Effects of Forage Source on Growth, Carcass Characteristics, and Market Opportunities for Lambs Finished on Forage

Dissertation

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Abstract

Grass-based livestock production is a sustainable system for raising animals to a marketable weight in many parts of the world, yet adoption of the practice is not common in the United States. A random sample mail survey and a series of experiments were conducted to discover: 1) what factors influenced conversion to and adoption of a grass-based system and use of a grazing system, 2) grazing systems that would allow acceptable growth and carcass characteristics in lambs, and 3) management strategies to utilize sheep in an organic cropping-based farm operation.

The survey of 344 Ohio beef and sheep farmers showed that the factors influencing conversion to a grass-based management system were: infrastructure, knowledge, technical skills, financial costs, and a desire to change practices. Grain-based producers reported equipment, markets, and regulation as barriers to conversion. Based on a logistic regression the factors found to influence the adoption of both grass-based management and use of a grazing system, were the respondent’s perception of the importance of pasture, their social interactions, and management of beef cows.

The first grazing experiment compared finishing systems that included grazed alfalfa (ALF), grazed ryegrass (RG), grazed alfalfa for 56 d followed by grazed ryegrass for the remainder of the trial (ALF/RG), grazed ryegrass for 56 d followed by grazed alfalfa for the remainder of the trial (RG/ALF), and a limit-fed, corn-based diet fed to
achieve a similar rate of gain as the grazed alfalfa treatment (CONC). The CONC lambs had heavier carcasses, with greater muscling and back fat than the ALF lambs. The lambs on the grazing treatments had similar carcass weight, loin eye area, and back fat depth; however, the RG and ALF/RG lambs took longer to reach the target weight than the ALF lambs.

A second experiment compared lamb production on grazed alfalfa (ALF), grazed chicory (CHI), and grazed sorghum-sudangrass (SSG). The SSG lambs were slaughtered 14 d earlier than either the ALF or CHI lambs due to frost and the potential for prussic acid poisoning with the SSG. Due to the earlier harvest, the SSG lambs produced lighter carcasses with a lower dressing percentage than the ALF lambs. The ALF lambs had similar carcass weight, loin eye area, and back fat as the CHI lambs. All three treatments produced adequate daily growth rate, but lambs would need more time to reach industry targets for carcass weights and loin eye area.

A third and fourth experiment were conducted to determine the efficacy of using sheep to control weeds in an organic crop production system. Results showed that mature ewes could be used to remove weeds from organic fields after crop harvest, whereby they were observed to eat most weeds present in crop fields. The amount they ate increased and dietary choices decreased at higher stocking densities. In a separate cafeteria-trial, with dry ewes fed a maintenance diet and then offered giant ragweed (*Ambrosia trifida* L.), lambsquarter (*Chenopodium album* L.), and sudangrass (*Sorghum bicolor* L. subsp. drummondii Nees ex Steud., var. Promax), all three species were consumed at a high rate (> 95%) of plants offered. Consumption increased in Day 2 for all except the forage...
sorghum. Giant ragweed was consumed the least of the three species ($P < 0.05$). Since the ewes were fed to meet their maintenance each day, the results indicate that both lambsquarter and giant ragweed are palatable to mature ewes.
Dedication

This document is dedicated to my wife, children and parents.
Acknowledgments

Work is rarely the sole product of one person. I have several people who assisted me along the way. I wish to thank Dr. Francis Fluharty who not only encouraged me to start this process, but also has served as a mentor, colleague, and occasionally motivator. Sometimes I got the sense that this was more stressful on him than me. I thank Dr. Steve Loerch, for always being willing to field calls from a county educator and continually stressing the use of sound science. I thank my advisory committee, Drs. Dave Barker, Henry Zerby, Steve Moeller, and Garry Lacefield for not only their advice but also their encouragement. Dr. Lois Morton and Leah Miller deserve thanks for their assistance in the sociological aspects of this project and helping me set deadlines.

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Finally to my family, Lisa, Morgan, and Sean. Your encouragement and understanding as I worked on this helped me get through. Thank you.
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Publications


**Fields of Study**

Major Field: Animal Science
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Chapter 1: Literature Review

Situation

In the United States, we have a well-established production practice of placing young growing animals in confinement feeding operations and feeding appropriate amounts of various concentrate rations to maximize gains and feed efficiency (NRC, 2008). Currently, the push for grain to be converted into ethanol and biodiesel has increased the cost of the concentrates used in that system (Anderson and Coble, 2010). The change in economics, due to higher input cost for feed grains, has caused many to look at alternative production systems.

According to the USDA 2007 Census of Agriculture, 6% of the land in the United States is classified as pastureland. Pasture has traditionally been expected to support the breeding herds and flocks. Some forage based systems are being used in natural and organic production systems and used as a marketing method (Shiflett et al., 2010). The products produced with forage based systems provide an opportunity for product differentiation or niche marketing, which is one way for smaller farms to capture a greater margin (profit) without the advantage of economies of scale, as these products are often sold for a higher price per pound than their commodity counterparts (Napolitano et al., 2007; NRC, 2008). Use of forage based systems by small farms matches well with the
distribution of sheep flock sizes, over half the sheep flocks in the United States are less than 500 head (NRC, 2011).

Understanding how to produce livestock in a forage-based system without diminishing meat quality when compared with grain fed livestock is critical (Berthiaume et al., 2006). Although most of the lamb produced in the US is fed concentrated diets, approximately 25% of the lamb produced is raised on forages. Imports from Australia and New Zealand make up close to 50% of the lamb consumed in the US (NRC, 2008). A vast majority of the lamb products imported from Australia and New Zealand are from forage-based systems. It is not apparent if imported, forage-based lamb products have an effect on consumer demand (Clemens and Babcock, 2004). However, if it is possible for a segment of the U.S. to produce lamb from forage without negatively impacting consumer preferences, then finding ways to produce lamb from forage more efficiently could be economically advantageous to small and mid-sized farms.

Farm flocks in the north central and eastern United States have a production cycle similar to the one Jones (2004) proposed in Fig. 1. Traditionally, for flocks lambing after March, lambs are grass finished following weaning beginning in June and encompassing the months when forage is available. To accomplish forage-based production, farmers normally utilize perennial pastures, populated mainly with cool-season grasses and legumes, and alternative forages that grow in the respective window, specifically from weaning (June) to finishing (approximately December).

**Nutrient Requirements**
Ruminant animals require water, energy, protein, minerals, and vitamins for their biological functions. In sheep, those functions include maintenance, development, growth, lactation, reproduction, fattening, and wool (NRC, 1985).

**Energy Source.** The primary sources of energy for ruminants are carbohydrates. There are several comprehensive reviews of carbohydrate digestion and absorption in the ruminant animal and the reader is referred to them for further information (Cerrilla and Martinez, 2003; Dijkstra et al., 2005; Huntington et al., 2006; Nozière et al., 2010). Briefly, carbohydrates in feedstuffs are classified as components of the cell wall of plants, fructan, or water-soluble carbohydrates. The carbohydrates of the cell wall are comprised of pectins, cellulose, hemicellulose, and lignin. Pectins are water-soluble, whereas cellulose, hemicellulose, and lignin are insoluble. Insoluble carbohydrates are classified as those insoluble in a neutral detergent solution (Van Soest et al., 1991) and are referred to as neutral detergent fiber (NDF). Further classification of cell wall carbohydrates, including cellulose and lignin (Van Soest et al., 1991), are the components that are insoluble in an acid detergent solution or acid detergent fiber (ADF). Cellulose and hemicellulose are partially digestible by the rumen micro flora. The proximity to and crosslinking of lignin in the cell wall can make it inaccessible to the fibrolytic enzymes of rumen micro flora (Jung et al., 1993). A fraction of carbohydrates remains unaccounted for in standard feed analysis (Nozière et al., 2010).

The rumen is the primary site of carbohydrate digestion in ruminant animals. Ruminants do not produce endogenous fibrolytic enzymes; rather, their rumen contains, bacteria, fungi, and protozoa that are the source of fibrolytic enzymes (Russell and
Rychlik, 2001). In this symbiotic relationship, the animal provides the microorganisms with a suitable environment for growth and multiplication, and the microbes supply nutrients for the animal. Energy for the ruminant animal’s metabolism is mainly derived from the products of the bacterial fermentation of carbohydrates. The products are volatile fatty acids (VFA), primarily acetic, propionic, and butyric acids (Russell and Rychlik, 2001). Differences in rumen microbial populations and their associated VFA production can be affected by the carbohydrate source (Russell and Rychlik, 2001). Annison and Armstrong (1970) reported that the acetate to propionate ratio decreased as concentrate intake increased. Propionate is quantitatively the most important single precursor of glucose in the ruminant and accounts for 70% of net liver glucose production (Huntington et al., 2006). Smith and Crouse (1984) found that acetate provided more acetyl units for lipogenesis in subcutaneous adipose tissue, than in intramuscular adipose tissue. Conversely, they found that glucose provided more of the acetyl units in the intramuscular adipose tissue than the subcutaneous adipose tissue. Another aspect of glucose production is the increase in insulin secretion (Bines and Hart, 1982). Insulin stimulates the synthesis of protein, inhibits the breakdown of protein, stimulates lipogenesis, and inhibits lipolysis (Lobley 1998; Bergen and Mersmann 2005).

In high concentrate rations some starch has been shown to make it to the lower gastrointestinal tract (GIT), likely as a function of increased passage rate of the digesta (Ørskov et al., 1969). Ruminants produce α- amylase in the pancreas which intern is available in the duodenum. Post-rumen starch digestion may account for 10% of the blood glucose (Huntington et al., 2006).
Production Aspects of Finishing

Many past research studies have shown that lambs will gain faster with grain based diets. More recent comparative lamb finishing studies have been conducted comparing performance of lambs provided *ad libitum* access to grain based diets with lambs grazing alfalfa (*Medicago sativa* L.) or perennial ryegrass (*Lolium perenne* L.). Lambs gained from 281 to 393 g/d on the grain-based diets, 223 to 319 g/d grazing alfalfa, and 140 to 213 g/d grazing ryegrass (McClure et al., 1994; McClure et al., 2000; Turner et al., 2002; Borton et al., 2005a). Studies comparing grazed forages before finishing on concentrate diets, when compared with finishing only on concentrate diets found similar results in terms of lamb gains from grazed forages (Arnold and Meyer, 1988; Notter et al., 1991; Murphy et al., 1994; McClure et al., 1995). Lambs have gained from 160 g/d to 407 g/d grazing perennial ryegrass in New Zealand (Lindsay et al., 2007; Thomson and Muir 2009; Schreurs et al., 2013). Fraser et al. (2004) and Speijers et al. (2004) reported lamb weight gains of 182 g/d to 184 g/d grazing perennial ryegrass and 200 g/d to 243 g/d grazing alfalfa in Wales, Great Britton.

Carcass Attributes

The effect of finishing system on carcass attributes in previously reported research studies depends on the slaughter criteria within the study. Slaughter criteria can be either a live weight target or an estimated back fat depth target. As an animal matures, it will have a higher proportion of fat in the carcass. In the first reported serial slaughter study, Haecker (1920) demonstrated the weight of fat in empty beef carcasses was greater than the weight of protein when the live weight exceeded 362 kg. Butterfield (1988)
reported the muscle to fat ratio decreased as a Merino ram proceeded to a mature live weight of 100 kg. Breed and sex of lamb can affect the overall muscle to fat ratio, but the trend for a reduction in the ratio holds as a lamb approaches maturity. One concern by the US sheep industry has been the production of too much back and seam fat (Blackburn et al., 1991; Shiflett et al., 2010), a finding that supports the need for additional research on the effects of nutrition on composition.

In a study comparing concentrate and grazing treatments, and basing the slaughter of all treatment groups on lambs on the concentrate treatment reaching a the target slaughter weight, resulted in carcass weights of lambs on all grazing treatments being lighter because of lesser gain per day (McClure et al., 1994). When slaughter criteria were based on a treatment reaching a live weight target, carcass weights were heavier for the concentrate fed lambs when compared with the grazed lambs (Arnold and Meyer, 1988; Notter et al., 1991; Murphy et al., 1994; Borton et al., 2005a). Although offal was not weighed in those studies, there was a dressing percentage effect with the grazed lambs exhibiting greater weight in internal organs. McClure et al. (1995) based slaughter on estimated back fat depth target and reported no difference between cold carcass weights from lambs fed concentrates, grazing alfalfa and or grazing ryegrass; however, they did report heavier carcass weights from lambs grazing ryegrass for 62 d followed by alfalfa grazing when compared with the lambs grazing alfalfa. In all the previous studies, except McClure et al. (1994) the grazing lambs took longer to reach the slaughter weight target than lambs fed concentrates.
The heavier carcass weights for concentrate fed lambs, in studies where live weight was the slaughter target, can be partially explained by the energy source effect on visceral organ mass (Fluharty et al., 1999; Finegan et al., 2001). Fluharty et al. (1999) fed concentrates at a limited amount to match the rate of gain of the lambs grazing alfalfa. This was done to match the energy intake, as expressed in weight gain, of both a grain and forage source. At slaughter, the concentrate lambs had a heavier carcass weight and lighter weight of the GIT. Finegan et al. (2001) found similar results when comparing lambs fed legume-grass silage and lambs fed a whole shell corn diet. The heavier GIT of the forage fed lambs in relation to live weight is directly correlated with the lighter carcass weights, and there is also evidence that in forage fed lambs the animal’s GIT contributes a large portion to the maintenance energy requirements of an animal (Fluharty et al., 1999; Swanson et al., 1999; Finegan et al., 2001).

Carcass to back fat and loin eye area measurements indicate that grazed lambs consistently have less muscling and fat (Notter et al., 1991; Murphy et al., 1994; Fluharty et al., 1999; Borton et al., 2005a) when compared with concentrate fed lambs.

**Forage Options**

Relatively few studies have compared growth and carcass characteristics of lambs grazing different forage species. Fraser et al. (2004) and Speijers et al. (2004) compared lambs grazing alfalfa, ryegrass, red clover (*Trifolium pretense* L.), and birdsfoot trefoil (*Lotus corniculatus* L.). They found no differences in either loin eye or back fat measurements from lambs finished on those species. They found greater rate of gain in
lambs grazing either alfalfa or red clover, and this was attributed to a greater rate of passage due to particle breakdown in the rumen.

**Chicory.** Another potential perennial forage for the warm season months is chicory (*Cichorium intybus* L). Chicory is an herb that will live for three to five years, and has been bred for forage production. In regards to lamb production, Turner et al., (1999) reported no difference between rate of gain for lambs on chicory when compared with orchardgrass. Lambs have gained between 148 g/d to 280 g/d (Marley et al., 2003; Miller et al., 2011; Schreurs et al., 2013) grazing chicory. Chicory has been found to contain secondary plant metabolites, sesquiterpene lactones, that may have an antiparasitic effect (Foster et al., 2011; Foster et al., 2011). Although not fully understood, the potential to decrease the impact of *Haemonchus contortus* and other internal parasites on lamb production is an additional benefit.

**Sorghum.** One potential warm season annual is brown midrib (BMR) sorghum (*Sorghum bicolor* (L.) Moench.) x sudangrass (*Sorghum sudanense* (L.) Piper) hybrids (Pratt et al., 1966; Ademosum et al., 1968; Beck et al., 2007; Stefaniak et al., 2012). This annual forage could provide: a) adequate dry matter during the summer slump of cool-season pastures (Pratt et al., 1966; Barker et al., 2005), b) adequate nutrition for lamb growth (Ademosum et al., 1968; Beck et al., 2007; Stefaniak et al., 2012), and c) an initial parasite-free field if tillage was employed in establishment. There is little in the published literature on growth of lambs grazing sorghum-sudangrass. One study reported that lambs grazing sudangrass after weaning, in July, and grazed to October gained at total of 6 ± 0.41 kg live weight (Kielsing and Swartz, 1997). They did not report the
grazing method, stocking density or even forage allowance to help put the reported rate of gain in context. However, this would have resulted in a calculated ADG of approximately 70 g/d which is lower than that needed to finish the animal.

With the industry push to finish animals efficiently on concentrates, forage based diets have been downplayed. Pimetel et al. (1980) demonstrated the resource constraints of moving from a grain-based system to a total forage-based system. Packers have indicated that the subcutaneous fat is more yellow and that the lean color was darker (Baublits et al., 2003, Ripoll et al., 2008, Carrasco et al., 2009) when lambs were fed forage-based diets. Producers realize that growth rate will be lower and that animals will have to be on feed for an extended period of time to meet a desired target market weight, (NRC, 2008) or they will be marketing lighter lambs (Shiflett et al., 2010) if an age or time period marketing is desired. They are also giving up efficiencies in rate of gain and feed conversion by not switching to grain for the last part of finishing (Fluharty et al., 1999).

