THE ADOPTION OF ULTRASOUND TECHNOLOGY FOR PREGNANCY DETERMINATION BY NEW MEXICO BEEF COW-CALF PRODUCERS

A Thesis

by

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ABSTRACT

The purpose of this study was to identify and describe the diffusion process and the rate of adoption of bovine ultrasound pregnancy determination by New Mexico cattle producers. The researcher from Texas A&M University and Caren Cowan from the New Mexico Cattle Producers Association collaborated on this work. Conclusions were drawn to provide suggestions on increasing the diffusion of ultrasound technology in New Mexico.

Data were collected from a sample of 99 producers in the state. Descriptive statistics such as frequencies and percentages of nominal data and means and standard deviations of intervally-scaled variables were employed to describe the sample of producers and their levels of familiarity and use of ultrasound technology. The following were among the findings.

Of the producers surveyed, most are using rectal palpation as their primary means of pregnancy determination. A small percentage of producers have adopted ultrasound and are using ultrasound alone, while another small percentage are using ultrasound in combination with other technologies to determine pregnancy in their herd. The diffusion process for ultrasound has begun and for some, it has been adopted. A plurality of producers are aware of the technology and know that it exists, with only a small percentage stating that they did not have any knowledge of the technology's existence. Most producers were not aware of other producers who use ultrasound but would consider using ultrasound themselves.

Producers learned about ultrasound from a veterinarian or their friends with only a very small percentage learning about the technology from an extension agent/extension specialist. Producers stated that they are not in contact with an extension agent/extension specialist about their cattle operation. The producers identified that their primary barrier to the adoption of ultrasound is the cost of the veterinarian/technician to perform the procedure.

Recommendations were made based on these findings for use by the New Mexico Cooperative Extension Service and the New Mexico Cattle Growers Association seeking to effect change by the diffusion of new innovations.

DEDICATION

To my Grandpa Swapp, Phillip W. Swapp

My grandpa Swapp was the entire reason that I learned that I loved agriculture. For many years he let me pull a ranch calf from his herd for me to have for my 4-H and FFA projects. It was through those show calves that I learned that I had a true passion for cattle. I think my grandpa and I are the only two people in our family who truly love cattle and everything about them.

He was a rancher his entire life. I hope that one day I will be, too. I wish that he were here to see what I have done with everything that he taught me. I hope that he is proud of me and I hope I have not let him down. I want to dedicate this thesis to him and all that he did for our family and the sacrifices he made. I know that he is looking down from heaven and watching over me. I hope that the grass is green, the water is clear, and the cows are many where you are. I love you and miss you every day, and I dedicate this work to you.

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CHAPTER I

INTRODUCTION

Background

New Mexico is considered a rural state filled with many small communities with a strong connection to agriculture. One of the more prevalent agricultural industries in New Mexico is cattle production. Many of the ranchers are in the cow/calf sector producing calves to be sold each year in the fall. Most of the operations are large in land size and have varying populations of cattle. The United States Department of Agriculture (USDA, 2013b) estimated New Mexico's total cattle and calves inventory for 2013 as 1,340,000 head of cattle. The inventory was down from the 2012 estimate of 1,390,000 head. Similarly, the number of beef cows that had calves in New Mexico in 2013 was 390,000 head of cattle. This inventory was lower by 45,000 head than the estimate in 2012. The number of farms in New Mexico in 2012 was 23,800 with an average of 1,845 acres (USDA, 2013c).

New Mexico is a state diversified in its topography. The higher elevations are mountainous with large land masses being covered by national forests. There also are lower elevations of desert with an average rainfall of 6.06 inches per year (National Oceanic and Atmospheric Association [NOAA], National Weather Service [NWS], 2013). Areas located on the east side of the state are primarily flat with considerable amounts of forage. The state is also compromised by large amounts of public land managed by the Forest Service (FS) and Bureau of Land Management (BLM). Private

property is dispersed throughout the state and is widely used for agriculture and cattle, sheep, and goat production. Each area has unique weather and, therefore, different forage options for animal agriculture operations. Some operations may have the opportunity to monitor their cattle on a daily basis while others may see their cattle only once per month. Sizes of operations also vary. In 2013, Union County, located in the northeastern portion of the state, had the highest inventory of beef cows at 26,000 head (USDA, 2012b).

Conversely, Santa Fe County, located in the north central part of the state, had the lowest beef cow inventory in 2013 of 2,800 head (USDA, 2012b). The other counties have numbers of beef cows between these two. Large sections of the state are divided into several Native American/Indian reservations. This land is considered to be separate from the state and is governed by different and separate rules.

Ultrasound is a technology of interest in the beef cattle industry. Originally, it was hypothesized that ultrasound could be used to detect brain tumors (Newman & Rozycki, 1998). However, the properties of ultrasound did not allow for the detection of brain tumors. The first application in animal science was in 1956 at Colorado A&M College when ultrasound was used to measure back fat thickness on beef cattle (Stouffer, 2004). This application eventually led to the use of ultrasound for pregnancy determination.

Ultrasound is described by Ribadu and Nakao (1999) as using high frequency sound waves to produce cross sectional images of the tissues and internal organs. The sound waves produce vibrations of the crystals on the transducer which then create

echoes that become evident as varying shades of gray on a screen (Ribadu & Nakao, 1999). Those varying shades of gray offer information as to which internal organs are being viewed.

A unique feature of ultrasound is the ability to use it for pregnancy determination. Internal medicine in humans has been using transvaginal ultrasound for the early detection of pregnancy in women for many years (Fossum, Davajan, & Kletzky, 1988). The technology used for women has been adapted to use on animals for the same purpose. This technology has been implemented in the cattle industry; Medan and Abd El-Aty (2010) expressed that early detection of pregnancy and fetal viability and development is an immense advantage of ultrasound.

In New Mexico's beef cattle industry, reproduction is of utmost importance. In such a rural setting and diversified topography, using ultrasound as a tool to manage the reproductive efficiency of the herd could benefit the enterprise. A decline in the number of cattle in New Mexico may provide evidence that more breeding technologies are needed. The herd could become more productive and efficient and more profitable for the owner if this technology is used. Use of ultrasound will aid in management of diversified operations and of the breeding season for cattle and, subsequently, the calving season. Ultrasound can assist in these operations by increasing herd productivity and increasing calf crop percentages, influencing profitability.

This innovation is preferable to determining pregnancy using the traditional rectal palpation method with numerous benefits and abundant management advantages for the producer. For the cattle industry to grow and prosper financially, ultrasound may

prove to be a vital tool that can be used to increase the cattle inventory and profits for producers. Richardson, Mortimer, and Whittier (2010) wrote that fewer fetal losses occur when using ultrasound. The loss of life to the fetus during rectal palpation is cause for replacement by a newer innovation.

The number of producers in the state of New Mexico is declining. So, too, is the number of cattle. For instance, in 2007, beef cow numbers in New Mexico were greater than 530,000. By 2012, the numbers had dropped almost 13% to less than 462,000 (USDA, National Agricultural Statistics Services [NASS], 2012a). However, cattle prices have continued to rise over the years. According to the United States Department of Agriculture (2013a), prices paid for 550-pound steer calves in 2004 were estimated to be around $110/cwt whereas $194/cwt was the selling price for 550-pound calves during late 2013. The law of supply and demand in a free market suggests that profitability must be a problem with falling cattle numbers even with increased prices for calves. Maximization of the breeding potential of the herd could return larger profits for beef cow-calf operations. The use of ultrasound could offer one possible solution to the sustainability of the ranching heritage in New Mexico.

Statement of the Problem

Because the state of New Mexico is incredibly diversified and exceptionally rural, ultrasound technology may not have reached many producers. The process by which producers receive information may vary. Multiple communication channels must be used in order to reach all of New Mexico's cattle producers. Numerous socioeconomic barriers may exist that might delay the adoption of this innovation. For example, the age of producers in the state varies and could inhibit or encourage the adoption of new breeding technologies. Education levels of cattle producers in the state may be diverse and may affect their decisions to adopt technology. Cattle operations in the state also vary in management styles based on where they are located which could also influence acceptance of breeding technology.

Ultrasound is not necessarily a new technology; however, the diffusion of it may be limited in New Mexico. Many producers may not know that this technology exists even though it has been around for many years. They might not know the benefits of its usage for their operations. Without knowledge of this innovation, producers are unaware of the potential benefits that they have been foregoing. Using ultrasound properly is an educationally-attained skill. If producers do not have the requisite skill, they can employ someone who has developed that skill, thus benefiting from ultrasound technology.

If the producers are aware of the technology and are capable of using it but are not, how can we influence their decision to adopt this technology? Perhaps the adoption decision process has been completed, and the ultrasound innovation has been rejected. It is unknown whether producers are aware in New Mexico that this pregnancy

determination technology exists and whether they would consider using it. If the technology is unknown to producers, how can the extension program educate producers of its potential advantages? Or, are there other change agencies more appropriate to lead the diffusion process?

Purpose of the Study

The purpose of this study was to identify and describe the diffusion process and the rate of adoption of bovine ultrasound pregnancy determination by New Mexico cattle producers.

Specific Objectives

Foremost, this study was undertaken as a way to explore the adoption of ultrasound pregnancy determination technology by New Mexico cattle producers. Additionally, this study will offer a basis for further research in the field. To accomplish the purpose of the study, the following objectives were established:

1. Describe selected characteristics and demographics of beef cattle producers in the state of New Mexico.
2. Describe selected characteristics of beef cow-calf operations in New Mexico.
3. Describe the relative innovativeness of New Mexico beef cow-calf producers as members of a social system.
4. Identify to what degree ultrasound technology for pregnancy determination has been adopted by New Mexico beef cattle producers.

5. Identify what barriers to the adoption of ultrasound exist for producers.
6. Identify what communication channels/diffusion methods have been more successful in the adoption of breeding technologies in the state.
7. Explore the rates of adoption and communication channels used related to selected characteristics of cattle producers in New Mexico and to their general innovativeness.

Theoretical Base for the Study

The adoption of new innovations has been studied for years. As new technological advances in the agricultural field have occurred, it has become important to study how to communicate those advances to the agriculture community. It has been important to study by which means new technologies are communicated and whether the producers respond to the communication channels. Knowledge of the innovation is one key to adoption. If the innovation is not known by the potential user, its rate of adoption is significantly reduced or halted.

Adoption of pregnancy determination technologies such as ultrasound is essential to the beef cattle industry. The benefits provided by ultrasound can aid the cattleman in gaining profitability and sustainability. Poock and Wilson (2011) agreed and added that early detection of pregnancy, fetal aging, sexing, and uterine and ovarian pathology all help the cattleman to increase profits. In order to feed a growing population we must learn how to produce the same product in a more efficient and effective way. Ultrasound is a tool that can be used to produce the product more efficiently and in a more

immediate method. Understanding whether producers are aware that this technology exists is imperative to the adoption of the technology. Exploring which methods of communication are used most prominently by producers will offer insight into which ways they prefer to receive information.

If the producers are aware of ultrasound technology and have rejected its adoption, this study can explain the concerns and problems they have experienced with its use. A description of the characteristics of the population can also be helpful. Ryan and Gross (1943) described the importance of new agricultural technologies in their study of the diffusion of a new hybrid corn in Iowa. Subsequent studies on the diffusion of innovations have been compiled by Rogers (2003). The diffusion process and the innovation decision process have many channels that must be completed for the actual adoption to take place.

The knowledge of this technology's adoption can offer further evidence of what New Mexico cattle producers find to be acceptable means of communication. Understanding the influences that impact the adoption decisions of producers in the state will allow the New Mexico Cattle Growers Association (NMCGA) and the New Mexico Cooperative Extension Service to better serve their producers with the information that they need.

Rogers (2003) explained that diffusion is a process by which information is shared and the channels that the information must go through in order to reach the intended audience. The adoption decision process explains the stages that producers must go through in order to adopt or reject new innovations (Rogers, 2003).

Understanding what stage in the decision process cattle producers in the state are in will better offer evidence of whether the innovation has been communicated effectively.

Research Questions

Considering the theoretical base for the study and the specific objectives established to accomplish the purpose of the study, the following research questions were formulated:

1. What are selected characteristics and demographics of beef cattle producers in the state of New Mexico?
2. What are selected characteristics of beef cow-calf operations in New Mexico?
3. What is the relative innovativeness of New Mexico beef cow-calf producers as a social system?
4. To what degree has ultrasound technology for pregnancy determination been adopted by New Mexico beef cattle producers?
5. What barriers to the adoption of ultrasound have the producers encountered?
6. What communication channels/diffusion methods have been relatively more successful in the adoption of breeding technologies in the state?
7. Are rates of adoption and communication channels used related to selected characteristics of cattle producers in New Mexico and to their general innovativeness?

These research questions have been developed from the initial objectives that inspired this study and provided the framework for analyzing the data collected through survey methods.

