to call you for a disease problem? (Please fill in the minimum, most likely, and maximum time it would take for a producer to call and circle the appropriate unit of measurement)

	Minimum Time Hours/Days/Weeks/Months	Most Likely Time Hours/Days/Weeks/Months	Maximum Time Hours/Days/Weeks/Months
Time to call with problem			

7. What percent of your livestock practice falls into the following categories?

Type of Practice	N/A	% of Practice
Sick animal	❑	
Preventative medicine	❑	
Obstetrics	❑	
Consultation	❑	
Surgery	❑	
Other, specify_____		

8. How often do you see the following conditions in cloven-hoofed livestock? (Please fill in the approximate number of times per month you see the condition where applicable)

Condition \ Month	N/A	All Year	Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sep.	Oct.	Nov	Dec
Lameness	❑													
Abortion	❑													
Diarrhea	❑													
Off feed	❑													
Excessive salivation	❑													
Neurological signs	❑													
Respiratory problems	❑													

VITA

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