Feed Impact on Meat Characteristics

There have been multiple reviews on the impact of feed on the characteristics of meat (Melton, 1990; Muir et al., 1998; Duckett and Kuber, 2001; Raes et al., 2004; Dunshae et al., 2005; Sinclair, 2007; Daley et al., 2010; Van Elswyk and McNeill 2014). These reviews have greater detail than is possible in this review, and the interested reader is directed to these review articles for further information. The health and palatability characteristics of products from grazing production methods continue to be actively studied (Duckett et al., 2007; Leheska et al., 2008; Ducket et al., 2009; Ducket et al.,
Products from grazing based production had a lower fat content, greater conjugated linoleic acid (CLA), and greater n-3 fatty acid content than conventional fed steers (Duckett et al., 2009; Duckett et al., 2013). Measurements of color indicated that grazing based production had darker and less red lean color (Duckett et al., 2007) and fat that was more yellow (Leheska et al., 2008) than conventional fed steers. Duckett et al. (2007) found no difference in Warner-Bratzler shear force values between feeding systems. Schmidt et al. (2013) compared carcass characteristics of steers grazed on different forages, ie. alfalfa, bermudagrass (Cynodon dactylon), chicory, cowpea (Vigna unguiculata L.), and pearl millet (Pennisetum glaucum L. R Br.). Finishing on alfalfa and cowpea increased dressing percentage, reduced Warner-Bratzler shear force values, and increased consumers preference, whereas finishing on bermudagrass and pearl millet increased CLA content.

One measurement that has not been reported in previous studies exploring the effect of different forages on lamb carcasses, is the pH of the muscle. The pH is a measure of glycolysis in the muscle tissue after exsanguination. The pH can impact the meat water holding capacity, color, and tenderness (McGeenin et al., 2001; Lambe et al., 2009; Hopkins et al., 2011). Ultimate pH of the loin (longissimus dorsi) muscle post rigor (24 h) in the range of 5.5-5.7 has been found to be acceptable for tenderness (Devine et al., 1993) and cooked odor and flavor (Braggins, 1996).

Grass-fed

Forage based systems are currently being used to raise animals producing meat for the natural, organic and direct-to-consumer outlets, as a holistic marketing method
(Shiflett et al., 2010). Grass-fed is a marketing term that embraces the animal’s natural adaptation to a grazing (forage based) system. In 2007 the USDA, Agricultural Marketing Service (AMS) finalized the standard to make the label claim for Grass-fed meat products. It is:

‘This claim applies to ruminant animals and the meat and meat products derived from such animals whose diet, throughout their lifespan, with the exception of milk (or milk replacer) consumed prior to weaning, is solely derived from forage, which for the purpose of this claim, is any edible herbaceous plant material that can be grazed or harvested for feeding, with the exception of grain. Forage-based diets can be derived from grass (annual and perennial), forbs (e.g., legumes, Brassica), and browse. Animals cannot be fed grain or grain byproducts and must have continuous access to pasture during the growing season. Growing season is defined as the time period extending from the average date of the last frost in spring to the average date of the first frost in the fall in the local area of production. Hay, haylage, baleage, silage, crop residue without grain, and other roughage sources also may be included as acceptable feed sources. Consumption of seeds naturally attached to forage is acceptable. However, crops normally harvested for grain (including but not limited to corn, soybean, rice, wheat, and oats) are only eligible feed if they are foraged or harvested in the vegetative state (pre-grain).’

Feeding grains or forages (grasses, legumes, forbs, etc.) to animals can impact the healthfulness attributes and palatability of meat (Melton, 1990; Daley et al., 2010). Healthfulness aspects may actually be bigger drivers of consumer acceptance of grass-fed products than other attributes (Umberger et al., 2009). Current emphasis on human nutrition and health has changed the demand for food products, especially meat products, in the United States (Resurreccion, 2003).
Health conscious consumers have driven the demand for “Natural or Organic” products in the marketplace. The 2007 National Meat Case Study (Sealed Air Corporation, 2007) revealed the top two issues impacting meat sales: 1) Natural and Organic, and 2) Nutrition labeling. A similar study design from 2010 revealed that the top issues impacting sales were: 1) Store branding, 2) Consumer information, 3) Case ready packaging, and 4) Natural claims (Sealed Air Corporation, 2010). ‘Consumer information’ included both health attributes and production statements. Natural and organic meat products representation, as a percentage of the retail case, has increased, respectively from 22% and 0.2% in 2004; 29% and 0.7% in 2007; to 32% and 0.9% in 2010. Lamb summary results from the 2010 survey indicated that Nutrition labeling doubled to 36% of all packages when compared with 2007 findings.

There are consumers that prefer this type of sustainable production system and, thus, have a preference for forage-based food animal products (Umberger et al., 2002, Stitz et al., 2005, Smith and Lawrance 2008, Umberger et al., 2009). Umberger et al. (2002), and Stitz et al. (2005) found that over 20% of the consumer taste panelists preferred grass fed beef and indicated they would have been willing to pay a higher price for this type of product. This was further supported by several other studies (McClusky et al., 2005; Lusk et al., 2008; and Umberger et al., 2009), where consumers preferred grass fed beef when they were shown the potential health benefits. The ability of the grass-based production model to meet consumer demand has been explored and findings suggest a great deal of potential (Pimentel et al., 1980; Martin and Rogers 2004; Meeh et al., 2013).
Grass-based livestock production has been promoted as a sustainable production model with agroecosystem benefits (Tillman et al., 2002; Winrock International, 2012). The shift of some livestock farmers to a more extensive, grass-based livestock production system has included “sustainability” claims. Worosz et al. (2008) cites three reasons: 1) grass-based systems can provide an improved ecosystem that reduces the risk of air and water pollution compared with confined animal feeding operations; 2) alternative animal agriculture systems may offer farmers an opportunity to gain price premiums by selling outside commodity marketing arrangements, and 3) farmers implementing grass-based systems self-report a high quality of life. Research discussions suggest grass-based livestock operations are economically profitable and improve the environmental quality of the natural resource base used for agricultural production (Crosson et al., 2006). Further, evidence suggests that grass-based systems are currently being used in the natural and organic outlets, as a holistic marketing method, embracing the animal’s natural adaptation to a grazing (grass-based) system (Rienhart and Baier 2011).

In contrast to the described benefits, farmer rates of adoption of a total grass-based production system are not high (Hanson 1995; Gillespie et al. 2007). Although not a direct measure of grass-based production, Management Intensive Grazing (MIG) is one production method that may be used in a total grass-based production system. The USDA 2007 Ag Census showed that only 38% of ruminant livestock farmers in Ohio reported that they practiced MIG, which closely matches the total US rate of 37%. The local grass-based meat production narrative overlooks both production and marketing changes that farmers must make in order to realize profitability. The scientific literature has very
little information regarding small to midsized livestock farmers. This includes limited
data regarding current management practices, or farmer capacity to meet the supply
requirements of new markets to make a net financial gain. Further, there is evidence that
farmers who attempt to transition to a grass-based system have a number of structural
challenges that must be addressed (Hanson 1995; Gillespie et al., 2007).

There has been limited research on the factors related to a producer’s decision to
adopt a grass-based production system, although there has been some research on grass-
based producers. Two surveys targeted only grass-based beef producers and focused on
their production and marketing practices (Lozier et al., 2005; Steinberg and Comerford
2009). Evans et al. (2007) used stochastic simulations to compare productions systems in
the Appalachian cow-calf sector. The stochastic or statistical distributions were used to
estimate seasonal variability in output, prices, pasture availability, and animal
performance. Lozier et al. (2006) used an ethnographic approach to explore the decision
to finish beef on pasture. The ethnographic or cultural anthropological approach was used to
help explain the decision making process in different cattle enterprises. Weber et al.
(2008) used grass-based beef production as an example to discuss the application of
mobilizing codes or cultural principles/definitions that organize a movement’s collective
meaning system to describe social movements in niche marketing. They showed that the
grass-based movement’s participants mobilized broad cultural codes that motivated
producers to enter and shape the forming niche market.

With any product or market, there is a supply and demand relationship. The grass-
fed market value chain is comprised mainly of direct to consumer or regional cooperative
marketing groups (Lozier et al., 2005; Weber et al., 2008; Steinberg and Comerford 2009; Winrock International 2010). Farmers can capture more of the consumer’s food dollar by direct marketing their agricultural products, with the farmer managing more of the supply chain instead of using the current conventional food systems model. In meat production systems, the supply chain has individuals who provide many services, including slaughtering, processing, packaging, storing, transporting, and promoting the product (Kirkpatrick and Bell 1995). Barriers identified by Myers (2010) to entering a market include finding a niche, product development and pricing, regulatory constraints, promotion and distribution, selling product, and managing risks.

Regardless of management systems and practices, the production of local meat products requires a different marketing channel than traditional meat animal marketing (MacDonald and McBride 2009). There are major structural issues for smaller scale farmers, including the scarcity of appropriate, accessible processing facilities, and the access to capital to cover start-up costs during the early years of an operation (Gwin 2009). The processing of livestock for local markets requires smaller-scale processing facilities that have the capacity and capability of cutting to the standards of consumers that may request specialized cuts. Additionally, start-up costs are associated with timing of meat availability, which is different between grain-based and grass-based systems with grass-based systems being more seasonal (Lozier et al., 2005; Steinberg and Comerford 2009). Thus, direct marketing of meat may be a critical factor influencing the decision to move to grass-based production.
Producer Perception of Grass Based Finishing

The growing movement of localized food production (Lyson 2004, 2005) has been driven by consumer interest in the origin of food with a focus on the production, processing, marketing, and consumption of locally grown products (Conner and Oppenheim 2008; Lyon et al. 2008; Abrams et al. 2009). In livestock systems, local production typically operates at a small to mid-sized scale utilizing a grass-based animal production model (Weber et al. 2008). Lusk (2011, p.573) points out “If recent history has revealed anything, it is that farmers are willing to change production practices to supply what consumers want,” as long as there are consumers who are willing to pay for these products. As a result, there has been substantive research on consumer interest in buying local, their willingness to pay, perceptions of health benefits as well as potential social and economic benefits of building local food systems (Umberger et al. 2009). However, much less is known about livestock farmer perceptions regarding the production and marketing changes which must occur for entry into these markets, and how these perceived changes impact management decisions. Understanding livestock farmer perceptions about producing for local markets, and related management decisions, is a critical step in addressing the supply side of local meat production potential.

Grazing Infrastructure Management. The management of the grass (forage? Not just grass) resources (pasture) and the animals grazing it are critical to the production of meat derived from grazed animals. The management of pastures, and grazing of those pastures, goes by several names: rotational grazing, prescribed grazing, or MIG. Work by several Land Grant Universities has promoted the adoption of grazing practices to help
farmers reduce the production costs associated with stored feed, machinery, fuel, and facilities by improving monthly pasture distribution utilization and yield (Undersander et al., 2002; McCutcheon et al., 2003; Heckman et al., 2007; Smith et al., 2011). A large proportion of the educational effort has been focused on the infrastructure and management changes needed to make these grazing systems work (Undersander et al., 2002; Heckman et al., 2007; Smith et al., 2011). Despite the work and benefits of adopting grazing, Ohio has only 38% of the ruminant livestock farms (USDA, 2007) using MIG to manage their pastures. The Census estimate does not differentiate among farm types so feedlots that background cattle and dairy farms are included in the estimate. Little information exists on the adoption of grazing management practices of beef and sheep farmers. Most of the published work has been conducted with dairy farms (Hanson 1995; Foltz and Lang 2005). In addition, limited knowledge exists about barriers to adoption of grazing management (Kim et al., 2005). Promoted benefits such as reduced machinery and facility needs have less impact when they already exist in an operation (Gillespie et al., 2007). Foltz and Lang (2005) postulated that in Connecticut dairy farms, land availability may limit adoption.

**Grazing Management Skills and Knowledge Resources.** Closely aligned to infrastructure investments are management production decisions that impact the quality of the meat product, a key focus of the meat industries (Hoffman et al., 2009; National Cattleman’s Beef Association 2011). Consumer preference is for intrinsic quality factors such as marbling first, then for extrinsic factors such as improved health, environmental sustainability, and animal welfare (Grunet et al., 2004; Gwin and Hardesty 2008).
Similar to the differences in healthfulness and palatability that are found when ruminants are fed different grains, the meat from animals raised on forages (grasses, legumes, brassicas, etc.) may also differ in the healthfulness and palatability attributes (Faucitno et al. 2008). Alterations in the type of feed that a farmer supplies to their animals can impact the chemical composition and organoleptic properties of the resulting meat products. Many forage and grazing studies have reported effects on animal performance, differences due to nutrition, and influences of management when studying grass-based systems, as well there are identified impacts regarding the nutritional benefits to the consumer. However, few reports have detailed the effects of varying grass-based systems on expected consumer perception of the meat product through extensive sensory panel evaluation. Understanding how to produce livestock on grass-based systems, without diminishing meat quality, when compared with grain fed livestock, is critical. Among the critical, negative economic impacts of farmers switching to grass-based systems are the effects of significantly lower hot carcass weight and USDA Quality Grade. Cattle targeted for grass-based, non-hormone implanted markets have been estimated to require a 16% premium to be economically competitive with conventional grain-finishing systems (Berthiaume et al., 2006).

Regardless of management systems and practices, the production of local meat products requires a different marketing channel than traditional meat animal marketing (MacDonald and McBride 2009). There are major structural issues for smaller scale farmers, including the scarcity of appropriate, accessible processing facilities, and the access to capital to cover start-up costs during the early years of an operation (Gwin
The processing of livestock for local markets requires smaller-scale processing facilities that have the capacity and capability of cutting to the standards of consumers that may request specialized cuts. Additionally, start-up costs are associated with the timing of meat availability, which are more seasonal with grass-based systems than grain-based systems. Calves in grain-based systems are typically marketed as feeder cattle at 6 to 8 months of age, at which time they go into the feedlot system where they are fed until they reach a marketable weight at 13 to 18 months of age, whereas grass-fed cattle are kept on pasture until they reach a marketable weight at 18 to 30 months of age. Therefore, the farmer must forego income for an additional year, on average.

Furthermore, with grass-fed beef, seasonality is a problem, as the majority of animals are harvested and processed during the fall, when forage supply is diminishing (Lozier et al., 2005). This can conflict with local small-scale processor availability since deer season and processing, a highly-profitable venture for small-scale meat processors limits capacity to process beef and lamb products. It is often not possible to add more labor in these small-scale plants for short-term needs due to space and meat cutting training limitations. Thus, for the farmer moving to a grass-based system and producing for the non-commodity marketplace, marketing and market timing, become critical control points for an operation.

Farmers have not adopted the direct-to-consumer marketing of meat products widely. In the 2007 USDA Agriculture Census, only 6.2% of US farms indicated direct marketing to consumers. However, the Census did not report what types of products were marketed to consumers. Low and Vogel (2011) found that most of the products that are
direct marketed to consumers are vegetables, fruit, and nuts. Specifically, those farms raising vegetables, fruit or nuts were eight times more likely to market their products directly to consumers (Low and Vogel 2011). Similarly, a 2009 direct marketing survey from the State of New York showed only 35% of the farms direct marketing their products sold any animal products (NASS 2010). The reported figure represents approximately 6% of the total farms in New York, and included milk and poultry in the reporting; therefore, the actual number of farms selling meat products may be less.
Figures for Chapter 1.

Figure 1: Typical sheep production cycle proposed by Jones 2004.

Chapter 2: Ohio Livestock Producers’ Perceptions of Producing and Marketing

Grass-Based Beef and Lamb

Abstract
Grass-based livestock production is a sustainable system, both ecologically and economically, yet producers’ perceptions about it vary, and adoption is highly dependent on an individual’s perceptions. In 2010, 344 Ohio beef and sheep farmers responded to a random sample mail survey and described their management system as grass-based (17.8%), grain-based (19%), and grass with some grain (63.2%). Factors influencing conversion to a grass-based management system were infrastructure, knowledge, technical skills, financial costs, and a desire to change practices. Grain-based producers reported equipment, markets, and regulation as barriers to conversion to a grass-based system, while grass-based producers rated the pasture as a key factor in converting to a grass-based system.