Importance of the Study

The answers derived from the research questions will lead to better understanding of whether cattle producers in the state are using ultrasound**.** The study will also offer perspective as to how producers share and receive information regarding breeding innovations. A better understanding of what characteristics producers share and how those characteristics and demographics may influence agricultural adoption decisions is essential. Findings will give awareness of the barriers that producers encounter when attempting to adopt new technologies. This study will impact the method of diffusion used to relay information to cattle producers in the state and will better allow change agents to tailor a plan to increase adoption of ultrasound. Information regarding how we can improve the adoption of pregnancy determination technologies can be used to develop a plan to better educate cattle producers of agricultural innovations. In order for cattle production to continue in the state, newer pregnancy determination technologies must be utilized. This study will offer the information needed to promote increased production and profits for cattle producers in New Mexico.

Delimitations

The population of the study was delimited to 99 of the 1,500 surveyed livestock producers who were members of NMCGA during July 2014. The study was also delimited to current cow-calf producers within the state of New Mexico. Finally, USDA typically refers to agricultural production units as farms whereas many producers in the western US refer to their operations as ranches and themselves as ranchers. Both forms (e.g., farms and ranches) are used to describe production units in New Mexico.

Limitations

The study was limited to cattle producers who were members of NMCGA during the time of the study; therefore, caution is advised when generalizing these findings to a larger population of cattle producers. In addition, the study was limited only to current cow-calf producers within the state of New Mexico. These results may not reflect the views and opinions of non-members of NMCGA.

Assumptions

The participants were representative of the total population of active cattle producers within the state of New Mexico in that they faced the same variations of economic, climatic, and environmental challenges. Also, it was assumed that all NMCGA members had access to the internet and email in order to answer the survey.

Nature of the Investigation

The results of this descriptive study were based on the responses of 99 cattle producers who were surveyed during July 2014 in New Mexico. The findings describe the adoption status of ultrasound for pregnancy determination by New Mexico cattle producers. These results can be used to develop strategies by the New Mexico Cooperative Extension Service to better serve the producers within the state as well as offer input on how producers are receiving their information.

Definition of Terms and Acronyms

For the sake of clarification throughout this thesis report, the following terms and acronyms used are identified below.

AI-Artificial Insemination

AU-Animal Units

BLM-Bureau of Land Management

FS-Forest Service

NMCGA-New Mexico Cattle Growers Association

NOAA-National Oceanic and Atmospheric Administration

NWS-National Weather Service

TAMU-Texas A&M University

USDA-United State Department of Agriculture

CHAPTER II

REVIEW OF LITERATURE

Adoption of Agricultural Technology

The adoption of agricultural innovations encounters many barriers. A basic understanding of previous research on agricultural adoption is imperative to influencing adoption of ultrasound technology by New Mexico cattle producers. Feder and Umali (1993) wrote that the type of technology and the characteristics of its reaction with other related technologies have been shown to be of significance in the adoption of innovations. Producers need to be able to see that ultrasound can have a positive outcome to their existing management strategies.

Understanding the barriers that producer's encounter and what environmental and climatic factors may be contributors or inhibitors of technology adoption is imperative to adoption (Feder & Umali, 1993). Another important factor to the adoption of ultrasound is price. Ultrasound is an expensive investment for the agricultural operation to make. Feder and Umali (1993) agree that attention to the price of that technology may enhance or reduce adoption if the value of the innovation is expected to change in the near future. However, contradicting research suggests that cost is not a factor and suggests that unfamiliarity of the technology was the greater factor influencing adoption. Gillespie, Kim, and Paudel (2007) revealed that cost of the technology was a minimal factor in non-adoption as most producers stated that

unfamiliarity was the major factor for non-adoption. If the technology is unfamiliar to the target audience, the cost of the technology is irrelevant.

Producers who are able to recognize the advantages of innovations may be more likely to adopt. Batz, Peters, and Janssen (1999) agreed, if the technology is deemed to offer more of an advantage to the farmer, the more likely they are to adopt. If the technology is considered too difficult to use, reduced rates in adoption will occur. Batz et al. (1999) went on to support their previous findings by stating that perceived complexity has been shown to influence the rate and speed of adoption of technology. Gillespie et al. (2007) added that many producers do not adopt due to complexity and level of commitment to the technology. Attitudes and perception are also a determinant in adoption of agricultural technology. Perceptions of the technology and previous opinions influence adoption. Farmers' attitudes and perspectives influence adoption of best management practices (Kim, Gillespie, & Paudel, 2005).

Along with difficulty level, education levels and lack of human capital can also influence the rate at which technology is adopted (Batz et al., 1999; Ward, Vestal, Doye, & Lalman, 2008). While human capital and education is important to the adoption of technology, the specific attributes of the technology are also important (Adesina & Zinnah, 1993). Producers are often reserved when it comes to taking risks. The adoption of ultrasound may offer a risk to the operation. If the technology is not a success, financial consequences will follow. Batz et al. (1999) explained that if producers perceive a technology to be a high risk, they may be less likely to adopt.

In the past, new technologies have been diffused on the basis of productivity and profitability (Pruitt et al., 2012). The innovation must be identified by the producer to increase productivity and also increase profitability of the operation. Some insight into the potential that New Mexico cattle producers may have is offered in that larger enterprises operated by college-educated people in the western United States are more likely to adopt agricultural technologies (Pruitt et al., 2012). However, Pruitt et al. (2012) wrote that cow-calf producers are less likely to adopt new technologies than their counterparts in the hog and dairy industries.

Technological advances in the dairy industry have lowered operating costs (El-Osta & Morehart, 2000). Lower operating costs lead to higher profits. Khanal and Gillespie (2013) agreed that adopters of new technology in the dairy industry are more profitable than non-adopters. These benefits could also be realized by the cow-calf sector in New Mexico, if the technology is adopted. Nonetheless, pregnancy determination technologies such as ultrasound are difficult to use and require a lot of labor. Pruitt et al. (2012) complemented this statement by adding that pregnancy determination technologies are typically labor intensive and therefore producers are resistant to adopt.

Education is a recurring factor in the adoption of new agricultural innovations across the entire industry. Many studies have found that educated producers having either a bachelor's degree or some college education are more likely to adopt new agricultural innovations such as ultrasound (Gillespie et al., 2007; Howley, Donoghue, & Heanue, 2012; Khanal, Gillespie, & MacDonald, 2010; Khanal & Gillespie, 2013; Kim

et al., 2005; Pruitt et al., 2012). Agricultural technologies can be difficult to learn and understand. Johnson and Ruttan (1997) agreed, writing that many new pregnancy determination technologies are information intensive and require a higher level of understanding about genetics and reproduction. Education levels of New Mexico ranchers may influence the adoption of this newer reproductive technology.

Age of New Mexico producers may also explain their adoption patterns toward breeding technologies such as ultrasound. Older ranchers may not be inclined to adopt breeding technologies leading to potential decreased profits. Research has found that younger agriculturists are more likely to adopt newer technologies than older agriculturists (Adesina & Zinnah, 1993; Howley et al., 2012; Khanal et al., 2010; Khanal & Gillespie, 2013; Ward et al., 2008). If this is true with New Mexican cattle producers, more educational programs can be developed in order to reach and convince an aging generation of ranchers in the state. However, other research disagrees and suggests that age is not a factor in agricultural adoption. In conservation practices the older the producer the more likely they were to adopt conservation best management practices (Kim et al., 2005). Within the hog industry Gillespie, Davies, and Rahelizatovo (2004) found that age was not a factor in adoption of breeding technologies.

Size of the operation influences the adoption of breeding technologies such as ultrasound within the cattle industry. Economies of size has been found to be an influence in the adoption of agricultural innovations within the beef and dairy industry (Adesina & Zinnah, 1993; Johnson & Ruttan, 1997; Khanal et al., 2010; Pruitt et al., 2012; Ward et al., 2008). In the hog industry the findings also agree that the size of the

operation has an influence on the adoption of breeding technologies: as the size increases the more likely the producer is to adopt (Gillespie et al., 2004). However, some research findings disagree, concluding that size is not a factor in the adoption of agricultural technological innovations. For instance, Kim et al. (2005) wrote that size was not a factor in the adoption of conservation best management practices. Contradicting their previous research, Gillespie et al. (2007) agreed that a larger operation does not contribute to an increased adoption of conservation technology; instead, they discovered that the smaller the operation the more likely conservation adoption was to occur.

Other characteristics that have shown to encourage adoption of agricultural technology are attributes such as operation diversification. Kim et al. (2005) supported this statement; they found that diversified farmers were more likely to adopt certain best management practices while less diversified operations were not. Complementarity has also been shown to be a significant factor in the adoption process. . Khanal et al. (2010) agreed that complementarity seems to have a positive effect on adoption. The technology would need to complement breeding technologies and management strategies already in place by the operation.

Compatibility is also another feature that producers are concerned with in the adoption of agricultural technologies such as ultrasound. Johnson and Ruttan (1997) found the compatibility of artificial insemination (AI) to the current existing systems of dairy operations to be an important decision factor for producers. Land ownership has also been discovered to have an increasing influence on the probability of agricultural technology adoption. Kim et al. (2005) echoed this by expressing that producers who

owned their land were more likely to adopt. This indicates that perhaps land ownership may ease some of the economic commitment required to obtain an ultrasound machine.

Another characteristics that is unique to the adoption of agricultural innovations is that legacy seems to play an important role in increasing adoption. Farmers with children are more likely to use new pregnancy determination technologies, perhaps inferring that legacy has an impact on adoption (Howley et al., 2012). Perhaps the operation is family owned and operated and will be passed from one generation to the next. Success of the current operation sets up the future generation for success.

Non-adoption for agricultural innovations is due to many factors. Poor communication of the innovation has been directly linked to poor adoption rates (Moreland & Hyland, 2013). Without communication producers are unaware that the technology exists. Yapa and Mayfield (1978), explained that a producer's economic class has more influence on their decision to adopt. Underprivileged classes of producers are not favored and the innovations will not benefit them so they do not adopt. Many producers do not adopt certain technologies because they feel the innovation is not applicable to their operation (Gillespie et al., 2007). If no benefit is perceived by the potential adopter typically they will not adopt the new innovation.

Cow-calf Management and Characteristics

The cow-calf industry relies heavily on the production of calves. In order to have this commodity, reproduction and management are vital to the continuation of the industry. Adkins, Riley, Little, and Coatney (2012) agreed that only cows that have

conceived will have calves that can be weaned and sold. The management of the reproductive efficiency of the herd will ultimately influence the profitability of the operation. Adkins et al. (2012), concur that any mismanagement of the reproductive efficiency of the herd can negatively influence the potential profitability of the herd.

Having an organized breeding season and subsequent calving season are imperative for the production of the product (Dargatz, Dewell, & Mortimer, 2004). Without this organization, calves may or may not be produced, and the dates of their arrival are dispersed and unpredictable. It has been stated again by Wittum et al. (1990), that reproductive efficiency has a significant impact by increasing the profitability of the herd. Through the usage of reproductive technologies, the overall health of the herd can be managed and a strategy can be implemented for the upcoming calving season. Wittum et al. (1990) again stated that through management, producers can determine the current reproductive status and health of the herd and can also better manage and plan for their calving season.

Wiltbank (1970) wrote that the "two main problems in beef cattle reproduction are low calf crops and long calving seasons" (p. 755). According to the recommendations of Vavra and Raleigh (1976), calving season in the Southwestern United States should be timed so that a calf is not born during the severe weather months and the subsequent suckling calf can benefit the most from high quality forage during the fall monsoon season. Grobler, Scholtz, Schwalbach, and Greyling (2013) added that cows calving earlier in the season have more of a chance to recover and therefore go into the next breeding season in better condition. Having a suggested succinct breeding

season of 63 days which includes 3 estrous cycles will lead to a more manageable calving season for the producer (Vavra & Raleigh, 1976).

Depending on the location of the operation, calving seasons may be different. In the higher elevations a fall calving season is more appropriate and offers less risk due to inclement weather, while in the lower elevations spring calving seasons beginning in January are more suitable (Vavra & Raleigh, 1976). Additionally, Funston, Musgrave, Meyer, and Larson (2012) found that increasing early calving frequency may increase progeny value at weaning and enhance carcass value. The earlier and more condensed the calving season the more potential profits can be realized by the producer. The ability to market a uniform calf crop is essential in getting the best price possible (Dargatz et al., 2004).

Disruption in the calving interval by late calving cows causes them to not have an adequate amount of time to return to estrus early in the breeding season (Wiltbank, 1970). If these cows do not return to estrus during the breeding season they will remain open and will subsequently be culled. Another complication of calving interval is younger cows have a larger interval from parturition to first estrus (Wiltbank, 1970). The longevity of their calving interval could also be cause for the producer to cull the younger cows. An extended calving interval causes a problem with having a succinct breeding season, thus hurting the chances that all cows will be rebred on time.