Key words: Grass-based, grain, beef, lamb, farmer perceptions, livestock systems,
**Introduction**

Grass-based livestock production, the feeding of ruminant livestock through grazing management and stored forages, has been promoted as a sustainable production model with agroecosystem benefits (Tillman et al. 2002; Winrock International 2012). Consumers have shown an interest in and willingness to pay for meat products produced from grass-based systems (Umberger et al. 2002; McClusky et al. 2005, Conner and Oppenheim 2008). The health and palatability characteristics of products from grass-based production methods continue to be actively studied (Duckett et al. 2007; Leheska et al. 2008; Schmidt et al. 2013; Van Elswyk and McNeill 2014). The ability of the grass-based production model to meet consumer demand has been explored with findings that suggest a great deal of potential (Pimentel et al. 1980; Martin and Rogers 2004; Meeh et al. 2013). Yet, grass-based meat marketing programs, like Tallgrass Beef Company and Thousand Hills Cattle Company, cannot find enough product to meet demand (Winrock International 2012). Small and mid-sized producers who lack large producer economies of scale are increasingly challenged to be profitable, and to find high value niche markets. Grass-based livestock production systems are better suited to hilly, steeply sloping highly erodible lands not appropriate for cultivated row crop agriculture; and increasing consumer demand offers producers opportunities for meeting livelihood needs. Thus, there is reason to encourage increased conversion of vulnerable lands to perennial grasses rather than grain crops. However, little is known about livestock producers’ perceptions
of grass-based systems and the barriers to converting to this type of livestock production system are not well understood.

Several studies have characterized the demographics of the people who already practice grass-based livestock production (Lozier et al. 2005; Weber et al. 2008; Gwin 2009; Steinberg and Comerford 2009). The present research study of Ohio beef and sheep livestock producers addresses gaps in existing knowledge by examining current types of livestock production systems and exploring factors thought to influence the decision to convert to grass-based production.

Specifically, we ask: 1) how do livestock producers describe their management system?; 2) how do operation and marketing characteristics differ among different management systems?; and 3) what are the key factors that influence a producers’ reasons for moving to (or not) a grass-based grazing system? We propose that there are identifiable operation characteristics and infrastructure needs for grass-based management, personal skill sets and resources, and measurable costs and benefits that are key underlying dimensions that influence the preferred type of production system.

**Grass-Fed Meat**

The terms grass-fed, grass, forage, and pasture have been used interchangeably in the literature. According to the USDA Agriculture Marketing Service, the official marketing standard for the ‘grass-fed’ label states, “The diet shall be derived solely from forage consisting of grass (annual and perennial), forbs (e.g., legumes, Brassica), browse, or cereal grain crops in the vegetative (pre-grain) state,” (Federal Register 2007, p. 58637). For this discussion, the term grass-based is used to describe the livestock
management system relying on grazing to harvest annual and or perennial grasses, legumes, forbs, browse, as well as feeding stored forages where appropriate.

The shift of some livestock farmers to a more extensive, grass-based livestock production system has included “sustainability” claims. Worosz et al. (2008) cite three reasons: 1) grass-based systems can provide an improved ecosystem that reduces the risk of air and water pollution when compared with confined animal feeding operations; 2) alternative animal agriculture systems may offer farmers an opportunity to gain price premiums by selling outside commodity marketing arrangements, and 3) farmers implementing grass-based systems self-report a high quality of life. Grass-based livestock operations can be economically profitable and improve the environmental quality of the natural resource base used for agricultural production (Crosson et al. 2006). Further, grass-based systems are currently being used in the natural and organic outlets, as a holistic marketing method, embracing the animal’s natural adaptation to a grazing (grass-based) system (Rienhart and Baier 2011).

In spite of the described benefits, farmer rates of adoption of a grass-based production system are not high (Hanson 1995; Gillespie et al. 2007). The USDA 2007 Ag Census showed that only 38% of ruminant livestock farmers in Ohio reported that they practiced Management Intensive Grazing (MIG), which closely matches the total US rate of 37%. The local grass-based meat production narrative overlooks both production and marketing changes that farmers must make in order to realize profitability. The scientific literature has very little information regarding small to midsized livestock farmers. This includes limited data regarding current management practices, or farmer capacity to meet
the supply requirements of new markets to make a net financial gain. Further, there is evidence that farmers who attempt to transition to a grass-based system have a number of structural challenges that must be addressed (Hanson 1995; Gillespie et al. 2007).

Both beef and sheep producers were the target of our study. Beef and sheep production practices share several similarities, the cow-calf and ewe-lamb farm rely on pasture with the terminal offspring predominately being finished on grain-based diets (National Research Council 2008). Additionally, both require similar infrastructure and skills to manage and because of slight differences in grazing preferences both can be effectively managed on the same pastureland (National Research Council 2008).

There has been limited research on the factors related to a producer’s decision to adopt a grass-based production system, although there has been some research on grass-based producers. Two surveys targeted only grass-based beef producers and focused on their production and marketing practices (Lozier et al. 2005; Steinberg and Comerford 2009). Evans et al. (2007) used stochastic simulations to compare productions systems in the Appalachian cow-calf sector. The stochastic or statistical distributions were used to estimate seasonal variability in output, prices, pasture availability, and animal performance. Lozier et al. (2006) used an ethnographic approach to explore the decision to finish beef on pasture. The ethnographic or cultural anthropological approach was used to help explain the decision making process in different cattle enterprises. Weber et al. (2008) used grass-based beef production as an example to discuss the application of mobilizing codes or cultural principles/definitions that organize a movement’s collective meaning system to describe social movements in niche marketing. They showed that the
participants in the grass-based movement mobilized broad cultural codes that motivated producers to enter and shape the forming niche market. Although informative about grass-based beef producers, those studies did not provide answers to our questions.

With any product or market, there is a supply and demand relationship. The grass-fed market value chain is comprised mainly of direct to consumer or regional cooperative marketing groups (Lozier et al. 2005; Weber et al. 2008; Steinberg and Comerford 2009; Winrock International, 2010). Farmers can capture more of the consumer’s food dollar by direct marketing their agricultural products. The farmer managing more of the supply chain instead of using the current conventional food systems model does this. In meat production systems, the supply chain has individuals who provide many services, including slaughtering, processing, packaging, storing, transporting, and promoting the product (Kirkpatrick and Bell 1995). Barriers identified by Myers (2010) to entering a market include finding a niche, product development and pricing, regulatory constraints, promotion and distribution, selling product, and managing risks.

Regardless of management systems and practices, the production of local meat products requires a different marketing channel than traditional meat animal marketing (MacDonald and McBride 2009). There are major structural issues for smaller scale farmers, including the scarcity of appropriate, accessible processing facilities, and the access to capital to cover start-up costs during the early years of an operation (Gwin 2009). The processing of livestock for local markets requires smaller-scale processing facilities that have the capacity and capability of cutting to the standards of consumers that may request specialized cuts. Additionally, start-up costs are associated with timing
of meat availability, which is more seasonal with grass-based systems compared to grain-based systems. Thus direct marketing of meat may be a critical factor influencing the decision to move to grass-based production.

Ohio is well suited as a case study to explore supply issues associated with the livestock value chain and the potential of local direct markets. Fifty-four percent of Ohio’s 26 million acres are in farms and the livestock sector is an important component of Ohio’s agriculture. Ohio’s total 2009-2010 cattle inventory was 1.28 million head with about 304,000 head of beef cows. Although Ohio ranks as the 13th state nationally in sheep numbers, it is the leading producer in the U.S. east of the Mississippi River (Ohio Department of Agriculture, 2011). In light of growing consumer interest in localized food production, Ohio’s strong agricultural base, combined with a population of more than 11.5 million people, suggests livestock producers have a number of opportunities to diversify production strategies and markets.

Methods

A livestock producer mail survey (Appendix A.) was conducted in spring 2010 to assess Ohio beef and sheep producers’ current management practices and factors that might influence a decision to transition to a grass-based system and engage in direct marketing. The survey instrument was developed by the authors, pilot tested with 18 farmers, and revised. The survey design and instrument were reviewed and approved by the university Office of Responsible Research Practices (Reference # 2010E0118).

Beef and sheep mailing lists were requested from all 88 Ohio countiees through The Ohio State University Extension offices. Only 73 out of the 88 county Extension
offices (83 percent) had mailing lists that could identify farmers raising beef or sheep species. In addition, statewide farmer associations, the Ohio Cattleman’s Association and the Ohio Sheep Improvement Association mailing lists were made available. Lists were combined, duplicates were removed, and final list had representative from every Ohio County. The available mailing list contained 9,553 beef farmers and 1,133 sheep farmers, representing producers who have either sought information from Extension and/or were associated with commodity groups. From the available sample, a random subsample was identified, providing a 4% Confidence Interval and a 95% Confidence Level based on an expected 50% return rate. The survey was mailed to 551 beef farmers and 393 sheep farmers for a total of 944 mail questionnaires. The Dillman (2000) method using three contacts was used to conduct the survey.

Twenty-three surveys were returned as undeliverable, and 418 of 921 delivered mailed surveys were returned for an overall response rate of 45%. Of those returned, 74 surveys were blank with indications the respondents were no longer producing either beef or lamb and did not feel capable of completing the survey, resulting in 344 completed surveys for analysis. To check for non-response error, early responses were compared against late respondents (Lindner et al., 2001). There were no significant differences between early and late respondents ($P > 0.05$). Sheep and beef producers were not statistically different ($P > 0.05$) in farm area owned, farm area rented, animals direct marketed, age, and income and were combined in this analysis to examine the grass-based aspect of livestock production rather than identifying the distinct differences in managing these two species.
The survey consisted of 35 questions conceptually grouped around type of livestock management system, characteristics of the respondent’s current management system, factors influencing a decision to convert (or not) to a grass-based system, barriers to conversion, and factors influencing their capacity to direct market animal products. Study analysis centered on comparing operation and marketing differences among three types of livestock management systems. Respondents were asked to indicate which best described their livestock management. The choices included: confinement animal feeding (GRAIN), pasture based with some grain (GWG), totally forage based with no harvested forages (GRASS), and totally forage based with harvested forages (GRASS). The two total forage systems were combined for analysis as one grass-based group GRASS. Four questions were analyzed to discover their perceived influence on conversion to a grass-based system and the direct marketing of meat and meat products originating from grass-based systems. The first question (Figure 2) provided a baseline of current practices and asked about the producer’s current farm management system. There were 17 items within this question representing equipment and facilities, forage management, topography and land, and market conditions that respondents rated on a 1-5 Likert scale of not important to very important.

The second question (Figure 3) asked about factors associated with converting to grass-based system. “In your opinion, to what extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system?” There were 11 influence items in this question representing infrastructure,
livestock genetics, management, and marketing that respondents rated on a 1-4 Likert scale from no influence to high influence.

A third question (Figure 4) asked respondents about barriers to conversion, “Please indicate your opinion on each of the following.” There were 10 statements or reasons for not converting to a grass-based system representing knowledge and experience, perceptions of costs, and investment of time concerns which were rated on a 1-5 Likert scale from strongly disagree to strongly agree.

The last question (Figure 5) in the analysis focused on direct marketing, “How do these factors influence a farmer’s ability to direct market animal products?” There were 15 influence variables related to customers, regulations, and logistics of direct marketing rated on a 1-5 Likert scale from not at all to very strong. This question also had a ‘don’t know’ category that was not included in this analysis.

Demographic data and the items in the four questions were analyzed using SAS 9.2 (Cary, NC) and two types of analyses were conducted: principal component analysis and analysis of variance. Principal component analysis (PCA), specifically Proc Factor with Varimax rotation and Kaiser normalization, was used to identify the underlying structure of each of the four questions and confirm (or not) conceptual factors posited to influence decisions to convert (or not) to a grass-based system (Appendix B). PCA is also an effective way to simplify a large set of variables into a smaller set of factors for a more parsimonious analysis (Kim et al. 2005; Greiner et al. 2009; Gillespie et al. 2007). An analysis of variance (Proc GLM with the probability between LS-means) was used to
explore demographic, management, and marketing differences between GRASS, GWG, and GRAIN farmers.

**Results**

There were 17.8% of all livestock respondents (Table 1) who reported that GRASS best described their livestock management system and 19% described their management system as GRAIN. The remaining 63.2% of respondents described their livestock management system as a hybrid of the two, grass with some grain (GWG).

The means from respondents were 93 hectares owned, managed 34 beef cows and 67 ewes, were 56.7 years old, and 94% male. Mean years of experience raising beef cattle were 32.9; and sheep producers reported 34 years of experience. According to the 2007 Ag Census (USDA), in Ohio the average beef herd was 32 head and sheep flock average size was 36 head, suggesting sheep producers with larger flocks were more likely to belong to the Sheep Association and/or associate with their county Extension Offices or respond to the survey. There were several respondents (n = 46 or 13%) who reported raising both beef and sheep in 2010, suggesting beef and sheep farmers tended to specialize. The percentage of GRAIN producers who direct marketed some form of animal product was 67% (n = 43), GWG was 41% (n = 125), and GRASS was 61% (n = 37).

There were no statistical differences \( P > 0.05 \) between farm area owned or rented between the three management systems (Table 2). Numerically, the GRAIN producers owned and rented more hectares than the GRASS producers, 93 and 170 compared with 75 and 98, respectively.
The number of beef cows managed did not differ ($P > 0.05$) between groups with the GRAIN, GWG, and GRASS groups managing 33, 34, and 31 cows, respectively. The number of finished cattle produced was greater for the GRAIN group, 141, than either the GWG or the GRASS group ($P < 0.01$), both reporting 19 head. Regardless of management system results indicated that all groups participated in some form of direct marketing beef, and systems were not different in the number of cattle direct marketed ($P > 0.05$).

The number of ewes managed was not statistically different between groups ($P > 0.05$), but numerically the GRASS group reported more ewes than the GRAIN group, 96 versus 50, respectively. Number of light lambs (< 41 kg) produced was greater for the GRASS group than the GRAIN group ($P < 0.05$), 139 vs 36 respectively, and none of the GRASS group reported producing lambs over 54 kg. The GRAIN group reported direct marketing over twice as many lambs as either the GWG group or the GRASS group ($P < 0.01$), 88 vs 27 and 35 respectively. Even though years of experience for the beef or lamb producers were not different between groups ($P > 0.05$) the GRAIN group was younger ($P < 0.01$) than either the GWG or GRASS group, 52 verses 58 years old respectively. Reported income level, measured on an 8 point scale, was not different between GRAIN, GWG or GRASS ($P > 0.05$), with all groups indicating approximately $50,000 - $74,999 net income.

**Current Management**

Based on responses to the factors important to respondent’s current management (Figure 2) there were four underlying dimensions to respondents’ current farm
management system: EQUIPMENT, PASTURE, RESOURCE, and MARKET (Table 3). Feeding equipment, livestock holding facilities, feed storage, manure handling equipment, and manure management structure loaded together under the EQUIPMENT dimension with a reliability estimate of 0.73 and explained 15.91 % of the total variance. Those items importance ratings ranged from 3.28 (a little important) to 3.96 (important). Five items (rotational grazing, balance forage supply with forage demand, use a variety of forage, watering infrastructure, and fencing) loaded on the PASTURE dimension with a reliability estimate of 0.79 and explained 15.81 % of the total variance. All PASTURE items were rated sometimes important to important. Fencing received the highest rating (4.35) in this dimension and the second highest rating of all 17 items in this question. The RESOURCE dimension (soil types, topography, competition for land, and financing) loaded together with a weaker reliability estimate of 0.65 and explained 11.02 % of the total variance. Individual items in the resource dimension were rated the lowest of all items, sometimes important. The final dimension of the Current Farm Management System question was MARKET, consisting of three items: profit margin on livestock, access to viable livestock markets, and produce high quality products for the market. This factor had three of the top four highest importance ratings and a reliability estimate of 0.71, but explained the least amount of total variance at 9.68 %.

**Decision to Convert to Grass-based Production**

Factor analysis of the respondent’s perceived influence of various factors on a decision to convert to grass-based production (Figure 3) revealed three factors: INFRASTRUCTURE, GENETICS, and MANAGEMENT (Table 4). The largest factor,
INFRASTRUCTURE, consisted of suitability of land, access to land, handling facilities, equipment, labor availability, and fencing/water infrastructure and had a strong reliability estimate of 0.86 and explained 31.21% of the total variance. Items within the INFRASTRUCTURE factor were the highest rated of all items, with access to land, suitability of land and fencing/water infrastructure rated moderate influence. No single item received a high influence rating suggesting that a suite of INFRASTRUCTURE issues influenced a decision rather than one dominating. The GENETICS factor (available livestock breeds, type of current livestock, and desired genetics) had a good reliability estimate of 0.78, explained 18.98% of the total variance, and had the lowest ranked items (some influence) in the decision to convert.