Use of Ultrasound to Determine Pregnancy

Ultrasound technology has been around for many years; yet, in the beef cattle industry it is rarely used to determine pregnancy (Fricke, 2006; Pohler et al., 2011). Adoption of this technology has been limited. The beef industry produces a commodity that could benefit from ultrasonic pregnancy determination. “The sustaining force in the production process is reproduction among the breeding herd, for without reproduction there is no production” (Dargatz et al., 2004, p. 998). The value and importance of pregnancy determination in beef cattle has long been established.

The traditional method of determining pregnancy is through rectal palpation. Palpation is inserting the hand and arm into the rectum and feeling the reproductive tract for pregnancy indications (Beverly, Sprott, & Carpenter, 2008). Trained technicians perform this procedure and once inside the internal cavity of the rectum can systematically feel with their hand for a fetus or the lack thereof inside the cow. According to Mortimer and Hansen (2006), the fetus becomes palpable within 65-70 days after conception and can easily be felt.

There are four methods to rectally examine a cow for pregnancy. The most commonly used method is rectal palpation for the fetus. Other methods include palpation of the amniotic vesicle, palpation of placentomes, and palpation of the membrane slip (Mortimer & Hansen, 2006). The amniotic vesicle, which is described by Mortimer and Hansen (2006) as a round fluid- filled object can be palpated at 28-32 days for heifers and 32-35 days after conception for mature cows. The accuracy for this method is best between 35-65 days of pregnancy (Mortimer & Hansen, 2006). However, Ball and

Carroll (1963), explained that amniotic vesicle method can be dangerous as the vesicle can rupture and the pregnancy will then terminate.

When cotyledons that are attached to the placenta are fused with the maternal caruncle, placentomes result (Mortimer & Hansen, 2006). These placentomes can be felt via rectal palpation during a small window of time 75 to 80 days post conception. This method may be the most difficult as the time frame for when the placentomes can be felt the most accurately is only during that 5-day time period. Mortimer and Hansen (2006) continue to explain that palpation of placentomes is the most inconsistent method used as the placentomes can be confused for ovaries.

The last method is the fetal membrane slip method in which the developing placenta can be felt within the lumen of the uterus as early as 30 days post conception (Mortimer & Hansen, 2006). The membrane slip method is completed by slipping the membrane between the thumb and forefinger (Zemjanis, 1970). While the membrane slip method can be used to determine pregnancy, the status and duration of that pregnancy cannot be determined using this method (Mortimer & Hansen, 2006). Without the knowledge of the status of the pregnancy, a predetermined calving date cannot be established using this procedure.

In recent years, ultrasound technology and blood test technology have been added as methods of pregnancy diagnosis. Do either of these technologies have added benefits to replace the current method of rectal palpation? If so, what are those benefits/characteristics that may lead to the adoption of one of these innovations? Alternatively, are both, one or the other, or neither superior to the existing method?

Accuracy

Ultrasound pregnancy determination technology has been cited many times to be highly accurate at determining pregnancy in beef cattle (Curran, Kastelic, & Ginther, 1989; Foote, 1996; Fricke, 2006; Hughes & Davies, 1989; Poock & Wilson, 2011). The incredibly accurate prediction of pregnancy can greatly influence the industry and increase profits though production. "The bovine conceptus can be detected as early as 12 to 14 days after ovulation, using the noninvasive technique of real-time diagnostic ultrasonography" (Curran, Pierson, & Ginther, 1986, p. 1289). Alternatively, studies have shown that palpation per rectum was not an accurate form of pregnancy diagnosis during the earlier stages of pregnancy (Romano et al., 2007).

Fetal Sexing

Along with high accuracy rates for pregnancy determination, the technology offers other information as well such as the sex of the fetus (Curran et al., 1989; Hughes & Davies, 1989; Medan & Abd El-Aty, 2010; Poock & Wilson, 2011; Stroud, 2005). The sex of the fetus is best determined after day 55 of gestation until parturition, as the genital tubercle is visible (Curran & Ginther, 1991). This procedure, while complex, can be as accurate as 94% according to Muller and Wittkowski (1986).

The knowledge of the fetal sex can give the producer the information needed to aid in calving management. Dargatz et al., (2004) wrote that calving management may be one of the most important factors in producing the commodity. Stroud (2005) added that grouping of heifers and cows based on the sex of the calf they are carrying can aid

in the management of dystocia, which typically occurs more often with male calves. Ultrasound also offers the benefit of identifying twins that may be same sex (both males or both females) or opposite sex (heifers usually freemartins) (Hughes & Davies, 1989; Stroud, 2005).

Fetal Aging

Fetal aging is another benefit of ultrasound technology. Management strategies for calving can also be implemented by grouping cows and heifers by their calving dates (Ribadu & Nakao, 1999). Fetal aging can aid the producer in estimating the calving date with highly accurate precision. Wright, White, Russel, Whyte, and McBean (1988) found that fetal aging can be determined precisely; the mean difference for the actual and predicted calving dates was 0.9± 9.0 *SD* days. Ultrasound determines fetal age through the usage of crown-rump measurements (Hughes & Davies, 1989; Medan & Abd El-Aty, 2010; Poock & Wilson, 2011).

Fetal Loss

Fetal loss is another detrimental attribute of rectal palpation that is eliminated with the use of ultrasound. "One of the greatest advantages of ultrasonography is that it is totally non-invasive and so repeated examinations of an animal's reproductive tract can be performed without impairing its breeding potential or having adverse effect on the conceptus" (Ribadu & Nakao, 1999, p. 13). Rectal palpation is an invasive procedure and can increase the risk of fetal loss. Hughes and Davies (1989) explained that

palpation per rectum does involve a risk to the life of the fetus and sometimes fetal death occurs. While it is difficult to separate fetal loss due to rectal palpation and natural fetal death, the overall fetal attrition in one study was found to be around 5.5% due to rectal palpation (Baxter & Ward, 1997; Mortimer & Hansen, 2006).

The incidence of fetal loss is detrimental to the productivity of the operation. However, using technology in conjunction with reproductive management can decrease costs and increase production through the reduction of calving loss (Ramsey et al., 2005). Ultrasound greatly reduces that risk and has no adverse effects on the dam or the fetus (Baxter & Ward, 1997; Beal, Perry, & Corah, 1992; Hughes & Davies, 1989; Ribadu & Nakao, 1999; Richardson et al., 2010).

Profitability (Cost versus Returns)

The use of ultrasonic scanning can increase the profitability and aid in the management of the herd's reproductive performance that will ultimately increase the productivity of the operation and increase the producer's bottom line (Pohler et al., 2011; Ramsey et al., 2005; Wittum et al., 1990). The potential profit can be realized through all the many attributes of ultrasound scanning the precision and accuracy, the ability to fetal age and fetal sex, and the ability to manage for twins. These types of information can increase profits for producers. "Ultrasound examination has one main disadvantage over other methods and that is the initial financial outlay for the equipment" (Baxter & Ward, 1997, p. 288).

The technology has a financial commitment attached; however, through its use profits for the future can be realized. While the machines are expensive, they are also portable and can be used almost anywhere (Medan & Abd El-Aty, 2010). The technology can be used in the pasture and the barn with no risk of damage to the scanner. Also, the sale of non-pregnant or late-bred cows that need to be culled can offer additional income—income often unrealized for the operation without the technology (Mortimer & Hansen 2006).

Reproductive Physiology

Ultrasound can also offer increased management of the herd's reproductive physiology and overall health. Maintaining the overall health of the herd increases their productivity. With no product there is no profit. Adkins et al. (2012) agreed that "only cows that conceive can eventually give birth to calves that are later weaned" (p. 11). Reproductive health of the herd is of utmost importance to producers. "Less than optimal reproductive performance in a beef herd reduces economic efficiency by increasing the cost per unit of production" (Wittum et al., 1990, p. 2642). A comprehensive view of the reproductive tract can be observed using ultrasound with no manipulation of the tract (Medan & Abd El-Aty, 2010; Ribadu & Nakao, 1999). No manipulation of the tract is an added benefit to the cow and the producer as it reduces the risk of injury.

Reproductive Health

Ovarian cysts, which may cause infertility, and other reproductive abnormalities such as endometritis, pyometra, fetal maceration, and fetal mummification can be identified and potentially treated (Ribadu & Nakao, 1999). The identification of the non-cycling cows can also be used as a management strategy to re-synchronize them for breeding (Beal et al., 1992). Managing the non-cycling cows and heifers and returning them to cycling can aid in the overall reproductive management and productivity of the herd. The use of ultrasound offers the freedom to use the technology when it best suits the operation.

Ultrasound can be used before the breeding season to differ the cycling from the non-cycling cows, so the producer can synchronize those cows or heifers to come into estrus during the breeding season. Ultrasound can also be used in the middle of breeding season to identify which cows are bred from those that have not conceived yet. The cows that are pregnant can be removed therefore increasing the opportunity for the open cows to pair with a bull. Using ultrasound in the middle of the season can also offer the producer the opportunity to synchronize the open females once again before the breeding season is over. Using the technology after the season can offer the producer the chance to make management decisions about the herd and culling unwanted open females.

Diffusion of Innovations

Adoption of agricultural innovations by ranchers in New Mexico may be limited. New Mexico is a rural state, and contact with an extension agent may be reduced/less

than in more densely populated states. The diffusion of pregnancy determination technologies such as ultrasound may be restricted as some of the producers may not have ever heard of the innovation. Rogers (2003) defined diffusion as a process by which an innovation is communicated to members of a social system. Another difficulty that may exist for this group of cattle ranchers is that contact with a change agent may be limited. The state is large and producers are dispersed within the state; extension agents along with their other responsibilities may have a difficult time reaching producers. Agricultural extension agents are change agents within the agricultural community. A change agent is a person who can influence people and their innovation decisions in a way thought to be desirable by a change agency (Rogers, 2003).

As described by Rogers (2003), diffusion of innovations has four main elements:

1. The innovation
2. Communication channels
3. Time
4. A social system

An innovation such as ultrasound follows these four elements of diffusion. Diffusion is described as the process by which an innovation is communicated over time to members of a social system (Rogers, 2003). The diffusion of ultrasound is impossible if the innovation is unknown by producers. So, communication of the innovation to potential adopters is a primary and initial step in the process of diffusion. In order for ranchers to adopt a new breeding technology such as ultrasound, knowledge of the

innovation must exist. Rogers (2003) outlines the innovation-decision process as five stages:

1. Knowledge stage
2. Persuasion stage
3. Decision stage
4. Implementation Stage
5. Confirmation Stage

In order for the adoption of ultrasound to occur, these stages of the innovation decision process must be fulfilled. This process may take a short period of time or an extended amount of time for individual producers. Opinion leadership, a social phenomenon, may be used during this time to influence the rate of adoption of ultrasound. Producers in an area may have more contact and more confidence in their community's opinion leader. An opinion leader is a person who can influence other people's opinions (Rogers, 2003). Communities that have an opinion leader who favors the use of ultrasound may adopt the technology at a faster rate. The rate of adoption is explained as the speed by which an innovation is adopted by the members of a social system (Rogers, 2003).

The attributes of the innovation (in this instance, ultrasound) may also influence the rate by which the technology is adopted. Rogers (2003) identified five specific attributes of innovations that may affect the rate of adoption of an innovation: relative advantage, compatibility, complexity, trialability, and observability. Further, he found

that these attributes are not necessarily inherent to the innovation. Rather, the attributes are as perceived by the potential adopters.

The technology must be believed to give a relative advantage over previous technologies utilized. Rogers (2003) explains that relative advantage is the amount by which an innovation is believed to be better than preexisting innovations. Ultrasound offers a distinct relative advantage over rectal palpation as the results are immediate and are highly accurate and offer less risk to the cow and her fetus (Hughes & Davies, 1989). According to Ribadu and Nakao (1999), one of the best advantages of ultrasound is that it is non-invasive and repeated examinations do not offer any unfavorable effects to the unborn fetus.

The cost of an ultrasound machine is from $6000 to $20,000 (M. Ward, personal communication, March 31, 2014). Buying an ultrasound machine requires a large financial commitment; however, if performed by an ultrasound technician, the price per head is typically increases $2 per head (M. Ward, personal communication, March 31, 2014). This small increase in cost is fiscally beneficial to the producer as the information received is extremely reliable and consistent. According to M. Ward (personal communication, March 31, 2014), the average price charged to the producer for rectal palpation is $3 per head, with ultrasound the price increases to $5 per head.

The innovation must also be compatible with the current operation and with the values of the producer. Compatibility has been expressed as the amount by which an innovation is thought be consistent with the current values, past experiences, and the needs of producers (Rogers, 2003). The needs of producers when determining pregnancy

in their herds, according to Mortimer and Hansen (2006), are accuracy, efficiency, and affordability. Ultrasound offers those qualities to producers. Ultrasound can detect pregnancy as early as 12 to 14 days after ovulation (Curran et al., 1986). The procedure is also safe and well-tolerated by the animal not requiring any sedation (Ribadu & Nakao, 1999). While the ultrasound machine itself could be a high cost to the producer, the potential profits due to the other attributes of accuracy and efficiency of ultrasound are immense. Using ultrasound to obtain profitable production levels while still maintaining efficiency is one of the innovations greatest compatibility attributes (Pohler et al., 2011).

One of the downfalls of ultrasound adoption may be its complexity. Complexity is defined as the degree of difficulty an innovation is perceived to be in order to use it (Rogers, 2003). The difficulty level and educational background required may be one of the biggest barriers to the adoption of ultrasound for pregnancy determination. However, Stroud (2005) explained that while learning ultrasound can be difficult, it can be attained with patience and practice. Ribadu and Nakao (1999) added that even individuals who are inexperienced in rectal palpation per rectum can attain ultrasonography skills quickly while still maintaining a high level of accuracy.

Another barrier to adoption may be the inability to use the technology on a trial basis. Trialability is described as the extent to which a technology may be used in an experimental trial (Rogers, 2003). Ultrasound machines are expensive and can be difficult to acquire and use without the proper education and knowledge level needed to use the technology. However, many ultrasound training programs offer machines that

can be used during the training period. This offers the trialability needed in order to make a decision about the technology.

The ability to observe the use of ultrasound and how it works is another aspect of this technology's adoption. Rogers (2003) describes observability as the ability to observe the results of an innovation. Observability may be where ultrasound excels as the results of the usage are immediate and observable on a screen. Fricke (2006) agrees that the results of ultrasound are rapid and the results are known immediately during the examination. This offers an enormous advantage over rectal palpation as the result of the exam can be instantly physically observed, whereas in rectal palpation the result is an educated guess by the technician.

Summary of Literature Review

In New Mexico the adoption status of ultrasound technology may be limited. The potential factors that contribute to this technology's limitations may be the price of the technology or may also be the difficulty level of operating the technology. Attributes of the producers themselves may also contribute to the adoption of this technology such as the age of the producers, size of the operation, diversification of the operation as well as ultrasounds compatibility with the operations existing operating procedures.

The traditional method of rectal palpation does not offer the extensive benefits of ultrasound such as increased accuracy to detect the fetus at an earlier stage. Ultrasound also allows the ability to gain information about the sex of the fetus as well as the approximate age of the fetus during gestation. Unlike rectal palpation, ultrasound does

not involve the increased risk to the viability of the fetus and less fetal loss has been reported. Ultrasound also offers the ability to examine the reproductive physiology and reproductive health of the female. The diffusion process of this technology could influence the future of the industry in New Mexico.

CHAPTER III

METHODS

The purpose of this study was to understand the rate of adoption of bovine ultrasound pregnancy determination by New Mexico cattle producers. The following methods were used to accomplish this purpose.

Research Design

The study used a descriptive correlational design. Described were demographics of cattle producers in New Mexico, characteristics of their beef cow-calf operations, and their experience with the use of ultrasound technology to determine pregnancy in beef cattle. Correlational techniques were employed to determine if selected characteristics were related to their experiences with, perceptions of, and rate of adoption of the ultrasound technology. Also examined were communication channels by which cattle producers receive information about new techniques and technologies.

Population and Sample

The target population for this study was beef cow-calf livestock producers in the state of New Mexico. Cow-calf producers were defined as producers whose primary goal is to breed cows who will ultimately give birth to a live calf and that the producer can then sell for a profit. According to the 2012 Census of Agriculture-State Data (USDA, 2012a), there were more than 11,000 farms in New Mexico with beef cattle (cows and

calves). Of these, more than 7,000 had beef cow herds of fewer than 20 cows; thus, fewer than 3,200 farms had beef cattle herds of 20 or more cows.

Names and addresses of the 11,000 producers were not available. Rather, the accessible population was identified as those beef cattle producers who were members of the NMCGA. Membership in the association included 1,500 ranchers with beef cow-calf operations as of July 1, 2014 (Caren Cowen, personal communication, October 13, 2014); the list of members of the association with beef cow-calf operations served as the sampling frame for the study. The respondents are representative of the 3,000 producers who have more than 20 head of cattle on their operation (Caren Cowen, personal communication, October 6, 2014).

Instrument

This study used descriptive survey methodology to gather information, perceptions, and opinions associated with the adoption and usage of ultrasound technology for pregnancy determination by New Mexico cattle producers. In this study of the rate of adoption of bovine ultrasound pregnancy determination by New Mexico cattle producers, one survey instrument in the form of a questionnaire was designed in Google docs© using the forms design.

The instrument was developed by the investigator with input and suggestions from the graduate committee, content experts, and Caren Cowan with NMCGA, based on the need for descriptive quantitative data about producers in the state. Similarly, the association agreed to endorse the study and encourage its members to respond, to assist

with follow-up contacts, and generally to serve as a collaborator in the study. Thus, a list of contact information of producers in the state was used by the NMCGA.

Using a five-point Likert response scale for statements about ultrasound technology, the instrument extracted information regarding the producer's use of, and preferences for, ultrasound pregnancy determination. Questions regarding the non-adoption of the technology were also asked. Supplemental information such as age, gender, education level, and size of operation were obtained using the instrument. Producers were asked to self-report this information. The data also provided information of the contact that producers had with the extension service and whether they are aware of current breeding technologies such as ultrasound.

Data Collection

After the instrument was entered into Google Forms, it was sent to Caren Cowan to be distributed to New Mexico cattle producers on July 11, 2014, using Dillman's (2011) suggestions for collecting data via the internet. The use of google docs-forms allowed the population of producers to remain anonymous to the investigator as the submitted responses channel back to Google Forms as a time stamped response with no personal data about the participant.

After 10 days on July 21, 2014, the instrument was again sent to Caren Cowan to be forwarded to producers. On this date the instrument was also uploaded to Facebook and the NMCGA website as an avenue to reach more of the target population of cattle producers within the state. On July 31, 2014, a final reminder was sent out to producers

via email and Facebook asking them to complete the survey. The survey remained open for 10 more days until August 10, 2014, when the survey was closed and no further responses were received.

Data Analysis

Descriptive statistics such as frequencies and percentages of nominal data, grouped/categorical representation with percentages and medians of ordinal data, and means and standard deviations of intervally-scaled variables were employed to describe the sample of producers and their levels of familiarity and use of ultrasound technology. Perceptions of its value and selected characteristics of the technology were described statistically. Correlational and comparative statistics, including inferential statistics as appropriate, were used to allow generalization to the target population. Non-response error were handled according to the recommendations of Lindner, Murphy, and Briers, (2001). Early respondents were compared to late respondents to determine if there were any differences in producers' demographics, characteristics of their operations, or their perceptions of technologies. Because there were no differences and because non-respondents are often similar to late respondents Lindner et al. (2001), the researcher concluded that the sample was representative of the accessible population. Thus, inferential statistics were appropriate in making inferences from the responding sample to the accessible population.

CHAPTER IV

FINDINGS AND DISCUSSION

This chapter presents the findings of the study to describe beef cow-calf producers in New Mexico, their cattle operations, their general innovativeness, and the rate of adoption and the diffusion process of ultrasound technology for pregnancy determination.

Data for Research Question One

Answering this research question required a description of characteristics of beef cow-calf operations in New Mexico. The detailed findings carefully describe the personal characteristics of the producers and their operations. The first research question was: What are selected characteristics and demographics of beef cattle producers in the state of New Mexico? Data for this question were retrieved from multiple questions asked on the survey.

The sample provided data to describe five demographic traits. The first trait was gender. This was done by asking a closed-ended question regarding their gender. Producers were instructed to mark the answer that most describes them. The question asked: What is your gender? Of the respondents, 78.1% were male and 21.9% were female (Table 1).

Table 1

Gender of Beef Cow-calf Producers in New Mexico

Gender	Frequency	Percent
Male	75	78.1
Female	21	21.9
Total	96	100.0

No response: *n*=3

Age was another demographic trait of interest. A closed-ended question was derived asking respondents to mark one answer that describes them. The question asked: What is your age? The responses were as follows: 20-29 years, *n*=2 or 2.1%; 30-39 years, *n*=13 or 13.5%; 40-49 years, *n*=13 or 13.5%; 50-59 years, *n*=32 or 33.3%; 60-69 years, *n*=27 or 28.1%; 70 or older, *n*=9 or 9.4%. Thus, a plurality of the participants were 50-59 years old, and the median age of producers was 56 years old (Table 2).

Table 2

Age of Beef Cow-calf Producers in New Mexico

Years of Age (Range)	Frequency	Percent
20-29	2	2.1
30-39	13	13.5
40-49	13	13.5
50-59	32	33.3
60-69	27	28.1
70 or older	9	9.4
Total	96	100.0

No response: *n*=3
Median Age=56

The next demographic was education. The question on the survey asked for the highest level of education attained. The responses were as follows: Less than high school diploma, *n*=1 or 1.0%; high school diploma, *n*=8 or 8.2%; some college, *n*=21 or 21.6%; Associate's degree, *n*=5 or 5.5%; Bachelor's degree, *n*=36 or 37.1% and graduate or professional degree, *n*=26 or 26.8%. Thus a plurality held a bachelor's degree. The bachelor's degree was also the median level of education attained (Table 3).

Table 3

Highest Level of Education Attained by Beef Cow-calf Producers in New Mexico

Level of Education	Frequency	Percent
Less than high school diploma	1	1.0
High school diploma	8	8.2
Some college	21	21.6
Associate's degree	5	5.5
Bachelor's degree	36	37.1
Graduate or Professional degree (M.S., PhD, DVM, etc.)	26	26.8
Total	97	100.0

No response: *n*=2
Median level of education attained = bachelor's degree

Years in the cattle industry was another question used to describe the producers. The question was an open-ended question, and producers were asked to write in their answers. The question asked was: How long have you been in the cow-calf business? These are the three most common answers: 50 or more, *n*=31 or 33%; 41-50, *n*=17 or 18% and 31-40, *n*=16 or 17%. Additional frequencies and percentages are listed on

Table 4. So, respondents had a median of 41 years in the cattle industry. Thus, one can calculate from the median age of 56 years that the average producer began his or her tenure in the cattle industry at age 15 (Table 4).

Table 4

Years in the Cattle Industry for Beef Cow-calf Producers in New Mexico

Years in Industry (Range)	Frequency	Percent
10 or fewer	8	8.5
11-20	11	11.7
21-30	11	11.7
31-40	16	17.0
41-50	17	18.0
More than 50	31	33.0
Total	94	100.0

No response: *n*=5
Median years in the cattle industry=41 years

The next part of the research was to transition from a description of the beef cattle producers themselves to a description of their operations. In that transition, number of years in the beef cattle industry remained part of the description of the personal characteristics—even though it begins to provide information germane to their beef cattle operations. Similarly, the first question to describe the operation helps with the transition: What percentage of your household income is derived from your cow-calf operation? The responses to that question were as follows: 0-25%, *n*=35 or 35.4%; 51-75%, *n*=25 or 25.3%; 76-100%, *n*=21 or 21.2%, 26-50% and *n*=18 or 18.2%. So, a plurality of the sample received 25% or less of their household income from the cow-calf operation. The median percentage of household income, however, was 46 (Table 5).

Table 5

Percentage of Household Income from the Cattle Operation of Beef Cow-calf Producers in New Mexico

% Household Income from Cattle Operation	Frequency	Percent
0-25%	35	35.4
26-50%	18	18.2
51-75%	25	25.3
76-100%	21	21.2
Total	99	100.0

Median Household Income from Cattle Operation=46%

Data for Research Question Two

Research question two sought to describe the beef cattle operations of respondents to the questionnaire. The first demographic specific to their beef cow-calf operation was the size of the operation in acres. Participants were asked to choose one answer from a list of four possible answers. The question asked: How would you classify the size of your operation in acres? The participants' responses were as follows: Less than 1,000 acres, n=12 or 12.1%, 1,000-5,000 acres, n=10 or 10.1%, 5,000-20,000 acres, n=31 or 31.3% and larger than 20,000 acres, n=46 or 46.5%. The median size of the operation was 18,550 acres. Producers described a plurality of their operations in New Mexico are very large having more than 20,000 acres (Table 6). These findings differ substantially from the average farm size in New Mexico. The average farm acreage in New Mexico was reported as 1,845 acres according to the 2012 census (USDA, 2013c).

Table 6

Size of the Operation in Acres of Beef Cow-calf Producers in New Mexico

Number of acres in ranch	Frequency	Percent
Less than 1,000 acres	12	12.1
1,000-5,000	10	10.1
5,000-20,000	31	31.3
Larger than 20,000 acres	46	46.5
Total	99	100.0

Median Size=18,550 acres

Finally, producers were asked to describe the size of their operations in cow numbers. How would you classify the size of your operation in cow numbers? The responses were as follows: fewer than 100 cows, n=29 or 29.3%, 101-200 cows, n=18 or 18.2%, 201-500 cows, n=30 or 30.3%, more than 500 cows, n=22 or 22.2%. A plurality of producers indicated cow numbers of 201-500. Grouped data analysis revealed a median number of mature cows to be 230 cows (Table 7).