The last factor, MANAGEMENT, consisted of niche marketing opportunities and knowledge of grass/forage management. The items in MANAGEMENT were rated moderate influence in the decision to convert, had a weaker reliability estimate of 0.66 and explained 14.95% of the total variance. The physical INFRASTRUCTURE factor was a strong parsimonious variable and offered confirmatory support to our posit that infrastructure was a key variable that influenced the decision to convert to a grass-based system.

**Barriers to Conversion to a Grass-based System**

Closely aligned with the decision to convert to a grass-based system were the barriers to conversion (Table 5). The ten items, (Figure 4) stated in the negative, received ratings strongly disagree, disagree, and no opinion. This suggested that in general none of the reasons were considered barriers to conversion. Seven of the items fell in the no
opinion range: not convinced about demand (3.22), banks are reluctant to provide financing (3.01), and safety net lacking (2.91). Barriers to conversion items loaded on to three different factors: desire to convert (DESIRE), KNOWLEDGE, and financial costs (FINCOST) to convert. The first factor, DESIRE (rather take an off farm job, don’t want to start something new, too busy, not convinced about the demand) had a solid reliability estimate of 0.71 and explained 22.71 percent of the total variance. The second factor, KNOWLEDGE, (reliability estimate 0.70 and 19.42 % of variance explained) consisted of no experience to manage the supply chain, uncomfortable marketing to consumers, and don’t know the markets. The last factor, FINCOST, had a weaker reliability estimate (0.66 and explained 19.07 % of the variance) and consisted of three items: believe banks are reluctant to provide financing, safety net lacking, and start-up costs for conversion too high. The factor analysis offers partial support confirming underlying dimensions of personal skill set (KNOWLEDGE) and assessment of costs and benefits (FINCOST) despite respondents not rating them as barriers to conversion.

**Direct Marketing Animal Products**

The factor analysis of the responses to the factors influencing a producer’s ability to direct market animal products (Figure 5) revealed three underlying dimensions of variables that influence ability to direct market animal products: CUSTOMERS, REGULATORY, and LOGISTICS (Table 6). All except one direct market item, product transport, had an average rating that could be categorized as a ‘strong’ influence (3.5-4.5). The six items with the highest mean ratings were finding customers; dealing with customers; pricing; finding a meat processor to cut the way customer requests;
communicating and scheduling with processor; and educating consumers about meat preparation and cooking, and loaded on the CUSTOMER factor (reliability 0.86 and explained 27.54% of the variance) along with advertising. The second factor, REGULATORY, had a strong reliability of 0.92, explained 21.57% of the variance and consisted of four items dealing with regulations of USDA, health department, Ohio Department of Agriculture, and packaging and storage. The third factor, LOGISTICS, had a reliability rating of 0.88 and explained 21.07% of the variance. It consisted of four items dealing with product storage, liability and transportation, and the seasonality of consumer demand.

Variations Among Livestock Management Systems

To answer the research question, how do these factors vary by livestock management systems, the identified factors from the four questions about current management, conversion to grass, barriers to conversion, and direct marketing were analyzed by livestock management system, GRAIN, GWG, GRASS (Table 7). A number of patterns emerged. First, in general, GWG and GRASS current management systems were significantly different \((P < 0.05)\) in how important EQUIPMENT and PASTURE were when compared with GRAIN systems, with EQUIPMENT factor ratings of 19.76 vs 17.77 and 16.91 and PASTURE factor ratings of 13.84 vs 18.77 and 19.69 for GRAIN, GWG and GRASS respectively. As expected, the respective groups rated items applicable to their operations as more important than items less applicable to their operations. The GRAIN group rated the EQUIPMENT more important than the mean of the total respondents (17.89) and the other two groups. The GRAIN group rated
PASTURE aspects less important than the mean of the total respondents (17.44) and the other two groups.

There were non-significant differences in the RESOURCE grouping \( (P > 0.05) \). This indicated that soil types, topography, competition for land, and financing concerns were similar in all three types of livestock systems. All three groups rated RESOURCE as ‘sometimes important’ to their operations. There was only a slight difference \( (P < 0.10) \) between how the GRAIN group and the GRASS group rated the importance of the MARKET factor, 12.24 vs 12.91 respectively.

Second, there were no significant differences \( (P > 0.05) \) in relationships between the three management systems in the influences on the conversion to grass decision. This suggested that the INFRASTRUCTURE, GENETICS, and MANAGEMENT were not distinctly different in the perceived influence on the decision to convert to a grass-based system among the three systems.

Third, the barriers to converting to a grass-based category revealed substantive variability among the livestock management systems. The barriers to convert to grass factor DESIRE showed significant differences \( (P < 0.01) \) between all three groups, 12.17 versus 10.68 vs 9.30 for GRAIN, GWG and GRASS respectively. It was expected that there would be differences between the GRAIN and GRASS groups since the GRASS group had already converted. The GWG group showed more agreement with the opinions, stated in the negative, in the DESIRE factor than the GRASS group. The barriers to convert to grass factor KNOWLEDGE showed differences \( (P < 0.01) \) between the agreements of GRASS group when compared with the other two groups with GRASS
having a lower score or least agreement with those opinions, with the GRAIN, GWG, and GRASS groups rating their agreements as 9.48, 8.81, and 7.91 respectively. The barriers to convert to grass factor FINCOST showed slight differences ($P < 0.1$) between GRASS and the other two groups, with GRAIN, GWG and GRASS groups rating their agreements as 8.85, 8.46, and 7.98 respectively.

Lastly, the direct marketing factors showed differences for the factors REGULATORY and LOGISTICS between the GRAIN group and the GWG and GRASS groups, with REGULATORY receiving 16.08 vs 14.26 and 13.74 and LOGISTICS receiving 15.63 vs 13.83 and 13.61 for the GRAIN, GWG and GRASS groups respectively.

**Discussion and Implications**

Grass-based livestock systems offer an opportunity for small and medium sized farms to increase productivity and profitability using a system of agriculture that has ecosystem benefits for water and soil resources. While consumers have shown considerable interest in grass-based animal products, there are a number of barriers to producers converting grain-based production to grass-based. This survey provided insights into those factors that influence the type of livestock management used and whether direct marketing is viewed as a strategy for increasing profitability.

Eighty percent of respondents used some type of grain in their system while only 18 percent classified their production system as grass-based only. Almost two-thirds of Ohio sheep and beef producers utilize a hybrid system of grass with some grain. Although this management system does not meet the Federal marketing standard for
“grass-fed,” it may meet sustainability standards of balancing ecosystem protection and economic livelihood needs associated with shorter-term income and heavier weights obtained from finishing on corn. There were a number of differences among GRAIN, GRASS, and GWG that are noteworthy. There was more variability in the hectares reported by the GRASS group compared with the other two groups. Steinberg and Comerford (2009), in their survey of grass-based producers from the North Eastern US, reported grass based producers used fewer hectares but there were regional differences in farm sizes (USDA 2007).

The respective management systems were not different in several key descriptors of their operations; land managed, years of experience, income, number of cows managed, number of beef direct marketed, and the number of ewes managed. Livestock management systems defined as GRAIN produced more head of finished beef and fewer head of light lambs than the other two groups. This reveals that the time required to produce heavier animals is resource constraints from grass-based production. Grass-based production methods have produced slower animal weight gains than feeding concentrates, which means taking the animals to heavier weights will take longer (Duckett et al., 2013). GRAIN producers also direct marketed a greater number of lambs and were younger than the other two groups.

Almost 61 percent of the respondents reported direct marketing some form of animal product. The number of finished cattle produced was greater for the GRAIN group and may relate to the emphasis on scale of the operation, which has been considered important for commodity beef production (MacDonald and McBride 2009).
The average for the GWG and GRASS aligned with what Steinberg and Comerford (2009) and Winrock International (2012) found in regard to grass-based beef numbers per farm. Lozier et al. (2005) and Steinberg and Comerford (2009) found a majority of grass-based beef were direct marketed and matched results from the present study when the number of head direct marketed was considered. The direct marketing of meat products involves more specialized infrastructure than production alone, and there have been issues and challenges with the scarcity of local meat processing (Gwin 2009; Gwin and Thiboumery 2013) limiting that market channel. This finding was demonstrated in the present study, whereby, regardless of management system, all groups participated in some form of direct marketing of beef and they were similar in the number of beef direct marketed, indicating that Ohio producers have access to processing facilities regardless of production type.

There were two key differences found in the number of lambs produced. Light lambs (< 41 kg) produced were five times greater for the GRASS group than the GRAIN group and none of the GRASS group reported producing lambs over 54 kg suggesting that the limitations of forage production (seasonality, forage type, forage quality) in Ohio may restrict the market weight options of lambs produced. The interesting aspect was the fact that the GRAIN group reported direct marketing over twice as many lambs as either the GWG group or the GRASS group. Although not fully explained it may be due to the multiple target weights accepted by the consumer and the multiple niche lamb-marketing channels (National Research Council 2008). There is little information about the extent of direct marketing by sheep producers (National Research Council 2008).
Although the producer groups were not different in their ratings, INFRASTRUCTURE and MANAGEMENT received moderate influence ratings that supported Kim et al. (2005) findings that land type and knowledge were factors in adoption of best management practices (BMP). GENETICS rated as having some influence on the decision to convert. Lozier et al. (2005) found genetics and frame size important selection criteria for their respondents. Steinberg and Comerford (2009) reported their respondents used predominately the beef breed Angus with the breeds Hereford, Limousin, Devon, and Red Angus, also being identified. Weber et al. (2008) described genetics as one of the many continuums in the mobilizing codes in converting to grass-based beef production, specifically the continuum between ‘‘Heritage breed’’ cattle” and “‘Performance breed’ cattle” (p. 539).

For both the KNOWLEDGE and FINCOST factors, the GWG and GRAIN groups agreed in their opinion ratings. This suggested that infrastructure conditions were not driving conversion, but personal reasons, knowledge, and financial costs were keys in influencing the type of livestock management system chosen. This was similar to the findings that knowledge about, and non-familiarity about, a practice were factors in adoption (Kim et al. 2005; Gillespie et al. 2007).

The slight difference in MARKET factor under Current Management suggests that profit margin, access to viable markets, and producing high quality products to meet demand were more important to the GRASS group. This finding was surprising since the management and production decisions that impact the quality of the meat product have been a key focus of the meat industries (Hoffman et al. 2009; National Cattleman’s Beef
Association 2011). Greater emphasis on MARKET factors may be the producer’s reaction to alleviating/ameliorating beef industry (MacDonald and McBride 2009) views that have discouraged grass-based diets. Packers have discounted products from grass-fed beef, and indicated that the fat was more yellow, and that the lean color was darker (Baublits et al. 2004) which meant these products were less desirable to U.S. consumers. Grass finishing systems for beef cattle and lamb are challenged to develop management strategies that keep animals growing during times the native forage is not nutritionally adequate to support that animal growth. This is a production challenge that requires farmers learn new and different management skills to assure animals are gaining weigh and achieving protein turnover so the connective tissue in the muscle does not become mature making the meat tougher (Crouse et al. 1986).

Both REGULATORY and LOGISTICS, factors within the Direct Marketing focal area, were identified by GRAIN respondents as having more influence on a producer’s ability to direct market animal products than was reported for CWG and GRASS groups. This finding was not explained by a lower percentage of animals direct marketed, as the GRAIN group direct marketed a higher percentage of lambs than GWG and GRASS classes, and all three groups direct marketed the same number of beef. Gwin and Thiboumery (2013) identified the spectrum of direct marketing from: animals sold live and the buyer handles the processing, to the farmer who handles all the details and sells individual products directly to individuals. Differences between production groups may be associated with where the respective groups land on that spectrum. The type of marketing was not accounted for in this paper. Lozier et al. (2005) and Steinberg and
Comerford (2009) both found over half of their respective respondents sold individual beef products. Average group scores for the direct marketing factor CUSTOMERS were not different, which was not surprising considering that all three groups participate in direct marketing.

The present study identifies that equipment and pasture resources, as well as perceptions of regulatory and logistics issues, were significantly different between GRAIN and GRASS or GWG. Further, desire to convert and knowledge needed to convert from a grain-based system to a grass-based system are significant barriers to changing management systems. This suggests that there are a number of non-financial factors underlying conversion. GRAIN respondents had more agreement with the negative opinions expressed in the desire and knowledge factors. Producers who classified their livestock management system as either GWG or GRASS rated the pasture factor as more important than GRAIN farmers. The production and marketing changes producers must make in order to realize any potential net financial gain likely plays an important role in the decision to change. This also sheds light on the management choices, farm resources, and environmental constraints faced by producers as they apply new production practices to their existing operations.

Land characteristics and existing equipment were of greater concern for producers who had not adopted grazing. Tied with the desire and knowledge about the alternative production method there is a high likelihood that those farmers may not change. Marketing related concerns were greater for those that were not currently involved in the process. Extension or educational programs and research can provide a supporting role in
the adoption process (De Buck et al. 2001). The grass-based production model has been closely tied with direct marketing (Lozier et al. 2005; Lozier et al. 2006; Evans et al. 2007; Weber et al. 2008; Gwin 2009), although the need to aggregate and coordinate production has been identified (Winrock International 2012; Gwin and Thiboumery 2013). To design local food programs, a better understanding of the system is needed. In meat production systems there are several specialized services needed to get the product to the consumer. The limitations, motivations, and risk attitudes of farmers also must be understood. Meat processors play one important role in the local production and marketing of meat. Little information exists on their willingness and even capacity to assist farmers with direct marketing. This may be another avenue of future research to understand the barriers and limitations of designing a grass-based system.

The present study did not target direct marketers or grass-based producers but the general beef and sheep producers in Ohio, many who have the potential to become grass-based producers. There have been previous studies on grazing adoption but nothing published on the adoption of total grass-based systems or grass-fed adoption. Results of the present research have begun to fill that gap, but much more research is needed to better understand grass-based livestock systems. There are a number of limitations to the present study. The study has used Ohio as a case study and only reported producer perceptions at one point in time (2010). Similar research in other states, especially western livestock producers would be fruitful to better understand the context in which producers make conversion decisions. Producers for this survey were drawn from
Extension and state commodity groups associations and may have missed other producers not in these networks.

**Conclusion**

Ohio beef and sheep described their management system as grass-based (17.8 %), grain-based (19 %), and grass with some grain (63.2 %). Operation and marketing characteristics showed few differences between all three management groups. The grain-based group produced more head of finished cattle, direct marketed more lamb, and was younger than either the grass with grain or the grass-based group. The grass-based group produced more head of light (< 41 kg) lambs than the grain-based and grass with grain groups. Key factors influencing conversion to a grass-based management system were identified as infrastructure, knowledge, technical skills, financial costs, and a desire to change practices. Grain-based producers reported equipment, markets, and regulation as barriers to conversion to a grass-based system, while grass-based producers rated the pasture as a key factor in converting to a grass-based system. The challenge continues in building the local food supply chain and meeting consumer demand for grass-based beef and lamb products. We centered on livestock producers. Study findings have provided insight about producer perceptions regarding the transition to a new management system.
Literature Cited


Duckett, S. K., J. P. S. Neel, R. N. Sonon, Jr., J. P. Fontenot, W. M. Clapham and G. Scaglia. 2007. Effects of winter stocker growth rate and finishing system on: II.


Meeh, D.C., J.E. Rowntree, and M.W. Hamm. 2013. Multi Species Pasture System for 10 million people. Renewable Agriculture and Food Systems DOI: http://dx.doi.org/10.1017/S1742170513000070


Tables for Chapter 2.

Table 1. Best description of respondents’ livestock management system

<table>
<thead>
<tr>
<th>Best description of livestock management system</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain-based</td>
<td>64</td>
<td>18.99</td>
</tr>
<tr>
<td>Grass with some grain</td>
<td>213</td>
<td>63.20</td>
</tr>
<tr>
<td>Grass-based</td>
<td>60</td>
<td>17.80</td>
</tr>
</tbody>
</table>
Table 2. Management systems effects for measured demographic parameters.

<table>
<thead>
<tr>
<th></th>
<th>Grain Based¹</th>
<th>Grass w/Grain</th>
<th>Grass-based</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>LSM</td>
<td>SE</td>
<td>N</td>
<td>LSM</td>
</tr>
<tr>
<td>Area Owned (ha)</td>
<td>300</td>
<td>93</td>
<td>24</td>
<td>97</td>
<td>14</td>
</tr>
<tr>
<td>Area Rented (ha)</td>
<td>171</td>
<td>170</td>
<td>33</td>
<td>115</td>
<td>21</td>
</tr>
<tr>
<td>Cows (hd)</td>
<td>204</td>
<td>33</td>
<td>7</td>
<td>34</td>
<td>3</td>
</tr>
<tr>
<td>Finished Cattle (hd)</td>
<td>142</td>
<td>141a</td>
<td>20</td>
<td>19b</td>
<td>15</td>
</tr>
<tr>
<td>Beef direct marketed</td>
<td>196</td>
<td>32</td>
<td>11</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Ewes (hd)</td>
<td>101</td>
<td>50</td>
<td>37</td>
<td>65</td>
<td>16</td>
</tr>
<tr>
<td>Lambs &lt; 41 kg (hd)</td>
<td>71</td>
<td>36a</td>
<td>38</td>
<td>49a</td>
<td>15</td>
</tr>
<tr>
<td>Lambs 41-54 kg (hd)</td>
<td>62</td>
<td>22</td>
<td>25</td>
<td>54</td>
<td>12</td>
</tr>
<tr>
<td>Lambs &gt; 54 kg (hd)</td>
<td>30</td>
<td>137</td>
<td>83</td>
<td>88</td>
<td>58</td>
</tr>
<tr>
<td>Lamb direct marketed</td>
<td>110</td>
<td>88a</td>
<td>20</td>
<td>27b</td>
<td>9</td>
</tr>
<tr>
<td>Age</td>
<td>318</td>
<td>52a</td>
<td>2</td>
<td>58b</td>
<td>1</td>
</tr>
<tr>
<td>Years raising beef</td>
<td>268</td>
<td>30</td>
<td>2</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>Years raising sheep</td>
<td>153</td>
<td>26</td>
<td>4</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Net Income²</td>
<td>286</td>
<td>6.25</td>
<td>0.2</td>
<td>5.78</td>
<td>0.1</td>
</tr>
</tbody>
</table>

¹ Least Square Mean (LSM) and Standard Error (SE)
² Net Income on 8 point scale 1 = < $2,500; 2 = $2,500-$9,999; 3 = $10,000 - $19,999; 4 = $20,000 - $34,999; 5 = $35,000 - $49,999; 6 = $50,000-$74,999; 7 = $75,000 - $99,999; 8 = $100,000 +.
a Within a row, means without a common superscript differ (P < 0.05).
Table 3. Descriptive statistics and factor loading of variables important to respondent’s current farm management system. a

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Equip</th>
<th>Past</th>
<th>Res</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding equipment</td>
<td>331</td>
<td>3.69</td>
<td>1.51</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock holding facilities</td>
<td>331</td>
<td>3.96</td>
<td>1.00</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Feed storage</td>
<td>330</td>
<td>3.80</td>
<td>1.09</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure handling</td>
<td>332</td>
<td>3.41</td>
<td>1.22</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure management</td>
<td>333</td>
<td>3.28</td>
<td>2.08</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotational grazing</td>
<td>327</td>
<td>3.59</td>
<td>1.42</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance forage supply with forage demand to minimize haying livestock in normal periods of forage shortage</td>
<td>328</td>
<td>3.61</td>
<td>1.25</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use a variety of forages to complement different seasonal growth patterns</td>
<td>323</td>
<td>3.03</td>
<td>1.26</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture watering infrastructure</td>
<td>328</td>
<td>3.36</td>
<td>1.48</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fencing</td>
<td>334</td>
<td>4.35</td>
<td>0.96</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Soil types</td>
<td>329</td>
<td>3.09</td>
<td>1.25</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topography</td>
<td>326</td>
<td>3.01</td>
<td>2.13</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Competition for land</td>
<td>325</td>
<td>2.96</td>
<td>1.42</td>
<td>0.64</td>
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<td></td>
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<tr>
<td>Financing</td>
<td>328</td>
<td>2.87</td>
<td>1.44</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit margin on livestock</td>
<td>332</td>
<td>4.27</td>
<td>1.00</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Access to viable livestock</td>
<td>329</td>
<td>4.00</td>
<td>1.09</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Produce high quality products for market</td>
<td>328</td>
<td>4.44</td>
<td>0.84</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Variance Explained: 15.91 15.8 11.0 9.68

Reliability: 0.73 0.79 0.65 0.71

---

a To what extent are the following factors important to your farm management system?

b Variable scale 1-4; with 1 = not important; 2 = a little important; 3 = sometimes important; 4 = important; 5 = very important

c Principal components analysis (PCA); rotation method used Varimax with Kaiser normalization.

d Equipment, Pasture, Resource, Markets

e Reliability estimate is Cronbach’s alpha for factor group
Table 4. Descriptive statistics and factor loading of variables influence on decision to convert to a grass-based system.\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Descriptives(^b)</th>
<th>PCA Factor Loading(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>Suitability of land</td>
<td>313</td>
<td>3.19</td>
</tr>
<tr>
<td>Access to land</td>
<td>314</td>
<td>3.06</td>
</tr>
<tr>
<td>Handling facilities</td>
<td>308</td>
<td>2.66</td>
</tr>
<tr>
<td>Equipment</td>
<td>312</td>
<td>2.74</td>
</tr>
<tr>
<td>Labor availability</td>
<td>311</td>
<td>2.81</td>
</tr>
<tr>
<td>Fencing/ watering</td>
<td>317</td>
<td>3.21</td>
</tr>
<tr>
<td>infrastructure</td>
<td>317</td>
<td>3.21</td>
</tr>
<tr>
<td>Available livestock</td>
<td>305</td>
<td>1.97</td>
</tr>
<tr>
<td>types</td>
<td>311</td>
<td>2.49</td>
</tr>
<tr>
<td>Desired genetics</td>
<td>304</td>
<td>2.39</td>
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<tr>
<td>Niche marketing</td>
<td>309</td>
<td>2.61</td>
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<tr>
<td>opportunities</td>
<td>308</td>
<td>2.97</td>
</tr>
<tr>
<td>Knowledge of grass/</td>
<td>308</td>
<td>2.97</td>
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<tr>
<td>forage management</td>
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<td></td>
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<tr>
<td>Variance Explained</td>
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<td>31.21</td>
</tr>
<tr>
<td>Reliability(^e)</td>
<td></td>
<td>0.86</td>
</tr>
</tbody>
</table>

\(^a\)In your opinion, to what extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system?

\(^b\)Variable scale 1-4; with 1 = no influence; 2 = some influence; 3 = moderate influence; 4 = high influence

\(^c\)Principal components analysis (PCA); rotation method used Varimax with Kaiser normalization.

\(^d\)Infrastructure, Genetics, Management

\(^e\)Reliability estimate is Cronbach’s alpha for factor group
Table 5. Descriptive statistics and factor loading of respondent’s opinions on barriers to conversion to grass-based production and marketing.  

<table>
<thead>
<tr>
<th>Variable</th>
<th>Descriptives</th>
<th>PCA Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>I would rather take an off farm job than start a grass-fed livestock enterprise</td>
<td>328</td>
<td>2.3</td>
</tr>
<tr>
<td>I don’t want to start something new</td>
<td>329</td>
<td>2.46</td>
</tr>
<tr>
<td>I am too busy with my current farm operation to get involved doing something different</td>
<td>328</td>
<td>2.78</td>
</tr>
<tr>
<td>I am not convinced about demand for grass-based</td>
<td>330</td>
<td>3.22</td>
</tr>
<tr>
<td>I don’t have sufficient business development experience to manage the supply chain of processing storing and marketing of grass-based products</td>
<td>331</td>
<td>2.9</td>
</tr>
<tr>
<td>I am uncomfortable trying to market directly to consumers</td>
<td>328</td>
<td>2.73</td>
</tr>
<tr>
<td>I don’t know the markets for grass-based livestock</td>
<td>330</td>
<td>3.1</td>
</tr>
<tr>
<td>I believe banks are reluctant to provide financing for grass-based livestock production</td>
<td>327</td>
<td>3.01</td>
</tr>
<tr>
<td>I believe the commodity program is a safety net that grass-based livestock</td>
<td>326</td>
<td>2.91</td>
</tr>
<tr>
<td>I believe start-up costs for conversion to grass-based system are too high</td>
<td>328</td>
<td>2.52</td>
</tr>
</tbody>
</table>

Variance Explained:  
- Desire: 22.71  
- Knowledge: 19.42  
- Financial Cost: 19.07  

Reliability:  
- Desire: 0.71  
- Knowledge: 0.70  
- Financial Cost: 0.66  

<sup>a</sup>Please indicate your opinion on each of the following statements  
<sup>b</sup>Variable scale 1-5; 1 = strongly disagree; 2 = disagree; 3 = no opinion; 4 = agree; 5 = strongly agree  
<sup>c</sup>Principal components analysis (PCA); rotation method used Varimax with Kaiser normalization  
<sup>d</sup>Desire to Convert, Knowledge, Financial Cost  
<sup>e</sup>Reliability estimate is Cronbach’s alpha for factor group
Table 6. Descriptive statistics and factor loading of variables influence on a farmer’s ability to direct market animal products. \(^a\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>PCA Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding customers</td>
<td>295</td>
<td>4.23</td>
<td>0.95</td>
<td>0.73</td>
</tr>
<tr>
<td>Dealing with customers</td>
<td>296</td>
<td>4.09</td>
<td>0.99</td>
<td>0.73</td>
</tr>
<tr>
<td>Finding a meat processor to cut the way customer request requests</td>
<td>297</td>
<td>3.91</td>
<td>1.16</td>
<td>0.68</td>
</tr>
<tr>
<td>Communicating and scheduling with processor</td>
<td>295</td>
<td>3.78</td>
<td>1.10</td>
<td>0.68</td>
</tr>
<tr>
<td>Pricing</td>
<td>288</td>
<td>4.03</td>
<td>0.99</td>
<td>0.63</td>
</tr>
<tr>
<td>Educating consumers about meat preparation &amp; cooking</td>
<td>283</td>
<td>3.74</td>
<td>1.13</td>
<td>0.51</td>
</tr>
<tr>
<td>Advertising</td>
<td>284</td>
<td>3.60</td>
<td>1.11</td>
<td>0.51</td>
</tr>
<tr>
<td>Dealing with USDA requirements</td>
<td>266</td>
<td>3.70</td>
<td>1.32</td>
<td>0.87</td>
</tr>
<tr>
<td>Dealing with health department retail sales regulations</td>
<td>261</td>
<td>3.72</td>
<td>1.29</td>
<td>0.86</td>
</tr>
<tr>
<td>Dealing with Ohio Department of Agriculture regulations</td>
<td>271</td>
<td>3.51</td>
<td>1.29</td>
<td>0.84</td>
</tr>
<tr>
<td>Packaging &amp; storage</td>
<td>281</td>
<td>3.63</td>
<td>1.16</td>
<td>0.58</td>
</tr>
<tr>
<td>Long term storage of product</td>
<td>275</td>
<td>3.55</td>
<td>1.17</td>
<td>0.81</td>
</tr>
<tr>
<td>Seasonality of consumer meat demand</td>
<td>278</td>
<td>3.59</td>
<td>1.12</td>
<td>0.79</td>
</tr>
<tr>
<td>Product liability</td>
<td>271</td>
<td>3.59</td>
<td>1.22</td>
<td>0.76</td>
</tr>
<tr>
<td>Product transport</td>
<td>281</td>
<td>3.40</td>
<td>1.14</td>
<td>0.69</td>
</tr>
<tr>
<td><strong>Variance Explained</strong></td>
<td></td>
<td>21.54</td>
<td>21.5</td>
<td>21.0</td>
</tr>
<tr>
<td><strong>Reliability</strong>             (^c)</td>
<td></td>
<td>0.86</td>
<td>0.92</td>
<td>0.88</td>
</tr>
</tbody>
</table>

\(^a\)How do these factors influence a producer’s ability to direct market animal products?  
\(^b\) Variable scale 1-5; 1 = not at all; 2 = a little; 3 = moderate; 4 = strong; 5 = very strong.  
\(^c\) Principal components analysis (PCA); rotation method used Varimax with Kaiser normalization.  
\(^d\) Customers, Regulatory, Logistics  
\(^e\) Reliability estimate is Cronbach’s alpha for factor group
Table 7. Respondent’s factor scores by livestock management system.

<table>
<thead>
<tr>
<th></th>
<th>Grain Based</th>
<th>Grass w/ grain</th>
<th>Grass-based</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSM</td>
<td>SE</td>
<td>LSM</td>
<td>SE</td>
<td>LSM</td>
</tr>
<tr>
<td>Current Management*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment a</td>
<td>19.76 b</td>
<td>0.60</td>
<td>17.77 c</td>
<td>0.32</td>
<td>16.91 c</td>
</tr>
<tr>
<td>Pasture</td>
<td>13.84 b</td>
<td>0.58</td>
<td>18.77 c</td>
<td>0.30</td>
<td>19.69 c</td>
</tr>
<tr>
<td>Resource</td>
<td>12.73</td>
<td>0.53</td>
<td>11.63</td>
<td>0.29</td>
<td>11.48</td>
</tr>
<tr>
<td>Market</td>
<td>12.24 b</td>
<td>0.31</td>
<td>12.47 bc</td>
<td>0.16</td>
<td>12.91 c</td>
</tr>
<tr>
<td>Conversion to Grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>17.27</td>
<td>0.66</td>
<td>17.73</td>
<td>0.35</td>
<td>18.29</td>
</tr>
<tr>
<td>Genetics</td>
<td>6.79</td>
<td>0.37</td>
<td>6.87</td>
<td>0.20</td>
<td>6.89</td>
</tr>
<tr>
<td>Management</td>
<td>5.43</td>
<td>0.25</td>
<td>5.45</td>
<td>0.13</td>
<td>6.02</td>
</tr>
<tr>
<td>Barriers to Convert to Grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire</td>
<td>12.17 b</td>
<td>0.43</td>
<td>10.68 c</td>
<td>0.23</td>
<td>9.30 d</td>
</tr>
<tr>
<td>Knowledge</td>
<td>9.48 b</td>
<td>0.37</td>
<td>8.81 b</td>
<td>0.20</td>
<td>7.91 c</td>
</tr>
<tr>
<td>Financial costs</td>
<td>8.85 b</td>
<td>0.28</td>
<td>8.46 b</td>
<td>0.15</td>
<td>7.98 c</td>
</tr>
<tr>
<td>Direct Marketing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customers</td>
<td>28.74</td>
<td>0.73</td>
<td>27.05</td>
<td>0.42</td>
<td>27.76</td>
</tr>
<tr>
<td>Regulatory</td>
<td>16.08 b</td>
<td>0.64</td>
<td>14.26 c</td>
<td>0.37</td>
<td>13.74 c</td>
</tr>
<tr>
<td>Logistics</td>
<td>15.63 b</td>
<td>0.53</td>
<td>13.83 c</td>
<td>0.31</td>
<td>13.61 c</td>
</tr>
</tbody>
</table>

* Current Management degrees of freedom were 320, 307, 311, and 317 respectively. Conversion to Grass degrees of freedom were 287, 292, and 297 respectively. Barriers to Convert to Grass degrees of freedom were 313, 316, and 318 respectively. Direct Marketing degrees of freedom were 263, 242, and 251 respectively.

a Within a row, means without a common superscript differ (P < 0.05).
Figures for Chapter 2.

**To what extent are the following factors important to your farm management system?**

Scale used:

1. Not important
2. A little important
3. Sometimes important
4. Important
5. Very important

- a. Balance forage supply with forage demand to minimize having livestock in normal periods of forage shortage (e.g., June-October dry period)
- b. Use a variety of forages to complement different seasonal growth patterns
- c. Rotational grazing
- d. Maintain uniform plant height in pastures/paddocks
- e. Maintain livestock in excellent body condition
- f. Run a diverse livestock operation by using a variety of livestock species at different stages of production
- g. Minimize livestock impacts to riparian zones/streams
- h. Produce high-quality products to meet market demand
- i. Livestock health facilities
- j. Feed storage
- k. Feeding equipment
- l. Manure management structure
- m. Manure handling equipment
- n. Fencing
- o. Access to stream
- p. Pasture watering infrastructure
- q. Financing
- r. Soil types
- s. Topography
- t. Competition for feed
- u. Access to viable livestock markets
- v. Profit margin on livestock

Figure 2. Question on aspects important to current management.
In your opinion, to what extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system?