These data differ from those reported in 2012 Census of Agriculture-State Data (USDA, 2012a). In the census, 11,004 farms reported beef cow herds, with a large plurality (5,028) of the farms reporting herd sizes of one to nine head. While 47.5% (47 of 99) of the respondents in this sample reported cow numbers of 200 or less, the census of producers identified that 10,493 of 11,004 farms (95%) in New Mexico had fewer than 200 cows.

Table 7

Number of Mature Cows to Indicate Size of Operation of Beef Cow-calf Producers in New Mexico

Number of mature cows	Frequency	Percent
Less than 100	29	29.3
101-200	18	18.2
201-500	30	30.3
More than 500	22	22.2
Total	99	100.0

Median Size=230 cows

In summary, the average or typical producer who was a respondent for this study was a 56 year-old male with 41 years in the cattle industry. He held a bachelor's degree and his operation was 18,550 acres with 230 head of cows. Thus, the typical stocking rate was 8 AUs per section or 1 AU per 80 acres. Finally, he was receiving a majority (54%) of his household income from off-ranch employment.

The next question was an open-ended question asking producers to identify the breed(s) of their cow herd: What breed(s) of cattle do you use/have in your cow herd? The participants were asked write in their answers in the blank provided on the survey. Data were analyzed first to determine how many producers used a single breed of cows in their operation, how many used two breeds, and how many used three or more. The data revealed that a plurality of producers (*n*=45) used one breed in their cow herds. More than half as many producers (*n*=27) used two breeds of cows. Finally, 24 producers reported using three or more breeds in their operations (Table 8). The three most commonly used breeds were: Angus, Brangus, and Hereford. A combination of

those breeds also accounted for the cows base of a large percentage of producers used to a much lesser extent—either as crosses or as straightbreds—were Charolais, Beefmaster, and Limousin. Three or more breeds were used by 25%. The most commonly used breeds were Angus, Hereford, and Charolais.

Table 8

Number of Breeds of Cattle Used in Cow Herd of Beef Cow-calf Operations in New Mexico

Number of Breeds	Frequency	Percent
One Breed	45	46.9
Two Breeds	27	28.1
Three or more	24	25.0
Total	96	100.0

No response: *n*=3
Median=Two Breeds

The next open-ended question asked producers to identify the breed(s) of bulls used in their operations. The question asked: What breed(s) of cattle do you use/have in your bull herd? Respondents were asked to write in their responses in the blank provided in the survey. The most common breeds used in their operation as sires were, again, Angus, 52%; Hereford, 12.8%, Brangus, 11.7%, and Charolais, 4.3%. All other breeds accounted for less than 20% of the bull breeds reported.

Data for Research Question Three

The following set of questions was used to describe the innovativeness of produces by their use of common best management practices. An open-ended question

asked producers to state the start date of their breeding season. Producers were asked to please write-in the blank with their answers. The question asked: What is your breeding season start date? The most prevalent responses to that question was as follows: May 1-May 30, 35.9%; April 1-April 30, 21.7%; June 1-June 30, 16.3%; 365 days (year round), 12.0%; July 1-July 30, 7.6%; January 1-January 30, 6.5% (Table 9).

Table 9

Starting Date of Breeding Season of Beef Cow-calf Operations in New Mexico

Starting Date	Frequency	Percent
January 1-March 31	6	6.5
April 1-April 30	20	21.7
May 1-May 31	33	35.9
June 1-June 30	15	16.3
July 1-November 30	7	7.6
365 days (year round)*	11	12.0
Total	92	100.0

No response: *n*=7
Median Starting Date of Breeding Season = May 14
*Excluded from the calculation of median starting date of breeding season.

To correspond with the previous question, producers were asked about the end of their breeding season. Producers were asked to write-in their responses in the blank provided on the survey. The most prevalent response was as follows: August 1-August 31 with 23.3%. The median of producers end their breeding season on August 18. (Table 10).

Table 10

Ending Date of Breeding Season of Beef Cow-calf Operations in New Mexico

Ending Date	Frequency	Percent
Before April 1	5	5.6
April 1-June 30	11	12.2
July 1-July 31	12	13.3
August 1-August 31	21	23.3
September 1-November 30	10	11.1
October1-October 31	12	13.3
November 1 or later	8	8.9
365 days (year round)*	11	12.2
Total	90	100.0

No response: *n*=9
Median Ending Date of Breeding Season = Aug 18
*Excluded from calculation of median ending date of breeding season.

Length of breeding season was calculated by subtracting the starting date (expressed as a number from 1 to 365) from the ending date (similarly expressed). Using start date and end date for breeding season, the researcher calculated the length of the breeding season for each operation. According to Deutscher, Stotts, and Nielsen (1991), a breeding season of 70 days is considered ideal for profit and productivity. Also, having a longer breeding season leads to increased production costs and decreased production (Ramsey et al., 2005). Therefore, producers with a more controlled/shorter breeding season may be more innovative (Table 11).

Table 11

Length of Breeding Season of Beef Cow-calf Operations in New Mexico

Length in Days	Frequency	Percent
30-60 days	7	7.9
61-90 days	19	21.3
91-120 days	23	25.8
121-150 days	13	14.6
151-180 days	7	7.9
181-210 days	7	7.9
210-279 days	2	2.2
365 days (year round)	11	12.4
Total	89	100.0

No response: *n*=10
Median length of breeding season = 108 days

Thus, adding 108 days to the median start of the breeding season—May 14—the median ending date of the breeding season was calculated to be August 31. This was similar to, but two weeks later than the median date calculated from the ending dates reported by producers.

The following set of questions was asked to describe the status of the adoption of selected best management practices in New Mexico. Do you use the following practices routinely in your operation? The first question asked: Do you … Creep feed calves? The responses were as follows: No, *n*=54 or 56.8%; Yes, *n*=41 or 43.2% (Table 12).

The subsequent question asked producers if they vaccinated for clostridial diseases: Do you…Vaccinate for blackleg and other clostridial diseases (7-way, 8-way)? The answers to the question are as follows: Yes, *n*=95 or 99%; No, *n*=1 or 1.0 (Table 12).

An additional question asked producers if they supplied mineral to their cow herd. The question asked: Do you …Supply minerals for cow herd? The responses were as follows: Yes, *n*=95 or 99%; No, *n*=1 or 1.0%.

Table 12

New Mexico Cow-calf Producers' Use of Best Management Practices

Best Management Practice	Yes N*	Percent	No N*	Percent
Creep feed calves	41	43.2	54	56.8
Vaccinate for blackleg and other clostridial diseases (7-way, 8-way)	95	99.0	1	1.0
Supply mineral to cow herd	95	99.0	1	1.0
Evaluate bulls for fertility	66	69.5	29	30.5
Examine bulls annually for breeding soundness	66	71.0	27	29.0
Record individual weaning weights on calves and match to cow record/Keep production records on each individual cow	24	25.5	70	74.5
Cull open cows	84	90.3	9	9.7
Market cull cows and bulls strategically	71	75.5	23	24.5
Castrate bull calves	87	92.6	7	7.4
Use hormone growth implants for steer and/or heifer calves	15	15.8	80	84.2
Deworm annually	79	84.0	15	15.6
Determine body condition scores annually	53	55.2	43	44.8
Use protein supplementation	94	98.0	2	2.1

*May not total 99 due to non-response.

The following question asked producers if they perform fertility exams on their bulls. The question asked: Do you … Evaluate bulls for fertility (semen exam)? The responses to that question were as follows: Yes, *n*=66 or 69.5%; no, *n*=29 or 30.5%.

Next, a question asked producers if they examined their bulls for breeding soundness. The question asked: Do you use the following practices routinely in your operation: Examine bulls annually for breeding soundness? The responses from the participants were as follows: Yes, *n*=66 or 71%; no, *n*=27 or 29%.

The following question was asked to help describe the characteristics of producers within the state. The question asked: Do you use the following practices routinely in your operation: Record individual weaning weights on calves and match to cow record/keep production records on each individual cow? The following responses were recorded: No, *n*=70 or 74.5%; yes, *n*=24 or 25.5%.

The next question asked was whether producers culled their open cows. The question asked: Do you use the following practices routinely in your operation: Cull open cows? The participants responded as follows: Yes, *n*=84 or 90.3%; no, *n*=9 or 9.7%.

The following question asked participants if they market culled open cows and bulls strategically. The question asked: Do you use the following practices routinely in your operation: Market cull cows and bulls strategically? The participants answers were recorded as follows: Yes, *n*=71 or 75.5%; no, *n*=23 or 24.5%.

The subsequent question that was asked was about producer's use of castration for their bull calves. The question asked was: Do you use the following practices routinely in your operation: Castrate bull calves? The corresponding answers from the participants were as follows: Yes, *n*=87 or 92.6%; no, *n*=7 or 7.4%.

The next question that was asked pertained to the use of growth implants by producers. The question that was asked was: Do you use the following practices routinely in your operation? Use growth implants for steer and/or heifer calves? The following answers from participants were recorded as follows: No, *n*=80 or 84.2%; yes, *n*=15 or 15.8%.

Additionally, a question about whether producers deworm their cattle annually was asked. The question asked was: Do you use the following practices routinely in your operation: Deworm annually? The participants responses were recorded as: Yes, *n*=79 or 84%; no, *n*=15 or 15.6%.

The next question asked producers if they determined body condition score routinely. The question asked: Do you use the following practices routinely in your operation: Determine body condition score annually? The results were recorded as follows: Yes, *n*=53 or 55.2%; no, *n*=43 or 44.8%.

The following question asked producers if they used protein supplementation in their cattle operation. The question asked: Do you use the following practices routinely in your operation? Use protein supplementation? The producers responded and the responses were recorded as: Yes, *n*=94 or 98%; no, *n*=2 or 2.1%.

The next closed-ended question corresponded with the previous question asking producers if they did use a protein supplement to identify what source or form was used. Participants were given a list of five different protein supplementation choices (block protein, cube protein, liquid protein, loose protein feed, high protein hay) and asked to mark all that they use. The question asked: If yes, which protein supplementation is

used? The most common practices were a mixture of several of the sources of protein; a total of 57 producers reported that they used more than one source of protein; 19 reported that they used three or more sources. Only 38 producers used a single source of protein supplement; protein blocks was the sole source used by 18 producers, and cube protein was used by 15 producers as the only protein supplement (Table 13).

Table 13

Type of Protein Supplementation Used by Beef Cow-calf Producers in New Mexico

Protein Supplementation	Frequency	Percent
Block Protein	18	18.9
Cube protein	15	15.8
Combination: Block Protein, Cube protein	8	8.4
Combination: Liquid protein, Cube protein	6	6.3
Combination: Cube protein, High protein hay (alfalfa, timothy, clover, etc.)	6	6.3
Combination of all others: Liquid protein, Block protein, Cube protein, High protein hay (alfalfa, timothy, clover, etc.), Loose protein feed (ground, pelleted, etc.)	42	44.2
Total	95	100.0

No response: *n*=4

Strategies to create replacements on the operation was the next question. The participants were asked to mark all that applied on the following closed-ended question: What strategy/ies do you use to create replacements on the operation? The common answer was: Raise my own, *n*=70 or 73%. Only three more producers used a single strategy something other than "raise my own": Two producers responded that they consolidated heifers from multiple sales and another indicated that he or she got all of the operation's replacements from a single source. Another 24 used a combination of "raise my own" and another strategy, and only one producer choose a combination that did not include "raise" my own. Thus, only four producers did not use the strategy of "raise my own" to some degree—either as the only strategy or in combination with one or more of the other strategies (Table 14).

Table 14

Replacement Strategies Used by Beef Cow-calf Producers in New Mexico

Strategy	Frequency	Percent
Raise my own	70	73.0
Combination: Raise my own, Buy them from a single source	12	12.5
Combination: Raise my own, Consolidate from multiple sales	8	8.3
Consolidate from multiple sales	2	2.1
Combination: Raise my own, Buy them from a single source, Consolidate from multiple sales	2	2.1
Buy them from a single source	1	1.0
Combination: Buy them from a single source, Consolidate from multiple sales	1	1.0
Total	96	100.0

No response: *n*=3

Marketing strategies used for calves was the next closed-ended question producers were instructed to mark all that they use. The question asked was: What marketing strategies do you use for calves? The choices were as follows: Local auction barn/market, direct buyer, video/internet sales, retained ownership through stocker phase and retained ownership through feedlot. More than half of the producers surveyed used either a direct buyer (n=19) or a local auction barn/market (n=16) or both (n=21).Thus, collectively those methods and no others were used by a majority of producers (n=56). In each case the auction barn was one of the strategies used (Table 15).