Scale used:


a. available livestock breeds  
b. type of current livestock  
c. desired genetics  
d. handling facilities  
e. access to land  
f. suitability of land  
g. labor availability  
h. equipment  
i. fencing/watering infrastructure  
j. knowledge of grass/forage management  
k. niche marketing opportunities

Figure 3. Question on the factors that influence a decision to convert to a grass based system.
Please indicate your opinion on each of the following statements.

Scale Used:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>I would rather take an off-farm job than start a grass-fed livestock enterprise</td>
</tr>
<tr>
<td>b.</td>
<td>I don't want to start something new</td>
</tr>
<tr>
<td>c.</td>
<td>I don't know the markets for grass-based livestock</td>
</tr>
<tr>
<td>d.</td>
<td>I am not convinced about demand for grass-based livestock</td>
</tr>
<tr>
<td>e.</td>
<td>I am uncomfortable trying to market directly to consumers</td>
</tr>
<tr>
<td>f.</td>
<td>I don't have sufficient business development experience to manage the supply chain of processing, storing, and marketing of grass-based products</td>
</tr>
<tr>
<td>g.</td>
<td>I believe startup costs for conversion to grass-based system are too high</td>
</tr>
<tr>
<td>h.</td>
<td>I am too busy with my current farm operation to get involved doing something different</td>
</tr>
<tr>
<td>i.</td>
<td>I believe the commodity program has a safety net that grass-based livestock production lacks</td>
</tr>
<tr>
<td>j.</td>
<td>I believe banks are reluctant to provide financing for grass-based livestock production</td>
</tr>
</tbody>
</table>

Figure 4. Question on the barriers to convert to a grass-based system
Figure 5. Question on the factors that influence a producer’s ability to direct market their meat products.
Chapter 3: Factors Affecting the Adoption of Grazing Systems and Grass-Fed Management by Beef and Sheep Producers in Ohio

Abstract

Grass-based livestock production is a sustainable system for raising animals to a marketable weight in many parts of the world, yet adoption of the practice is not common in the United States. In 2010, 344 Ohio beef and sheep farmers responded to a random sample mail survey to determine what influences the decision to adopt grass-based management and the adoption of the associated using a grazing system. Factors found to influence the adoption of both grass-based management, and use of a grazing system, were the respondent’s perception of the importance of pasture, their social interactions, and management of beef cows.

Key words: Grass-based, grazing, beef, lamb, farmer perceptions, adoption
Introduction

The growing movement of localized food production (Lyson 2004, 2005) has been driven by consumer interest in the origin of food with a focus on the production, processing, marketing, and consumption of locally grown products. (Conner and Oppenheim, 2008; Lyon et al., 2008; Abrams et al., 2009). For livestock, local production typically operates at a small to mid-sized scale utilizing a grass-based animal production model (Weber et al., 2008). Lusk (2011, p.573) points out “If recent history has revealed anything, it is that farmers are willing to change production practices to supply what consumers want,” as long as there are consumers who are willing to pay for these products. As a result, there has been substantive research on consumer interest in buying local, their willingness to pay, perceptions of health benefits as well as potential social and economic benefits of building out local food systems (Umberger et al., 2009).

Even with indications that consumers are willing to pay, grass-based meat marketing programs cannot find enough product to meet demand (Winrock International, 2012). Several studies have reported on the production practices and demographics of the people who already practice grass-based livestock production (Lozier et al., 2005; Weber et al., 2008; Gwin 2009; Steinberg and Comerford, 2009). None have looked at factors that have influenced the decision to adopt grass-based production practices.

The management of the grass resources (pasture) and the animals grazing it are critical to the production of meat derived from grazed animals. The management of pastures, and grazing of those pastures, goes by several names: rotational grazing, prescribed grazing or management intensive grazing. Work by several Land Grant
Universities has promoted the adoption of grazing practices to help farmers reduce the production costs associated with feed, machinery, fuel, and facilities by improving monthly pasture distribution utilization and yield (Undersander et al. 2002; McCutcheon et al. 2003; Heckman et al. 2007; Smith et al. 2011). A large proportion of the educational effort has been on the infrastructure and management changes needed to make these grazing systems work (Undersander et al. 2002; Heckman et al. 2007; Smith et al. 2011). Despite the work and benefits of adopting grazing, in Ohio only 38% of our ruminant livestock farms (USDA, 2007) use pastures. The Census estimate does not differentiate among farm types, so feedlots that background cattle and dairy farms were included in the estimate. Little information exists on the adoption of grazing management practices of beef and sheep farmers, or the perceptions and beliefs that impact the decision to adopt grazing management. Most of the work has been conducted with dairy farms (Hanson, 1995; Foltz et al. 2005). In addition, limited knowledge exists about barriers to adoption of grazing management (Kim et al 2005). Promoted benefits such as reduced machinery and facility needs have less impact when they already exist in an operation (Gillespie et al. 2007). Furthermore, land cost and pressure for alternative uses of the land may impact adoption of grazing, as Foltz and Lang (2005) postulated that in Connecticut dairy farms, land availability may limit adoption.

This research on Ohio beef and sheep livestock producers addresses this gap in knowledge by examining general livestock producers, and exploring factors thought to influence the decision to convert to grass-based production, and using a grazing system.
Specifically we ask what are the key factors that influence the adoption of a grass-based production system? Tied closely with that what are the factors that influence the adoption of a grazing system? We propose that the operation characteristics, infrastructure needed for grass-based management, desire to convert to grass-based systems, personal skill sets and resources, assessment of costs and benefits, income, and social interactions are key underlying dimensions that influence the producer’s choice of a production system.

Beef and sheep production practices share several similarities and were combined in the survey, because of these similarities. The cow-calf and ewe-lamb farm rely on pasture with the terminal offspring predominately being finished on grain-based diets (NRC-NAS 2008). Both require similar infrastructure, and skills, to manage and because of slight differences in grazing preferences both can be effectively managed on the same pastureland (NRC-NAS 2008).

The terms grass-fed, grass, forage, and pasture have been used interchangeably in the literature. According to the USDA Agriculture Marketing Service the official marketing standard for the ‘grass-fed’ label states “The diet shall be derived solely from forage consisting of grass (annual and perennial), forbs (e.g., legumes, Brassica), browse, or cereal grain crops in the vegetative (pre-grain) state.” (Federal Register 2007, p. 58637). For discussion the term grass-based will be used to describe the livestock management system relying solely on grazing to harvest annual and perennial grasses, legumes, forbs, browse, and feeding stored forages where appropriate.
Methods

A farmer survey was conducted in spring 2010 to assess Ohio beef and sheep farmers’ current management practices and factors that might influence a decision to transition to a grass-based system and engage in direct marketing. Details were described in McCutcheon et al. (2014) but briefly the survey instrument, developed by the authors, pilot tested with 18 farmers, and revised, consisted of 35 questions. The survey design and instrument were reviewed and approved by OSU’s Office of Responsible Research Practices (Reference # 2010E0118).

Beef and sheep mailing lists were requested from 88 county Ohio State University Extension offices and statewide farmer associations, the Ohio Cattleman’s Association and the Ohio Sheep Improvement Association were solicited for their mailing list. The survey was mailed to a total of 944 mail questionnaires. The Dillman (2000) three contact method was used to conduct the survey.

Twenty-three surveys were returned as undeliverable leaving 921 mailed surveys. Returned surveys were 418 or 45% of the mailed surveys. Of those returned, 74 were blank with indications the respondents were no longer producing either beef or lamb and did not feel capable of completing the survey.

Respondents were asked to indicate which best described their livestock management. The choices included: confinement animal feeding, pasture based with some grain, totally forage based with no harvested forages, and totally forage based with harvested forages. The two total forage systems were combined in our analysis as one
grass-based group. One question asked if they used a grazing based system to manage their livestock.

Three questions were used to create factors associated with the operation characteristics, infrastructure, desire to convert to grass-based systems, and personal skill sets and resources. The first referred to the respondent’s current management. “To what extent are the following factors important to your farm management system?” A 1-5 Likert scale of not important to very important was used. From that, four factors were created using principle component analysis (PCA) (McCutcheon et al. 2014). EQUIPMENT was a factor created from answers about feeding equipment, livestock holding facilities, feed storage, manure handling equipment and manure management. PASTURE was a factor created from answers about rotational grazing, balance forage supply with forage demand, use a variety of forage, watering infrastructure, and fencing. MARKET was a factor created from answers about profit margin on livestock, access to viable livestock markets, and produce high quality products for the market. RESOURCE was the last factor created from answers about soil types, topography, competition for land, and financing.

The second question used asked their opinions on the “extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system?” A 1-4 Likert scale from no influence to high influence was used for this question. Three factors were created from the PCA of this question. INFRASTRUCTURE was the factor created from answers about suitability of land, access to land, handling facilities, equipment, labor availability and fencing/water
infrastructure. GENETICS was the factor created from answers about available livestock breeds, type of current livestock and desired genetics. MANAGEMENT was the last factor created from this question and included answers about niche marketing opportunities and knowledge of grass/forage management.

The final question used in this analysis was their opinions on reasons not to convert to a grass-based system. A 1-5 Likert scale from strongly disagree to strongly agree was used for this question. Three factors were created from the PCA. DESIRE was the factor created from answers related to statements: rather take an off farm job, don’t want to start something new, too busy, not convinced about the demand. KNOWLEDGE was the factor created from answers related to statements: no experience to manage the supply chain, uncomfortable marketing to consumers, and don’t know the markets. Finally, FINANCIAL COST was the factor created from answers related to statements: believe banks are reluctant to provide financing, safety net lacking, and start-up costs for conversion too high.

To determine social interactions respondents were asked the percentage of their neighbors that were using a grass-based operation, the 7 categorical responses ranged from none to 76-100%. The categories were unequal due to the fact that reported rates of adoption of grass-based production were not high. The respondents were also asked what organizations they belonged to by checking beside the listed group.

Producer demographic information including, age, number of beef cows managed, number of feeder calves sold, number of finished beef sold, number of ewes managed, number of market lambs sold at less than 90 lbs. or from 90 to 120 lbs., number
of acres owned, and income are reported in McCutcheon et al. (2014). For the present analysis, dummy binary variables were created for all variables except age. Logistic regression procedures were used to analyze the underlying factors that influence a decision to use grass-based management or a grazing system. Odds ratio (Exp B) statistics are reported as the number expressing the characteristic divided by the number not expressing the characteristic. The odds ratio is basically the odds of the outcome in one group divided by the odds of the outcome in the other group (Grimes and Schulz 2008). The analysis was performed using SPSS software (SPSS Inc., Chicago, Illinois, USA).

**Results and Discussion**

The descriptive statistics of the variables are listed in Table 8. The means of the binary variables are the proportion of respondents indicating that particular attribute. For example, 38% of the respondents identified their operation as grass-based, while 73% of respondent’s self-reported using a grazing system to manage their livestock.

**Factors with a Positive Influence on Grass-Based**

The results of the logistic regression for grass-based management are presented in Table 9. This model was significant ($P = 0.001$) and had goodness of fit tests within ranges of other published literature (Young and Shumway 1991; Johnson et al. 2010; Pruitt et al. 2012). Several factors had a significant ($P = 0.05$) positive influence on the grass-based group. The current management factor PASTURE showed that for each unit increase in that factor score respondents had an 19% greater odd of being grass-based ($P = 0.02$). The significance of the influence was expected since the factor was associated
with the management of forage resources. The current management factor MARKET showed a trend ($P < 0.1$) toward positive influence with each increase in factor score corresponding with a 27.6% increase in the odds of being grass-based ($P = 0.063$). This association was also expected since grass-based production tends to be marketed through direct to consumer channels (Lozier et al. 2005; Weber et al. 2008; Gwin 2009; Steinberg and Comerford 2009). Respondents belonging to a recreation group had 5.9 times greater odds of being grass-based than those that did not belong to similar organizations ($P = 0.015$). Conner and Oppenheim (2008) found consumers placed great importance on product attributes associated with grass-based production. Weber et al. (2008) in their analysis of mobilizing codes, or cultural principles/definitions that organize a movement’s collective meaning system to describe social movements, found the grass-fed movement evolved through “alliances that brought together previously unconnected stakeholders” ($P = 535$). If recreation groups place the respondents in social context with consumers then this influence would make sense.

Most of the research on grass-based production has focused on beef producers (Lozier et al. 2005; Weber et al. 2008; Steinberg and Comerford 2009). It was not surprising that each category of beef cows managed had a positive relationship. Since grass-based production is usually associated with small to medium scale farms it was also not surprising that the smallest category of cow management had the greatest influence. Managing beef cows showed a positive influence with respondents managing 12 or fewer head had 13.85 times greater odds of being grass-based than those who did not ($P = 0.002$). Respondents that managed 13 to 20 head of beef cows had 7.3 times greater odds
of being grass-based than those that did not \((P = 0.018)\). While respondents that managed 21-40 head of beef cows had 7.59 times greater odds of being grass-based than those who did not \((P = 0.034)\). Respondents that managed more than 40 head of beef cows had 8.5 times greater odds of being grass-based than those that did not \((P = 0.031)\). Those that reported <$10,000 annual income had 30 times greater odds of being grass-based than those that did not \((P = 0.021)\).

**Factors with a Negative Influence on Grass-Based**

For each increase in the EQUIPMENT factor meant the respondent had a 14% lesser odd of being grass-based \((P = 0.004)\). Since this factor was associated with importance of non-grazing specific equipment this makes sense. Belonging to the Ohio Cattlemen’s Association meant a 58% lesser odd of being grass-based \((P = 0.108)\), while belonging to a service or fraternal organization showed a trend of a 74 % lesser odd of being grass-based \((P = 0.086)\). Grass-based production methods have generally been discouraged in the livestock industry. Packers have discounted products from grass-fed cattle, and indicated that the fat is more yellow and that the lean color was darker \((\text{Baublits et.al., 2004})\). The Ohio Cattlemen’s Association membership is made up of active members in the industry and the negative influence on grass-based production therefore follows an expectation.. Although not completely known, the service organization may be comprised of people with similar values in the local community and this may influence the traditional production practices. Winsten et al. (2010) in a survey of dairy farmers found that skepticism of other farmers was a factor in adoption of management intensive grazing when the respondent was a conventional dairy farmer.
Finally, respondents who indicated they sold finished lamb at 41 kg or greater had a 89% lesser odd of being grass-based than those who did not sell lambs at that weight ($P = 0.02$). McCutcheon et al. (2014) reported that this might show the production challenges associated with producing heavier lambs using grass-based production.

**Factors with a Positive Influence on Grazing System**

The decision to adopt a grazing system for livestock management could be completely independent from the decision to adopt a total grass-based management system. When the same explanatory variables used in the grass-based logistic regression are applied to the independent variable of grazing system adoption different patterns emerge. Results of the logistic regression for grazing system management are presented in Table 10. This model was also significant ($P < 0.001$) and had goodness of fit tests stronger than the grass-based logistic regression, which indicated it explained the grazing system decision better than the grass-based decision. Several factors had a positive influence on the grazing system with indications of similar outcomes to the grass-based group. The current management factor PASTURE showed that for each unit increase in that factor score respondents had an 36.7% greater odd of using a grazing system ($P < 0.001$). Similar to the grass-based model, the respondents that managed between 13 to 20 head of beef cows had 13.41 times greater odds of using a grazing system than those that did not ($P = 0.004$). Respondents that managed 21-40 head of beef cows had 8.95 times greater odds of using a grazing system than those who did not ($P = 0.024$). Respondents that managed more than 40 head of beef cows had 15.47 times greater odds of using a grazing system than those that did not ($P = 0.011$). Of note, the smallest beef cow
management category was not significant and the second and fourth categories had the stronger relationship with grazing system. Coinciding with cow management findings, respondents who indicated they sold beef feeders had a trend of 2.92 times greater odd of using a grazing system than those who did not sell beef feeders \((P = 0.101)\). One category of ewe management was significant with respondents who own 13 head or less of sheep having 15.54 times greater odds of using a grazing system \((P = 0.042)\). This indicated that the adoption of grazing systems was greater with smaller flocks.

**Factors with a Negative Influence on Grazing System**

The current management factor RESOURCE showed that for each unit increase in that factor score respondents had an 14.4% lesser odd of using a grazing system \((P = 0.047)\). Since the factor Resource was associated with land this reinforced Foltz and Lang (2005) who proposed that competition for suitable land was a factor in the adoption of grazing. For each unit increase in the DESIRE factor respondents had a 12% lesser odd of using a grazing system \((P = 0.017)\). Desire was associated with motivations and this may indicate that there has not been suitable promotion of the practice for all respondents to adopt. Greiner et al. (2009) found motivation to be highly correlated with the adoption of best management practices (BMP) associated with conservation practices. The only social interaction variable significantly associated with the adoption of a grazing system was belonging to a farmers cooperative, a 75% lesser odd of using a grazing system \((P = 0.022)\). Since farmer’s cooperatives are either associated with product marketing and input buying there may be no incentive for them to promote grazing systems.
Factors Not Significantly Associated with Either Grass-Based or Grazing System Adoption

It is interesting to note the factors not significantly \( (P > 0.05) \) associated with either grass-based production or using a grazing system. The conversion to grass-based production factors (Infrastructure, Genetics, and Management) and the barriers to convert to grass-based production factors (Knowledge and Financial Cost) were not significant in the statistical model. In contrast, Gillespie et al. (2007), in a survey of Louisiana beef producers, found knowledge about a practice and if the farmer thought it was applicable to their current operation were both factors in the adoption of BMP’s. One highly adopted BMP in their study was rotational grazing. Conversely, Winsten et al. (2010) found the lack of on-farm technical assistance was not a barrier to adoption of management intensive grazing for dairy farmers.

Along the lines of social interactions, having neighbors practicing grass-based production was not a significant factor in the adoption of the grass-based system. With the average response of < 5% of their neighbors practicing grass-based production, it may be associated with the low level of grass-based production. Non-significant results for organization memberships such as watershed group may indicate this is not solely an environmental issue. Church and civic or political groups were also not significant in their associations with either the adoption of grass-based production or use of a grazing system. All three groups may have membership broader than just farmers, but their respective purposes or structures may not allow for discussion on production practices.
Membership in the Ohio Sheep Improvement Association, management of greater than 14 ewes, and selling lighter lambs (42 kg.) were not significantly associated with adoption of either system. This may suggest that grass-based production has focused on beef. Sheep production utilizing grazing has an additional challenge of parasite management, which may have influenced this finding.

Acreage, age, and income were not significant in this analysis, and previous reports have shown mixed results in their influence on the adoption of practices (Prokopy et al., 2008). In some studies they were positively significant, others they were negatively significant and in the majority of studies each of the factors were not significant contributors.

The limitations of this study include the fact that only Ohio beef and sheep producers were surveyed and the survey was conducted in one production year, 2010. Conducting similar research in other states would help identify and understand what influences producer conversion decisions. Respondents to the present survey were drawn from Extension and state commodity group association contacts, which may have influenced access to some segments; however, data generated support variability from which to make statements and draw conclusions relative to the sample.

**Conclusion**

Grass-based production and utilizing a grazing system can help producers to be environmentally, socially, and economically sustainable. However, reported rates of adoption for either production practice were not large. The present study identified several factors that influence a decision to adopt grass-based production and the adoption
of a grazing system. The factors include not only production aspects, but also respondent value placed on current resources, desire and social interactions. Factors such as how respondent’s rate the importance of pasture to their farm operation, belonging to a recreation group, all levels of the number of cows managed but predominantly <12 head, and net farm income of < $10,000 had a strong association with the adoption of grass-based management. Conversely producing heavy lambs (54 kg.) and the rating of the importance of equipment to the farm operation had negative associations with the adoption of grass-based management. The factors associated with the adoption of a grazing system included not only the respondent’s rating of the importance of pasture to the farm operation but also managing < 13 head of ewes and managing 13 head or more beef cows. Negative associations with grazing system adoption included the respondent’s rating of the importance of resources to their farm operation, their desire to convert to a grass-based system, and their membership in a farmer cooperative. One of the most important contributions of results from the present research is that adoption of grass-based or grazing systems by ruminant livestock producers in Ohio are not general and just an economic decision.

**Literature Cited**


Tables for Chapter 3.

Table 8. Summary of variables used in binary logistic regression models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass-based</td>
<td>Operation type. (1 = total forage based, 0 = total confinement or pasture with grain)</td>
<td>0.18</td>
</tr>
<tr>
<td>Grazing System</td>
<td>Producer uses a grazing based system to manage livestock. (1 = yes, 0 = no)</td>
<td>0.73</td>
</tr>
<tr>
<td>Explanatory Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Management</td>
<td>To what extent are the following factors important to your farm management system? (1-5 Likert scale of not important to very important)</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>Factor created from answers about feeding equipment, livestock holding facilities, feed storage, manure handling equipment and manure management</td>
<td>4.75</td>
</tr>
<tr>
<td>PASTURE</td>
<td>Factor created from answers about rotational grazing, balance forage supply with forage demand, use a variety of forage, watering infrastructure, and fencing.</td>
<td>5.15</td>
</tr>
<tr>
<td>MARKET</td>
<td>Factor created from answers about profit margin on livestock, access to viable livestock markets, and produce high quality products for the market.</td>
<td>2.45</td>
</tr>
<tr>
<td>RESOURCE</td>
<td>Factor created from answers about soil types, topography, competition for land, and financing</td>
<td>4.15</td>
</tr>
<tr>
<td>Conversion to Grass</td>
<td>In your opinion, to what extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system? (1-4 Likert scale from no influence to high influence)</td>
<td></td>
</tr>
<tr>
<td>INFRASTRUCTURE</td>
<td>Factor created from answers about suitability of land, access to land, handling facilities, equipment, labor availability and fencing/water infrastructure.</td>
<td>5.39</td>
</tr>
<tr>
<td>GENETICS</td>
<td>Factor created from answers about available livestock breeds, type of current livestock and desired genetics.</td>
<td>2.70</td>
</tr>
<tr>
<td>MANAGEMENT</td>
<td>Factor created from answers about niche marketing opportunities and knowledge of grass/forage management.</td>
<td>1.85</td>
</tr>
<tr>
<td>Barriers to Convert to Grass</td>
<td>Please indicate your opinion on each of the following reasons for not converting to a grass-based system. (1-5 Likert scale from strongly disagree to strongly agree)</td>
<td></td>
</tr>
<tr>
<td>DESIRE</td>
<td>Factor created from answers about rather take an off farm job, don’t want to start something new, too busy, not convinced about the demand.</td>
<td>3.50</td>
</tr>
<tr>
<td>KNOWLEDGE</td>
<td>Factor created from answers about no experience to manage the supply chain, uncomfortable marketing to consumers, and don’t know the markets.</td>
<td>2.85</td>
</tr>
<tr>
<td>FINANCIAL COST</td>
<td>Factor created from answers about believe banks are reluctant to provide financing, safety net lacking, and start-up costs for conversion too high.</td>
<td>2.20</td>
</tr>
<tr>
<td>Social influence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighbors Grass Finishing</td>
<td>Portion of neighbors finishing animals on grass (1 = none, 2 = &lt;5%, 3 = 5-10%, 4 = 11-25%, 5 = 26-50%, 6 = 51-75%, 7 = 76-100%)</td>
<td>1.64</td>
</tr>
<tr>
<td>Organization Membership</td>
<td>Indicate the following organizations you belong to.</td>
<td></td>
</tr>
<tr>
<td>Ohio Farm Bureau</td>
<td>State general agriculture organization (1 = yes, 0 = no)</td>
<td>0.66</td>
</tr>
</tbody>
</table>
Table 8. continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization Membership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Continued</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio Cattleman’s Association</td>
<td>State beef commodity organization (1 = yes, 0 = no)</td>
<td>0.46</td>
</tr>
<tr>
<td>Ohio Sheep Improvement Association</td>
<td>State sheep commodity organization (1 = yes, 0 = no)</td>
<td>0.13</td>
</tr>
<tr>
<td>Watershed group</td>
<td>Local watershed organization (1 = yes, 0 = no)</td>
<td>0.07</td>
</tr>
<tr>
<td>Service/Fraternal Organization</td>
<td>Local service/fraternal organization ie. Lions, Kiwanis, etc. (1 = yes, 0 = no)</td>
<td>0.12</td>
</tr>
<tr>
<td>Recreation Group</td>
<td>Local recreational group ie. bowling league, gardening club, card club, softball league, etc. (1 = yes, 0 = no)</td>
<td>0.09</td>
</tr>
<tr>
<td>Farmer Cooperative</td>
<td>Local Farmer cooperative (1 = yes, 0 = no)</td>
<td>0.26</td>
</tr>
<tr>
<td>Church Related</td>
<td>Local church groups (1 = yes, 0 = no)</td>
<td>0.48</td>
</tr>
<tr>
<td>Political/Civic Groups</td>
<td>Local Parent Teacher Associations, historical societies, development groups, library, etc. (1 = yes, 0 = no)</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Farm Structure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ewes &lt; 13 head</td>
<td>Number of ewes managed. (1 = &lt; 13 head, 0 = otherwise)</td>
<td>0.08</td>
</tr>
<tr>
<td>Ewes 14-25 head</td>
<td>Number of ewes managed. (1 = 14-25 head, 0 = otherwise)</td>
<td>0.08</td>
</tr>
<tr>
<td>Ewes 26-60 head</td>
<td>Number of ewes managed. (1 = 26-60 head, 0 = otherwise)</td>
<td>0.08</td>
</tr>
<tr>
<td>Ewes &gt; 60 head</td>
<td>Number of ewes managed. (1 = &gt; 60 head, 0 = otherwise)</td>
<td>0.07</td>
</tr>
<tr>
<td>Finished Lamb 41 kg.</td>
<td>Sell market lambs &lt; 41 kg. (1 = yes, 0 = otherwise)</td>
<td>0.21</td>
</tr>
<tr>
<td>Finished Lamb 54 kg.</td>
<td>Sell market lambs 41 – 54 kg. (1 = yes, 0 = otherwise)</td>
<td>0.18</td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows &lt; 12 head</td>
<td>Number of beef cows managed. (1 = &lt; 12 head, 0 = otherwise)</td>
<td>0.18</td>
</tr>
<tr>
<td>Cows 13-20 head</td>
<td>Number of beef cows managed. (1 = 13-20 head, 0 = otherwise)</td>
<td>0.14</td>
</tr>
<tr>
<td>Cows 21-40 head</td>
<td>Number of beef cows managed. (1 = 21-40 head, 0 = otherwise)</td>
<td>0.15</td>
</tr>
<tr>
<td>Cows &gt; 40 head</td>
<td>Number of beef cows managed. (1 = &gt; 40 head, 0 = otherwise)</td>
<td>0.13</td>
</tr>
<tr>
<td>Beef Feeder</td>
<td>Sell beef feeder calves. (1 = yes, 0 = otherwise)</td>
<td>0.51</td>
</tr>
<tr>
<td>Finished Beef</td>
<td>Sell finished beef. (1 = yes, 0 = otherwise)</td>
<td>0.43</td>
</tr>
<tr>
<td>Acreage owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acres &lt; 61 acres</td>
<td>Number of acres owned. (1 = &lt; 61 acres, 0 = otherwise)</td>
<td>0.22</td>
</tr>
<tr>
<td>Acres 61-135 acres</td>
<td>Number of acres owned. (1 = 61-135 acres, 0 = otherwise)</td>
<td>0.22</td>
</tr>
<tr>
<td>Acres 136-250 acres</td>
<td>Number of acres owned. (1 = 136-250 acres, 0 = otherwise)</td>
<td>0.23</td>
</tr>
<tr>
<td>Acres &gt; 250 acres</td>
<td>Number of acres owned. (1 = &gt; 250 acres, 0 = otherwise)</td>
<td>0.21</td>
</tr>
<tr>
<td>Age</td>
<td>Respondent’s age.</td>
<td>56.71</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income &lt; $10,000</td>
<td>Net income (1 = &lt; $10,000, 0 = otherwise)</td>
<td>0.02</td>
</tr>
<tr>
<td>Income $10,000-34,999</td>
<td>Net income (1 = $10,000-$34,999, 0 = otherwise)</td>
<td>0.16</td>
</tr>
<tr>
<td>Income $35,000-74,999</td>
<td>Net income (1 = $35,000-74,999, 0 = otherwise)</td>
<td>0.34</td>
</tr>
<tr>
<td>Income &gt; $75,000</td>
<td>Net income (1 = &gt; $75,000, 0 = otherwise)</td>
<td>0.33</td>
</tr>
</tbody>
</table>
Table 9. Parameter estimates of the binary logistic regression model for factors influencing the adoption of grass-based management in Ohio.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>S.E.</th>
<th>Wald</th>
<th>$P$</th>
<th>Exp($B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>-0.155</td>
<td>0.054</td>
<td>8.136</td>
<td>0.004</td>
<td>0.856</td>
</tr>
<tr>
<td>PASTURE</td>
<td>0.171</td>
<td>0.073</td>
<td>5.452</td>
<td>0.02</td>
<td>1.186</td>
</tr>
<tr>
<td>MARKET</td>
<td>0.243</td>
<td>0.131</td>
<td>3.449</td>
<td>0.063</td>
<td>1.276</td>
</tr>
<tr>
<td>RESOURCE</td>
<td>-0.086</td>
<td>0.07</td>
<td>1.519</td>
<td>0.218</td>
<td>0.918</td>
</tr>
<tr>
<td><strong>Conversion to Grass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INFRASTRUCTURE</td>
<td>-0.006</td>
<td>0.051</td>
<td>0.015</td>
<td>0.903</td>
<td>0.994</td>
</tr>
<tr>
<td>GENETICS</td>
<td>-0.091</td>
<td>0.099</td>
<td>0.855</td>
<td>0.355</td>
<td>0.913</td>
</tr>
<tr>
<td>MANAGEMENT</td>
<td>0.059</td>
<td>0.151</td>
<td>0.156</td>
<td>0.693</td>
<td>1.061</td>
</tr>
<tr>
<td><strong>Barriers to Convert to Grass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESIRE</td>
<td>-0.021</td>
<td>0.096</td>
<td>0.049</td>
<td>0.824</td>
<td>0.979</td>
</tr>
<tr>
<td>KNOWLEDGE</td>
<td>-0.067</td>
<td>0.099</td>
<td>0.466</td>
<td>0.495</td>
<td>0.935</td>
</tr>
<tr>
<td>FINANCIAL COST</td>
<td>-0.002</td>
<td>0.126</td>
<td>0</td>
<td>0.989</td>
<td>0.998</td>
</tr>
<tr>
<td>Neighbors Grass Finishing</td>
<td>-0.048</td>
<td>0.212</td>
<td>0.051</td>
<td>0.822</td>
<td>0.953</td>
</tr>
<tr>
<td><strong>Organization Membership</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio Farm Bureau</td>
<td>0.183</td>
<td>0.524</td>
<td>0.122</td>
<td>0.727</td>
<td>1.201</td>
</tr>
<tr>
<td>Ohio Cattlemen's Association</td>
<td>-0.866</td>
<td>0.538</td>
<td>2.588</td>
<td>0.108</td>
<td>0.421</td>
</tr>
<tr>
<td>Ohio Sheep Improvement Association</td>
<td>-0.096</td>
<td>0.908</td>
<td>0.011</td>
<td>0.916</td>
<td>0.909</td>
</tr>
<tr>
<td>Watershed group</td>
<td>0.787</td>
<td>0.91</td>
<td>0.748</td>
<td>0.387</td>
<td>2.198</td>
</tr>
<tr>
<td>Service/Fraternity Organization</td>
<td>-1.34</td>
<td>0.782</td>
<td>2.94</td>
<td>0.086</td>
<td>0.262</td>
</tr>
<tr>
<td>Recreation Group</td>
<td>1.782</td>
<td>0.736</td>
<td>5.866</td>
<td>0.015</td>
<td>5.943</td>
</tr>
<tr>
<td>Farmer Cooperative</td>
<td>-0.515</td>
<td>0.605</td>
<td>0.723</td>
<td>0.395</td>
<td>0.498</td>
</tr>
<tr>
<td>Church Related</td>
<td>0.088</td>
<td>0.463</td>
<td>0.036</td>
<td>0.85</td>
<td>1.092</td>
</tr>
<tr>
<td>Political/Civic Groups</td>
<td>0.504</td>
<td>0.649</td>
<td>0.602</td>
<td>0.288</td>
<td>1.655</td>
</tr>
<tr>
<td><strong>Sheep</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ewes &lt; 13 head</td>
<td>0.165</td>
<td>1.25</td>
<td>0.017</td>
<td>0.895</td>
<td>1.179</td>
</tr>
<tr>
<td>Ewes 14-25 head</td>
<td>-0.86</td>
<td>1.309</td>
<td>0.431</td>
<td>0.511</td>
<td>0.423</td>
</tr>
<tr>
<td>Ewes 26-60 head</td>
<td>0.698</td>
<td>1.311</td>
<td>0.283</td>
<td>0.595</td>
<td>2.009</td>
</tr>
<tr>
<td>Ewes &gt; 60 head</td>
<td>0.258</td>
<td>1.362</td>
<td>0.036</td>
<td>0.85</td>
<td>1.295</td>
</tr>
<tr>
<td>Finished Lamb 41 kg.</td>
<td>-0.07</td>
<td>1.011</td>
<td>0.74</td>
<td>0.39</td>
<td>0.419</td>
</tr>
<tr>
<td>Finished Lamb 54 kg.</td>
<td>-2.219</td>
<td>0.954</td>
<td>5.409</td>
<td>0.02</td>
<td>0.109</td>
</tr>
<tr>
<td><strong>Beef</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows &lt; 12 head</td>
<td>2.628</td>
<td>0.844</td>
<td>9.696</td>
<td>0.002</td>
<td>13.852</td>
</tr>
<tr>
<td>Cows 13-20 head</td>
<td>1.989</td>
<td>0.842</td>
<td>5.582</td>
<td>0.018</td>
<td>7.308</td>
</tr>
<tr>
<td>Cows 21-40 head</td>
<td>2.028</td>
<td>0.954</td>
<td>4.52</td>
<td>0.034</td>
<td>7.597</td>
</tr>
<tr>
<td>Cows &gt; 40 head</td>
<td>2.14</td>
<td>0.994</td>
<td>4.632</td>
<td>0.031</td>
<td>8.5</td>
</tr>
<tr>
<td>Beef Feeder</td>
<td>-0.485</td>
<td>0.56</td>
<td>0.751</td>
<td>0.386</td>
<td>0.616</td>
</tr>
<tr>
<td>Finished Beef</td>
<td>-0.646</td>
<td>0.473</td>
<td>1.869</td>
<td>0.172</td>
<td>0.524</td>
</tr>
<tr>
<td><strong>Acreage owned</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acres &lt; 61 acres</td>
<td>-0.819</td>
<td>1.118</td>
<td>0.537</td>
<td>0.464</td>
<td>0.441</td>
</tr>
<tr>
<td>Acres 61-135 acres</td>
<td>-1.148</td>
<td>1.079</td>
<td>1.131</td>
<td>0.288</td>
<td>0.317</td>
</tr>
<tr>
<td>Acres 136-250 acres</td>
<td>0.101</td>
<td>1.076</td>
<td>0.009</td>
<td>0.925</td>
<td>1.106</td>
</tr>
<tr>
<td>Acres &gt; 250 acres</td>
<td>-1.096</td>
<td>1.125</td>
<td>0.95</td>
<td>0.33</td>
<td>0.334</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income &lt; $10,000</td>
<td>3.402</td>
<td>1.477</td>
<td>5.306</td>
<td>0.021</td>
<td>30.01</td>
</tr>
<tr>
<td>Income $10,000-34,999</td>
<td>0.63</td>
<td>0.96</td>
<td>0.43</td>
<td>0.512</td>
<td>1.877</td>
</tr>
<tr>
<td>Income $35,000–74,999</td>
<td>0.182</td>
<td>0.837</td>
<td>0.047</td>
<td>0.828</td>
<td>1.199</td>
</tr>
<tr>
<td>Income &gt; $75,000</td>
<td>0.166</td>
<td>0.855</td>
<td>0.038</td>
<td>0.846</td>
<td>1.181</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>-4.019</td>
<td>2.834</td>
<td>2.012</td>
<td>0.156</td>
<td>0.018</td>
</tr>
</tbody>
</table>