Table 15

Marketing Strategies for Calves Sold by Beef Cow-calf Producers in New Mexico

Strategy	Frequency	Percent
Direct buyer	19	20.0
Local auction barn/market	16	16.8
Combination: Local auction barn/market, Direct buyer	21	22.1
Combination: Local auction barn/market, Direct buyer, Video/Internet Sales	8	8.4
Combination: Local auction barn/market, Video/Internet Sales	5	5.3
All other Combinations: Local auction barn/market, direct buyer, video/internet sales, retained ownership through stocker phase, retained ownership through feedlot	26	27.4
Total	95	100.0

No response: *n*=4

The next question asked the marketing strategies used by producers for their culls. The question was closed-ended and asked participants to choose one answer. The question asked: What marketing strategies are primarily used for culls? The participant's answers were recorded as: Local auction barn/market, 67 or 67.7%; direct buyer, *n*=28 or 28.3% and no response, *n*=4 or 4.0% (Table 16).

Table 16

Marketing Strategies for Cull Cows and Bulls Used by New Mexico Beef Cow-calf Producers

Marketing Strategy	Frequency	Percent
Local auction barn/market	67	70.5
Direct Buyer	28	29.5
Total	95	100.0

No response: *n*=4

The final question used to determine the innovativeness asked: How soon after removing bulls do you do pregnancy determination? The respondent's results are as follows: 60-89 days, 35.6%; 30-59 days, 31%; 90 days or more, 25.3% and less than 30 days, 8%. The median days after removal were 69 days (Table 17).

Table 17

Days After the Removal of Bulls for Pregnancy Determination of Beef Cow Herds in New Mexico

Number of Days	Frequency	Percent
Less than 30 days	7	8.0
30-59 days	27	31.0
60-89 days	31	35.6
90 days or more	22	25.3
Total	87	100.0

No response: *n*=12
Median days after bull removal = 69 days

Data for Research Question Four

A question used to understand producer's degree of adoption of ultrasound asked producers how they determined pregnancy in their cow herd. To elicit answers to this question, the survey contained a closed-ended question with four response choices; producers were instructed to mark all that apply. The question was asked as follows: How do you determine pregnancy in your cow herd? Rectal palpation was used most with 44 responses or 46.8% and visual appraisal with 27 responses or 28.7% were most common. Only 6.4% reported that they were currently using only ultrasound to determine pregnancy on their operation. But an additional 8.5% were using ultrasound along with a combination of other technologies to determine pregnancy.

Five respondents used none of the methods of pregnancy determination (or failed to respond). Of those who indicated a single method, six marked that they used ultrasound only. Only one other producer indicated a single method: blood test. Sixteen producers used two or more methods; all of them used rectal palpation with another method. Ultrasound was used either alone or in conjunction with another method or methods by a total of 14 producers (Table 18).

Table 18

Technology Used by Beef Cow-calf Producers in New Mexico to Detect Pregnancy

Technology	Frequency	Percent
Rectal palpation	44	46.8
Visual Appraisal	27	28.7
Combination: Rectal palpation, Ultrasound	7	7.4
Ultrasound	6	6.4
Combination: Visual Appraisal, Rectal Palpation	6	6.4
Combination: Rectal palpation, Blood test	2	2.1
Combination: Rectal palpation, Blood test, Ultrasound	1	1.1
Blood test	1	1.1
Total	94	100.0

No response: *n*=5

The next question asked to answer this research question was another closed-ended question that asked: If you do not use ultrasound, are you aware of ultrasound pregnancy determination technology? Respondents were asked to mark one answer, yes or no. Responses to this question were as follows: *n*=77 or 86.5% reported yes; *n*=12 or 13.5%, no (Table 19). Thus, a large majority of producers were aware of the technology.

Table 19

Awareness of Ultrasound by Beef Cow-calf Producers in New Mexico

Aware of Ultrasound?	Frequency	Percent
Yes	77	86.5
No	12	13.5
Total	89	100.0

No response: *n*=10

Also, a closed-ended question was used: Would you consider the use of ultrasound within your operation? Participants were asked to choose one answer from a list of five choices. The results were as follows: Yes, *n*=30 or 32.3%; not sure, *n*=25 or 26.8%; probably not, *n*=17 or 18.3%; probably so, *n*=16 or 17.2% and no, *n*=5 or 5.4% (Table 20).

Table 20

Ultrasound Usage Consideration by Beef Cow-calf Producers in New Mexico

Consider Using Ultrasound?	Frequency	Percent
Yes	30	32.3
Probably So	16	17.2
Not sure	25	26.8
Probably not	17	18.3
No	5	5.4
Total	93	100.0

No response: *n*=6

Assuming that the 14 producers who responded that they were already using ultrasound also responded that yes, they would consider using ultrasound, we can

infer/calculate that 16 who were not currently using ultrasound answered yes, they would consider using it. The same number of producers (n=16) reported that they would probably consider using ultrasound and 25 were not sure, 17 indicated that they would probably not consider it, and 5 responded no, they would not.

The 14 producers who indicated that they were already using ultrasound can be classified as innovators, according to Rogers (2003). The following group of 16, who indicated that yes, they would consider using ultrasound but had not currently adopted the technology, fall into the early adopter category. The next 16 producers who said probably so, are the early majority. Similarly, the large group of 25 fall in the early majority and late majority categories. The 17 producers who indicated probably not could also be grouped into the late majority category. The typical laggards are represented by the five producers who indicated that no, they would not consider using ultrasound in their operation.

Data for Research Question Five

The first option asked producers to identify what barriers they encountered when considering the use of ultrasound. This closed-ended question asked participants to mark all that applied to them. The question asked: What barriers prevent your using ultrasound for pregnancy determination? The three most common answers for the respondents were as follows: Cost of equipment and cost of veterinarian/technician, 40; Do not know how to use, n=29; No access to a veterinarian/trained technician, n=27; Did not know existed, n=7 (Table 21).

Table 21

Barriers to Adoption of Ultrasound by Beef Cow-calf Producers in New Mexico

Possible Barriers to Adoption	Frequency	Percent
Cost of equipment	40	47.1
Cost of veterinarian/technician	40	47.1
Do not know how to use	29	34.1
No access to a veterinarian/trained technician	27	31.8
Did not know existed	7	8.2

Respondents: *n*=85
No response: *n*=14

Data for Research Question Six

The sixth objective was to identify relationships between rates of adoption and selected characteristics of the producers in the state. The questionnaire asked: How did you initially learn about ultrasound technology? Producers were instructed to choose one answer from a list of six possible choices. The results were as follows: friend, *n*=23 or 26.7%; veterinarian, *n*=23 or 26.7%; print source, *n*=17 or 19.8%; internet, *n*=15 or 17.4% and extension agent, *n*=8 or 9.3%. So, more than half of those who knew about ultrasound use had learned of the technology from a friend or a veterinarian (Table 22).

Table 22

Introduction of Knowledge of Ultrasound to Beef Cow-calf Producers in New Mexico

Source of Information	Frequency	Percent
Veterinarian	23	26.7
Friend	23	26.7
Print Source	17	19.8
Internet	15	17.4
Extension Agent	8	9.3
Total	86	100.0

No response: *n*=13

However, contact with extension or the lack thereof is not predictive of their adoption of ultrasound. ANOVA was used to examine the influence of each source of information (extension agent/extension specialist, friend, veterinarian, internet, and print source) in affecting whether they would consider using ultrasound technology to determine pregnancy. Producers were most likely to adopt after learning about ultrasound from their veterinarian with a mean of 2.73 and a standard deviation of 1.20. Conversely, the internet was the least likely to prompt producers to adopt with a mean of 1.6 and a standard deviation of 0.51. A mean of 1 (indicates the least likely to adopt) and a mean of 4 (indicates most likely). An effect size was calculated; using the mean of 2.73 for veterinarians, a combined mean of 1.90 for all others, and a standard deviation of 0.99, the effect size was 0.84. An effect size of greater than 0.70 is a large effect size. So, learning from a veterinarian causes one to be much more likely to adopt the technology than any of the other four sources (Table 23).

Table 23

Descriptive Statistics for the Adoption of Ultrasound by Beef Cow-calf Producers in New Mexico

Avenue of Introduction to Ultrasound	Frequency	Mean	Standard Deviation
Veterinarian	22	2.73	1.20
Friend	24	2.00	0.89
Print Source	16	1.94	0.77
Extension Agent/ Specialist	7	1.86	1.07
Internet	15	1.60	0.51
Total	84	2.10	0.99

No response: *n*=15

The last question pertained to how often producers were in contact with an extension agent/specialist. This closed-ended question asked producers to choose one answer that best described their relationship with their extension agent/specialist. The question asked: How often are you in contact with an extension agent/extension specialist about your cattle operation? The responses were recorded as follows: Never/rarely, *n*=63 or 66.3%; several times a year, *n*=19 or 20.0%; annually, *n*=11 or 11.6%; monthly, *n*=1 or 1.0% and weekly, *n*=1 or 1.0%. The median contact with and extension agent/extension specialist was never or rarely (Table 24).

Table 24

Contact with an Extension Agent/Specialist by Beef Cow-calf Producers in New Mexico

	Frequency	Percent
Never/Rarely	63	66.3
Annually	11	11.6
Several times a year	19	20.0
Monthly	1	1.1
Weekly	1	1.1
Total	95	100.0

No response: *n*=4
Median and mode contact with extension agent/extension specialist=Never/rarely

Data for Research Question Seven

The final research question asked: Is rate of adoption related to general innovativeness of cattle producers in New Mexico In order to answer this question, several steps were taken. The thirteen best management practices (BMPs) serving to describe beef cattle operations earlier were used to create an innovativeness scale for New Mexico beef cattle producers. An assumption made was that those producers who had adopted more BMPs were generally more innovative than those who had adopted fewer BMPs. Each best management practice was given a score of 1 for "yes, the respondent did use the BMP," or a 0 for "no, they did not use the BMP." The thirteen best management practices were: creep feed calves, vaccination for blackleg and other clostridial diseases, supply mineral to cow herd, evaluate bulls for fertility, examine bulls annually for breeding soundness, record individual weaning weights/keep production records, cull open cows, market cull cows and bulls strategically, castrate

bull calves, use growth implants, deworm annually, determine body condition score annually, and use protein supplementation. The practices were then scored (0 for "no" and 1 for "yes) and summed to reveal the general innovativeness of the producers Table 25 shown below displays the results. The scale, deemed "Innovativeness," was examined for internal consistency. Cronbach's coefficient alpha of .64 showed the scale to be of "acceptable reliability" (Kline, 2000, p. 13).

Table 25

Innovativeness of New Mexico Beef Cow-calf Producers

Innovativeness Score	Frequency	Percent
2-6	10	10.3
7-8	24	24.7
9-10	46	47.4
11	14	14.4
12-13	3	3.1
Total	97	100.0

No response: *n*=3
Mean = 8.97; *SD* = .96; Cronbach's coefficient alpha = .64

Rogers (2003) explained that people in a social system fall into one of five adopter categories, with a typical percentage of each as follows: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (16%). The findings shown in Table 25 correspond with those categories and percentages; thus, producers can be categorized into one of the adopter categories.

The producers who scored 12 or 13 on the innovativeness scale (those who use 12-13 BMPs) can be categorized as the innovators (3.1%) of the group. Innovators are

described by Rogers (2003) as venturesome. Next in innovativeness is the category of early adopters (n=14, 14.4%)—those who are using 11 of 13 BMPs. Early adopters are more integrated into the social system as explained by Rogers (2003) and, therefore, have the highest level of opinion leadership in most systems.

A large number of producers fell into the early majority category. Of the producers who responded, 46 (47.4%) use 9 or 10 of the BMPs listed. The early majority adopt new ideas just before the average member (who adopted 8.7 BMPs in this research) of the social system and deliberate for a longer period of time before making an adoption decision (Rogers, 2003). The second largest category that producers fell into was the late majority category. Members of the late majority category are considered to be skeptical and adopt new ideas after the average member of the social system (Rogers, 2003). Among the producers, 24 (24.7%) fell into this category as late majority. Finally, the last group comprised ten producers (10.3%) was the laggard category. Laggards are the last in a social system to adopt new ideas and are considered to be traditional in their thought process with essentially no opinion leadership (Rogers, 2003).

Determination of Dependent Variable and Its Relationships With Other Variables

The dependent variable for this study was innovativeness with respect to the adoption/use of ultrasound technology to determine pregnancy. Responses to two items were used to quantify the dependent variable. The descriptive data for these two items are shown in Table 18 and Table 20. Next, a "pregnancy determination score" was produced. Those producers who responded as using ultrasound or in combination with

another technology for pregnancy determination were scored a four. Meanwhile, producers using blood tests only were scored a three. The usage of rectal palpation or visual appraisal or some combination of both was scored a two, and visual appraisal only was scored as a one. Thus, the practice that was most "innovative" was using ultrasound, with using blood test more innovative than rectal palpation but less innovative than ultrasound, and rectal palpation considered more innovative than using visual appraisal alone. Scores ranging for 4 (high innovativeness) to 1 (low innovativeness) characterized producers.

The mean pregnancy determination score was 2.05 with a standard deviation of 0.95. Thus, those producers who used ultrasound technology to determine pregnancy—whether alone or in combination with another method—were assumed to be further along in the adoption process. Alternatively, those who used visual appraisal only were assumed to be late adopters (Table 26).

Table 26

Pregnancy Determination Score for Beef Cow-calf Producers in New Mexico

Method of Determining Pregnancy	Pregnancy Determination Score	Frequency	Percent
Visual Only	1	26	27.7
Rectal Palpation or Visual and Rectal	2	51	54.3
Blood Test Only in Combination with Rectal and/or Visual	3	3	3.2
Ultrasound Only or Combination	4	14	14.9
Total		94	100.0

No response: *n*=5
Mean=2.05, s*d*=0.95

Next, the degree to which producers would consider using ultrasound technology to determine pregnancy was scored numerically, with "yes" being scored 5, "probably so," 4, "unsure," 3, probably not, 2, and "no," 1 (Table 27). A score of 5, then, was used to indicate that producers were likely to be innovative—that they would or had adopted ultrasound technology to determine pregnancy. Conversely, a score of 1 indicated that the producer was likely to be a laggard with respect to his or her willingness to consider using ultrasound (Table 27).

Table 27

Degree to Which New Mexico Beef Cow-calf Producers Would Consider Using Ultrasound Technology for Pregnancy Determination

Consider Using Ultrasound?	Score	Frequency	Percent
Yes	5	30	32.3
Probably So	4	16	17.2
Not sure	3	25	26.8
Probably not	2	17	18.3
No	1	5	5.4
Total		93	100.0

No response: *n*=6
Mean= 3.55; *SD* =1.38

Finally, in this determination of innovativeness, the two scores—one for method of determining pregnancy and another for consideration of using ultrasound—were examined for internal consistency (Cronbach's coefficient alpha of 0.68) as a measure. Because the internal consistency was acceptable, the two scores were summed to get a score for a construct labeled Innovativeness in Adopting Ultrasound Technology to Determine Pregnancy, or "Adopt Ultrasound" for short (Table 28).

Table 28

Innovativeness of New Mexico Beef Cow-calf Producers in Adopting Ultrasound Technology to Determine Pregnancy

Innovativeness in Adopting Ultrasound Technology to Determine Pregnancy	Interpretation	Frequency	Percent
2.0	Least	3	3.1
3.0	Innovative	9	9.4
4.0		22	22.9
5.0		15	15.6
6.0		14	14.6
7.0		17	17.7
8.0		4	4.2
9.0		12	12.5
Total	Most Innovative	96	100.0

No response: n=3
Mean=5.61; SD=1.94

Next, using the producer's innovativeness, correlations were tabulated using several different independent variables in order to observe their correlation to the dependent variable. Producer's innovativeness score was positively correlated to the consideration of using ultrasound (r=0.28). Also producer's innovativeness score was correlated to their usage of pregnancy determination in their cattle operation (r=0.41).

Finally, length of breeding season was determined to be of particular interest as it was assumed that a more controlled breeding season was indicative of a producer who was more innovative. Using Spearman's Rho (r_s) for non-parametric data, it was determined that length of breeding season was negatively correlated to producer's innovativeness (r_s= -0.35). Thus, as producer's innovativeness increased, the length of

breeding season decreased. Length of breeding season also was correlated significantly to the use of ultrasound by producers (r_s= -0.43). This means that producers who had shorter, more controlled breeding seasons were more likely to adopt ultrasound in their operation.

Other correlations of significant interest were age and years in the cattle business. As expected, the older a cattle producer is the more years of experience they have in the cattle business (r_s= 0.56). Also the higher level of education attained by a producer, the more likely they were to adopt ultrasound (r_s= 0.27). Size of the operation in acres and size in number of cows was also statistically significantly, positively correlated (r_s= 0.78).The larger the operation was in acres, the more cows they were likely to have. Producers who have larger operations are more likely to derive more of their household income from their cattle operation (r_s= 0.49) and are more likely to adopt ultrasound (r_s=0.23). A higher dependency on income from the cattle operation has influenced the adoption of the technology. Producers who rely heavily on bred cows for their income cannot risk losing income due to open cows.

Size of the operation in cow numbers was also correlated to the level of income earned from the operation (0.64). Understandably, producers who have larger operations with large numbers of cattle are not particularly considered to be hobby farmers. Having a larger number of cattle was also positively correlated with the adoption of ultrasound (0.35). Again, this suggests that producers who have larger operations with respect to cow numbers are interested in using the best technology possible to determine pregnancy in their cow herd (Table 29).

Table 29

Spearman Correlations Between Selected Variables for New Mexico Cow-calf Producers

	Ed. Level	Yrs.in Bus.	Size (ac.)	Size (cows)	Income % from Cattle	Innov.	Length of Breeding Season	Length to Preg. Deter.	Adopt of Ultra.
Age	.01	.56**	.13	.07	.10	-.05	.20	-.09	-.11
Ed. Level		-.00	.05	.11	-.05	.12	-.17	-.07	.27**
Yrs in Bus.			.12	.09	.14	.09	.02	-.24*	-.04
Size (Ac.)				.78**	.49**	.07	.04	-.17	.23*
Size (Cows)					.64**	.10	-.03	-.14	.35**
Percent Income						.02	.00	-.08	.17
General Innov.							-.35**	-.13	.41**
Breeding Season Length								-.05	-.43**
Days to Preg. Deter.									-.13

**p<.01
*p<.05

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

Beef cattle production is one of the primary agricultural industries in New Mexico. Most of the operations are large in land size and have varying numbers of cattle. New Mexico is diversified in topography as well as culturally. The state has areas that are very arid, desert landscapes while other parts of the state are mountainous. Areas to the east are flat and have considerable amounts of forage. The state has large areas of land managed by the U.S. Forest Service and the Bureau of Land Management. Part of the state is separated into several Native American/Indian Nations. The land that lies within these national boundaries is governed by a different set of rules and regulations than those of the state of New Mexico.

Beef cow-calf production is an important industry in New Mexico. And, as with most businesses/industries, technology and innovation are critical to success. This study examined ultrasound technology to detect pregnancy in beef cows. The first application of ultrasound to the beef industry was in 1956 at Colorado A&M College where ultrasound was used to measure back fat thickness on beef cattle (Stouffer, 2004). Eventually this application led to the use of ultrasound for pregnancy determination. Ultrasound is a complicated technology that requires a monetary and a personal investment. Since the technology is complicated to use, a higher level of understanding and education is beneficial.

While ultrasound is a complicated innovation, previous research has shown that larger enterprises operated by college-educated people in the western United States are more likely to adopt agricultural technologies. Age has also been found to be significant in the adoption of pregnancy determination technologies with younger agriculturists more likely to adopt. Size of the operation may influence the adoption of agricultural innovations in the beef industry. Communication is important in the adoption of an innovation; poor adoption rates have been linked to weak communication of the innovation.

The traditional method of determining pregnancy is through rectal palpation. Ultrasound may have relative advantage compared to rectal palpation: accuracy, early detection of the fetus, sex determination, fetal aging, and reduced fetal loss. Disadvantages of ultrasound are initial cost of the equipment and training required to use the equipment.

The target population for this study was beef cow-calf producers in New Mexico. The accessible population was the 1,500 members of NMCGA. This study used descriptive survey methodology to gather information, perceptions, and opinions associated with the adoption and usage of ultrasound technology for pregnancy determination by New Mexico cattle producers. Communication channels by which cattle producers receive information about new techniques and technologies was examined. Correlational techniques were used to determine if selected characteristics were related to their experiences with, perceptions of, and rate of adoption of the ultrasound technology.

Conclusions

The average beef cow-calf producer in New Mexico was male, 56 years old, and had been in the cattle business for over 40 years. He had a bachelor's degree and a slight majority of his income was derived from off-farm endeavors. His operation of 230 head of Angus cows bred to Angus bulls were grazed on 18,550 acres. He used most of the best management practices in his operation: vaccinated for blackleg, used supplemental minerals, evaluated bulls for fertility and examined bulls for breeding soundness, culled open cows and marketed those culled cows and bulls strategically. He castrated bull calves, dewormed his cattle, determined body condition score, and supplemented with block protein. Conversely, he did not creep feed calves, did not record individual weaning weights on calves to match to cow record nor did he use growth hormone implants.

He marketed his calves through using a direct buyer or a local auction barn and raised his own replacement heifers. He began his breeding season in May and removed the bulls in August, a breeding season of about 90 days. Then 75 days after removing bulls he used rectal palpation to determine pregnancy status of his cows.

Most producers reported that they did not use ultrasound as a means of pregnancy determination for their herd; rather, they used rectal palpation as their main technology to determine pregnancy in their cow herd. Small numbers of producers used ultrasound—either alone or in combination with other pregnancy determination technologies. Furthermore, most producers knew the technology existed and indicated that they would consider the use of ultrasound in their operation in the future.

Cost of the equipment and of the veterinarian/technician was the first significant barrier to the adoption of ultrasound. Second, not knowing how to use ultrasound was also a reason for not adopting the technology. Producers learned about ultrasound from a veterinarian or a friend and not surprisingly, producers explained that they were not in contact with an extension agent/specialist about their cattle operation.

Innovativeness of producers was determined based on whether they adopted best management practices. Rogers' (2003) distribution of adopter categories is a normal distribution with half of the population being relatively early to adopt, innovators (2.5%), early adopters (13.5%), and early majority (34%). He categorized the 50% of later adopters as late adopters (34%) and laggards (16%) (Figure 1).

Scores for innovativeness of cattle producers in New Mexico revealed a somewhat different distribution within adopter categories. This social system comprised 3 innovators (3.1%), 14 early adopters (14.4%), and 46 early majority (47.4%)—all of which are higher than Rogers' numbers—24 late majority (24.7%), and 10 laggards (10.3%)—both smaller numbers than Rogers' reported. Thus, this social system can be classified as progressive rather than traditional (Figure 1.)

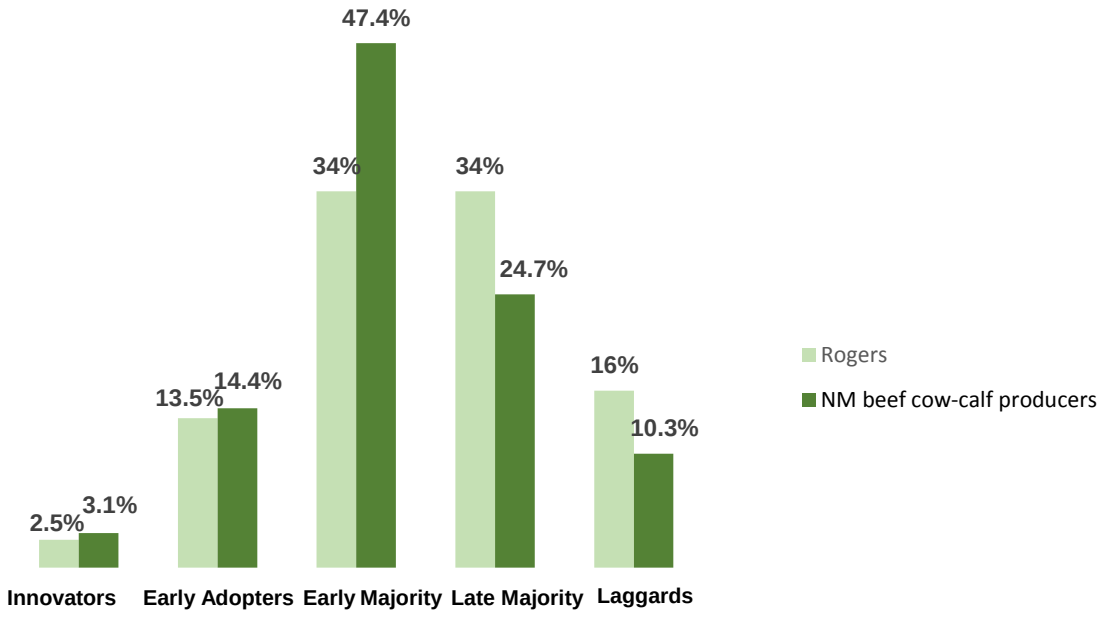

Figure 1. Comparision of Rogers' (2003) theoretical distribution of adopters and the distribution of New Mexico beef cow-calf producers.

Finally several independent variables were correlated with the dependent variable, ultrasound adoption: innovativeness of a producer, length of breeding season, age, education, size of operation, and percent income from cattle operation were all related to ultrasound adoption. Producers were more likely to adopt ultrasound if they were more innovative in general, had a shorter breeding season, were younger, more highly educated, had larger operations both in acres and in number of cows, and depended on their cattle operation for more of their household income.

Implications

The implications of this research are based on the findings and conclusions concerning the adoption of ultrasound for pregnancy determination by New Mexico cow-calf producers. The sample of producers in the study were relatively old (56 years old) and experienced (41 years) in the cattle business, and few had adopted ultrasound. Research suggests that younger agriculturists are more likely to adopt newer technologies than are older agriculturists (Adesina & Zinnah, 1993; Howley et al., 2012; Khanal et al., 2010; Khanal & Gillespie, 2013; Ward et al., 2008). Appealing to older and more experienced producers and influencing them to try something new could be challenging.

However, the finding that many producers were 56 years of age or older suggests that they were likely to have children and grandchildren. Producers with children are more likely to use new breeding technologies, and perhaps one can infer that legacy has an impact on adoption (Howley et al., 2012). Appealing to a producer's sense of legacy could help in encouraging producers to adopt ultrasound. That is, if ultrasound could offer producers a way to pass a successful operation on to the next generation, their sense of legacy may influence them to adopt.

Producers who derive more of their household income from the cattle operation are more likely to adopt ultrasound. This implies that producers whose livelihood is directly related to the success of the cattle operation are more open to adopting technologies that will increase their profit margins.

Many of the operations were larger than 20,000 acres and had hundreds of head of cattle. Producers running cattle on operations that are 20,000 acres or larger may not have access to their cattle at all times. One time that they see their cattle is during the fall roundup. Ultrasound could be used during the fall roundup to check for pregnancy before returning cows to the vast and possibly remote locations of their operations. Ultrasound is also performed quickly; thus, large numbers of cows can be checked in an efficient and timely manner. This can greatly enhance management decisions, possibly increasing productivity and profitability.

Understanding the relative innovativeness of the cattle producers in the state aids in the prediction of whether they would consider using ultrasound in their operation. For the change agents who hope to encourage innovation, identifying those producers who are more innovative and have shorter, more controlled breeding seasons is key in promoting the adoption of ultrasound, as they are more likely to adopt ultrasound than those producers who are less innovative.

While most producers do not currently use ultrasound, they know the technology exists and they are open to the possibility of using it in the future. Producers indicating that they would consider using ultrasound in their operation in the future means that they are more likely to want to learn more about the technology and how the technology could benefit their operation.

So what is keeping them from doing so currently? The most commonly-identified barrier to the adoption of ultrasound was cost. The financial commitment for the equipment and/or for a person who is trained to use it, such as a veterinarian or a

technician, is inhibiting the adoption process. For those producers who are interested in learning how to ultrasound for themselves, the cost of the machine can be absorbed within seven years on average (de Vries, Bartolome, & Broaddus, 2005). However, it may be more beneficial to hire a trained veterinarian/technician to perform the service. More research is needed to provide data concerning cost analysis, comparing ultrasound and rectal palpation, and determining which is more profitable.

Producers received most of their information on ultrasound technology from a friend or a veterinarian rather than from an extension agent/extension specialist. Moreland and Hyland (2013) found that poor communication of the innovation has been directly linked to poor adoption rates. Not only did producers learn about the technology from veterinarians but also they were more likely to adopt the technology if they learned about it from a veterinarian. Until recently, the position of state veterinarian in New Mexico was unfilled; the state filled that open position in August, 2014. The lack of a state veterinarian may have inhibited the adoption of ultrasound.

A pregnancy diagnosis school that discussed ultrasound along with other pregnancy diagnostic technologies was held in Lordsburg, NM, in September, 2014; however only 15 attended the school (Steve Lucero, personal communication, October 30, 2014) Low attendance could be due to lack of marketing and advertising. Also, convenience could play a role in low attendance as travel expenses may discourage producers from attending schools/seminars that require a significant amount of travel. Because producers are more likely to adopt ultrasound when learning about it from a veterinarian, more seminars/classes need to be hosted where veterinarians are used as a

primary communication channel. This could significantly impact attendance and the adoption of ultrasound for pregnancy diagnosis. Using fellow cow-calf producers to help inform other producers by giving presentations/lectures about ultrasound would also have an impact on the adoption of ultrasound as their opinion leadership is valued among producers.

Many of the producers were innovative in their overall willingness to adopt new ideas. However, Rogers (2003) explained that the innovation-decision process takes time. But the time to adoption can be decreased if one understands and uses principles diffusion of innovations. Prospective adopters must be presented with evidence of benefits of ultrasound, how to use ultrasound, and who else is using it. Then, they will probably adopt ultrasound if they deem it valuable and helpful to their operations.

Producers have little contact with their extension agent/specialist—the public-supported change agents in the community. Without this contact with producers, agents have few opportunities to influence change in the community. This may explain one of the reasons for the lack of attendance at the pregnancy diagnosis class in Lordsburg. If producers were able to attend the class and hear from a fellow cattle producer and a veterinarian about their experiences using ultrasound, they may be more likely to adopt.

Recommendations

Based on the findings, conclusions, and implications, the following recommendations are offered to improve the diffusion process and the rate of adoption of ultrasound pregnancy determination by New Mexico cattle producers.

Cow-calf producers in New Mexico who are older and have more experience are typically set in their ways and unlikely to seek out new technological innovations. Producers who are younger and, therefore, may be more likely to adopt ultrasound should be identified during the diffusion process. Appealing to those with high opinion leadership in the social system could influence producers to adopt ultrasound. Additionally, when introducing ultrasound, providing information on the benefits of ultrasound and how its adoption can provide a legacy to future generations of cattle producers should be emphasized.

Identifying producers who derive a majority of their income from cattle operations that are large in size and cow numbers, who are higher educated, and who use several best management practices, including short breeding seasons, should be targeted for the adoption of ultrasound. These innovative producers are more likely to adopt ultrasound than their less innovative counterparts; they are also likely to have high opinion leadership.

Increasing the communication lines and contact relationships between producers and extension agents may aid in increasing the adoption of ultrasound and other agricultural innovations. A positive relationship between the Cooperative Extension Service and the cattle producers of New Mexico is important for the growth and profitability of cattle operations in the state. Measures need to be taken to strengthen these relationships and create more confidence in the extension agents/specialists.

Change agents should use information in seminars/conferences and classes that will provide producers with the cost-benefit analysis of adopting ultrasound. Producers

need to be provided with information about the benefits and specific characteristics that can contribute to their overall profitability. Also, they need to be informed of how long it will take for them to see a return on their investment by learning to use the technology themselves or by hiring a veterinarian or a trained technician.

Using veterinarians as a conduit to introduce the technology to producers will aid in adoption of the technology. Similarly, using opinion leaders in a community to discuss their successful experiences with ultrasound in a seminar/class setting should increase adoption. Having classes that are well advertised and more centrally located may increase attendance and thus knowledge of the innovation. Individually and collectively, all of these should increase the adoption of ultrasound for pregnancy determination in beef cow-calf operations in New Mexico.

Need for Further Study

A similar study would be appropriate to evaluate what changes, if any, have occurred in the diffusion process of ultrasound by New Mexico cattle producers. The study should sample more producers so more accurate generalizations can be made.

The study needs to evaluate additional demographics of producers; for example their involvement in leadership positions may contribute to the diffusion of information about ultrasound. Other demographics pertaining to ethnicity and race of producers may also useful in the evaluation. The future study needs to evaluate how producers are receiving their information and their relationships with the New Mexico Cooperative

Extension Service. Also, the study needs to evaluate more completely what BMPs in beef production are and whether producers are currently using them.

Relationships between extension agents/extension specialists and producers should be studied to determine how to improve the relationships—beginning perhaps simply with numbers of contacts could be improved are also needed. Currently, ultrasound costs about $5 per head (J. Wenzel, personal communication, October 6, 2014). A study needs to evaluate the cost per head and the expected monetary return to determine if cost is a legitimate (in terms of economics) barrier to adoption of the technology.

Limitations of this study in terms of responding sample suggest the need for further study with and about cattle producers of New Mexico. This study represented only a small fraction of producers in the state. Because the accessible population and the subsequent responding sample was different that the target population generalizations should be made with caution and only to the accessible population. Many producers in New Mexico were not able to participate in this survey. Their opinions are valuable and would offer additional understanding of how producers get information, whether they act on that information, and whether they are using the most up-to-date technologies available to them.

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APPENDIX A

SURVEY INSTRUMENT

Hello,

My name is Jessica Lucas and I am working with Caren Cowan and the New Mexico Cattle Growers Association to better understand your needs as a New Mexico cattle producer. I am a fellow New Mexican and a graduate student at Texas A&M University. Your input is highly valuable in determining the adoption of ultrasound technology in cattle operations within the state. Attached you will find a short survey regarding your cattle ranch operation.

Please open the attachment and answer each question to the best of your ability. Download the document and open in Microsoft Word, then enable editing on the view tab. This will allow you to put your answers in. After you fill in your answers please save the document to your computer and email your response as an attachment back to Caren Cowan at nmcga@nmagriculture.org

This survey will take only a few minutes of your time. Your participation in this survey is voluntary. A summary of the findings of this study will be sent to you as a participant. Your participation is greatly appreciated.

Thank you,

Jessica Lucas

How would you classify the size of your operation in acres? ***(Please mark your answer with an X)***

_____Larger than 20,000 acres

_____5,000-20,000 acres

_____1,000-5,000 acres

_____Less than 1,000 acres

How would you classify the size of your operation in cow numbers? ***(Please mark your answer with an X)***

_____Less than 100

_____101-200

_____201-500

_____501+

What percentage of household income is from the cattle operation? ***(Please mark your answer with an X)***

_____0-25%

_____26-50%

_____51-75%

_____76-100%

What breed(s) of cattle do you use/have? ***(Please write in the blank(s) provided)***

Cow herd breed(s)? _____

Bull breed(s)? _____

When is your breeding season? ***(Please write in the blank(s) provided)***

Start date: _____

End date: _____

How soon after removing bulls do you do pregnancy determination? ***(Please place an X on your answer)***

_____Less than 30 days

_____30 days – 59 days

_____60 days – 89 days

_____90 days or more?

How do you determine pregnancy in your cow herd? ***(Mark all that you use with 1 being the most often used, 2, second, etc.)***

_____Visual appraisal

_____Rectal palpation

_____Blood test

_____Ultrasound

If you do not use ultrasound, are you aware of ultrasound pregnancy determination technology? ***(Please mark your answer with an X)***

_____Yes ____No

If so, how did you learn about this technology? ***(Please mark all that apply with an X)***

_____Extension Agent

_____Veterinarian

_____Internet

_____Friend

_____Print Source

What barriers prevent your using ultrasound for pregnancy determination? ***(Please mark all that apply with an X)***

_____Do not know how to use

_____No access to a veterinarian/trained technician

_____Cost of the equipment

_____Cost of the veterinarian/technician

_____Did not know the technology existed

Would you consider the use of ultrasound within your operation? ***(Please mark your answer with an X)***

_____No

_____Probably Not

_____Not Sure

_____Probably So

_____Yes

Do you know other producers who use ultrasound pregnancy determination in their operation? ***(Please mark your answer with an X)***

Yes____ No____

Do you use the following practices routinely in your operation? ***(Check YES or NO)***

Yes___ No___ Creep feed calves?

Yes___ No___ Vaccinate for blackleg and other clostridial diseases? (7-way, 8-way)

Yes___ No___ Supply minerals for cow herd?

Yes___ No___ Evaluate bulls for fertility? (semen exam)

Yes___ No___ Examine bulls annually for breeding soundness?

Yes___ No___ Record individual weaning weights on calves and match to cow record/Keep production records on each individual cow?

Yes___ No___ Cull open cows?

Yes___ No___ Market cull cows and bulls strategically?

Yes___ No___ Castrate bull calves?

Yes___ No___ Use hormone growth implants for steer and/or heifer calves?

Yes ___ No___ Deworm annually?

Yes___ No___ Determine body condition score annually?

Yes ___ No___ Use protein supplementation?

If yes, which protein supplementation is used? ***(Please mark all that apply with an X)***

_____Liquid protein

_____Block protein

_____Cube protein

_____High protein hay (alfalfa, timothy, clover, etc.)

_____Loose protein feed (ground, pelleted, etc.)

What strategy/ies do you use to create replacements on the operation? ***(Please mark all that apply with an X)***

_____Raise my own

_____Buy them from a single source

_____Consolidate from multiple sales

What marketing strategies do you use for calves? ***(Please mark all that apply with an X)***

_____Local Auction Barn/Market

_____Direct Buyer

_____Video/Internet Sales

_____Retained Ownership through stocker phase

_____Retained Ownership through feedlot

What marketing strategies are used for culls? ***(Please mark all that apply with an X)***

_____Local Auction Barn/Market

_____Direct Buyer

_____Video/Internet Sales

How often are you in contact with an extension agent/extension specialist about your cattle operation? ***(Please mark one answer with an X)***

_____Weekly

_____Monthly

_____Several times a year

_____Annually

_____Never/Rarely

How long have you been in the cow-calf business? _____ ***(Please fill in the blank)***

Highest education level earned? ***(Please mark one answer with an X)***

_____Less than high school diploma

_____High school diploma

_____Some college

_____Associate's degree

_____Bachelor's degree

_____Graduate or Professional degree (M.S., PhD, DVM, etc.)

What is your gender? _____Male _____Female ***(Please mark your answer with an X)***

What is your age? ***(Please mark your answer with an X)***

_____younger than 20

_____20-29

_____30-39

_____40-49

_____50-59

_____60-69

_____70 or older

THANK YOU FOR YOUR PARTICIPATION!