1 Model $\chi^2 (41, N=272) = 73.182 \ p = 0.001$. Cox & Snell $R^2 = 0.236$, Nagelkerke $R^2 = 0.395$. Hosmer and Lemeshow Test $\chi^2 (8, N=272) = 9.048 \ p = 0.338$. 

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Table 10. Parameter estimates of the binary logistic regression model for factors influencing the adoption of grazing systems in Ohio.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
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<tbody>
<tr>
<td>Current Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>-0.056</td>
<td>0.067</td>
<td>0.702</td>
<td>0.402</td>
<td>0.945</td>
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<tr>
<td>PASTURE</td>
<td>0.313</td>
<td>0.067</td>
<td>21.556</td>
<td>&lt;0.001</td>
<td>1.367</td>
</tr>
<tr>
<td>MARKET</td>
<td>0.021</td>
<td>0.105</td>
<td>0.04</td>
<td>0.841</td>
<td>1.021</td>
</tr>
<tr>
<td>RESOURCE</td>
<td>-0.143</td>
<td>0.072</td>
<td>3.954</td>
<td>0.047</td>
<td>0.866</td>
</tr>
<tr>
<td>Conversion to Grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INFRASTRUCTURE</td>
<td>0.013</td>
<td>0.055</td>
<td>0.056</td>
<td>0.812</td>
<td>1.013</td>
</tr>
<tr>
<td>GENETICS</td>
<td>0.037</td>
<td>0.103</td>
<td>0.131</td>
<td>0.718</td>
<td>1.038</td>
</tr>
<tr>
<td>MANAGEMENT</td>
<td>0.049</td>
<td>0.146</td>
<td>0.113</td>
<td>0.737</td>
<td>1.05</td>
</tr>
<tr>
<td>Barriers to Convert to Grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESIRE</td>
<td>-0.253</td>
<td>0.106</td>
<td>5.737</td>
<td>0.017</td>
<td>0.776</td>
</tr>
<tr>
<td>KNOWLEDGE</td>
<td>0.095</td>
<td>0.116</td>
<td>0.673</td>
<td>0.412</td>
<td>1.1</td>
</tr>
<tr>
<td>FINANCIAL COST</td>
<td>-0.237</td>
<td>0.149</td>
<td>2.531</td>
<td>0.112</td>
<td>0.789</td>
</tr>
<tr>
<td>Neighbors Grass Finishing</td>
<td>0.08</td>
<td>0.201</td>
<td>0.16</td>
<td>0.689</td>
<td>1.084</td>
</tr>
<tr>
<td>Organization Membership</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio Farm Bureau</td>
<td>0.328</td>
<td>0.543</td>
<td>0.366</td>
<td>0.545</td>
<td>1.389</td>
</tr>
<tr>
<td>Ohio Cattlemen's Association</td>
<td>-0.694</td>
<td>0.566</td>
<td>1.504</td>
<td>0.22</td>
<td>0.5</td>
</tr>
<tr>
<td>Ohio Sheep Improvement Association</td>
<td>-0.744</td>
<td>0.827</td>
<td>0.81</td>
<td>0.368</td>
<td>0.475</td>
</tr>
<tr>
<td>Watershed group</td>
<td>-1.086</td>
<td>1.054</td>
<td>1.062</td>
<td>0.303</td>
<td>0.338</td>
</tr>
<tr>
<td>Service/Fraternal Organization</td>
<td>0.549</td>
<td>0.813</td>
<td>0.456</td>
<td>0.499</td>
<td>1.732</td>
</tr>
<tr>
<td>Recreation Group</td>
<td>0.878</td>
<td>0.959</td>
<td>0.839</td>
<td>0.36</td>
<td>2.407</td>
</tr>
<tr>
<td>Farmer Cooperative</td>
<td>-1.391</td>
<td>0.608</td>
<td>5.23</td>
<td>0.022</td>
<td>0.249</td>
</tr>
<tr>
<td>Church Related</td>
<td>0.129</td>
<td>0.488</td>
<td>0.16</td>
<td>0.689</td>
<td>1.138</td>
</tr>
<tr>
<td>Political/Civic Groups</td>
<td>0.242</td>
<td>0.827</td>
<td>0.086</td>
<td>0.769</td>
<td>1.274</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ewes &lt; 13 head</td>
<td>2.743</td>
<td>1.351</td>
<td>4.123</td>
<td>0.042</td>
<td>15.538</td>
</tr>
<tr>
<td>Ewes 14-25 head</td>
<td>0.882</td>
<td>1.055</td>
<td>0.699</td>
<td>0.403</td>
<td>2.416</td>
</tr>
<tr>
<td>Ewes 26-60 head</td>
<td>2.073</td>
<td>1.3</td>
<td>2.544</td>
<td>0.111</td>
<td>7.95</td>
</tr>
<tr>
<td>Ewes &gt; 60 head</td>
<td>1.921</td>
<td>1.302</td>
<td>2.177</td>
<td>0.14</td>
<td>6.828</td>
</tr>
<tr>
<td>Finished Lamb 41 kg.</td>
<td>-1.35</td>
<td>0.88</td>
<td>2.35</td>
<td>0.125</td>
<td>0.259</td>
</tr>
<tr>
<td>Finished Lamb 54 kg.</td>
<td>-0.725</td>
<td>0.745</td>
<td>0.947</td>
<td>0.33</td>
<td>0.485</td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows &lt; 12 head</td>
<td>1.295</td>
<td>0.859</td>
<td>2.269</td>
<td>0.132</td>
<td>3.65</td>
</tr>
<tr>
<td>Cows 13-20 head</td>
<td>2.597</td>
<td>0.904</td>
<td>8.259</td>
<td>0.004</td>
<td>13.417</td>
</tr>
<tr>
<td>Cows 21-40 head</td>
<td>2.192</td>
<td>0.972</td>
<td>5.088</td>
<td>0.024</td>
<td>8.95</td>
</tr>
<tr>
<td>Cows &gt; 40 head</td>
<td>2.739</td>
<td>1.073</td>
<td>6.514</td>
<td>0.011</td>
<td>15.466</td>
</tr>
<tr>
<td>Beef Feeder</td>
<td>1.074</td>
<td>0.655</td>
<td>2.683</td>
<td>0.101</td>
<td>2.92</td>
</tr>
<tr>
<td>Finished Beef</td>
<td>-0.095</td>
<td>0.541</td>
<td>0.031</td>
<td>0.861</td>
<td>0.91</td>
</tr>
<tr>
<td>Acreage owned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acres &lt; 61 acres</td>
<td>-1.442</td>
<td>1.208</td>
<td>1.426</td>
<td>0.232</td>
<td>0.236</td>
</tr>
<tr>
<td>Acres 61-135 acres</td>
<td>-1.052</td>
<td>1.153</td>
<td>0.833</td>
<td>0.361</td>
<td>0.349</td>
</tr>
<tr>
<td>Acres 136-250 acres</td>
<td>-0.448</td>
<td>1.247</td>
<td>0.129</td>
<td>0.719</td>
<td>0.639</td>
</tr>
<tr>
<td>Acres &gt; 250 acres</td>
<td>-0.96</td>
<td>1.217</td>
<td>0.622</td>
<td>0.43</td>
<td>0.383</td>
</tr>
<tr>
<td>Age</td>
<td>-0.018</td>
<td>0.02</td>
<td>0.77</td>
<td>0.38</td>
<td>0.982</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income &lt; $10,000</td>
<td>-1.841</td>
<td>1.517</td>
<td>1.472</td>
<td>0.225</td>
<td>0.159</td>
</tr>
<tr>
<td>Income $10,000-34,999</td>
<td>-1.107</td>
<td>0.951</td>
<td>1.355</td>
<td>0.244</td>
<td>0.33</td>
</tr>
<tr>
<td>Income $35,000–74,999</td>
<td>-0.88</td>
<td>0.838</td>
<td>1.103</td>
<td>0.294</td>
<td>0.415</td>
</tr>
<tr>
<td>Income &gt; $75,000</td>
<td>-1.053</td>
<td>0.864</td>
<td>1.485</td>
<td>0.223</td>
<td>0.349</td>
</tr>
<tr>
<td>Constant</td>
<td>4.232</td>
<td>2.982</td>
<td>2.014</td>
<td>0.156</td>
<td>68.842</td>
</tr>
</tbody>
</table>

*Model $X^2 (41, N=275) = 137.77, p = <0.001. Cox & Snell $R^2 = 0.394$, Nagelkerke $R^2 = 0.59$. Hosmer and Lemeshow Test $X^2 (8, N=275) = 6.425, p = 0.6.$*
Chapter 4: Comparison of Four Perennial Forage Finishing Systems and a Limit-Fed Corn-Based Finishing System on Lamb Growth and Carcass Characteristics

Abstract

With lambs, there is a lack of information comparing grazing alfalfa (*Medicago sativa* L.) versus grasses, in similar and differing time periods, and the effects on lamb growth rate and carcass characteristics. Likewise, information is lacking comparing forage-based finishing systems to grain-based finishing where the grain is limit-fed to match the rate of gain achieved on one designated forage finishing system. The objective of the present study was to compare four perennial pasture forage finishing systems and a limit-fed, corn-based, confined finishing system on lamb growth rate and carcass characteristics. Ewe (n = 30) and wether (n = 60) lambs blocked by body weight were allocated to treatments. Each treatment consisted of three fields or pens of six lambs per field or pen. The finishing systems were grazed alfalfa (ALF), grazed ryegrass (RG) (*Lolium perenne*, L.), grazed alfalfa for 56 d followed by grazed ryegrass for the remainder of the trial (ALF/RG), grazed ryegrass for 56 d followed by grazed alfalfa for the remainder of the trial (RG/ALF), and a limit-fed, corn-based diet (CONC) fed to achieve a similar rate of gain as the grazed alfalfa treatment. The amount of concentrate
Feed was adjusted every two weeks to match the rate of gain achieved for the alfalfa groups for the previous two weeks. Forage analysis from samples taken every two weeks, revealed ALF had lower acid detergent fiber (ADF) and neutral detergent fiber (NDF) content than ryegrass throughout the trial \((P < 0.05)\) and greater CP content for all but four weeks \((P < 0.05)\). Predetermined contrasts between ALF and the other finishing systems were conducted using LSMESTIMATE in PROC MIXED. The slaughter target was a replicate average of 58 kg live weight. The CONC lambs had heavier carcasses, with greater muscling and back fat depth than the ALF lambs \((P < 0.05)\). The ALF lambs were not different in carcass weight, loin eye area, and back fat depth than the RG, RG/ALF and ALF/RG lambs \((P > 0.05)\). Compared with the ALF lambs the RG and ALF/RG lambs took longer to reach the target weight \((P < 0.05)\).

**Keywords:** Lambs, alfalfa, ryegrass, growth, carcass composition

**Introduction**

Grazed forages are the primary feed used to finish lambs throughout the world. In the US, feeding grains (concentrates) to finish lambs predominates. However, when concentrate prices are high, many US producers explore grazing available forage to grow lambs to a marketable finish weight. Studies have reported the growth rate and carcass characteristics of concentrate verses forage finishing systems (McClure et al., 1995; Fluharty et al., 1999; McClure et al., 2000; Turner et al., 2002). Grazing legumes, primarily alfalfa \((Medicago sativa\ L.)\), produces more animal weight gain and heavier carcasses than grazing grasses (McClure et al., 1994; Speijers et al., 2004; and Fraser et
al., 2004) per unit of time. Alfalfa has more limitations on suitable soils than grasses, due to its intolerance of wet conditions and acidity, is a more expensive crop to establish and maintain than grasses, and can cause bloat. Few studies have investigated grazing alfalfa in different stages of lamb production, versus grazing alfalfa throughout the growing and finishing period. McClure et al. (1995) compared lamb growth rate from grazing alfalfa after a period of grazing ryegrass (Lolium perenne, L.) with grazing alfalfa, ryegrass, or grain as sole treatments. McClure et al. (2000) compared lambs grazing alfalfa following a concentrate ration with lambs fed either a concentrate ration or grazing alfalfa as single treatments. The literature lacks information comparing grazed alfalfa at different periods in lamb production with grasses and grazing systems compared with a grain ration limit-fed to match gains on one of the forage finishing system.

The objective of the present study was to determine the effects of four perennial cool season pasture forage systems and a limit-fed, corn-based, confined finishing system on lamb growth rate and carcass characteristics. The authors’ hypothesis was that lamb growth rate and carcass characteristics would be similar for concentrate feeding and alfalfa but greater than alfalfa/ryegrass combinations or ryegrass.

**Materials and Methods**

The Agricultural Animal Care and Use Committee of The Ohio State University approved all animal procedures. The study was conducted at the Sheep Center of the Ohio Research and Development Center, Wooster (40° 43’44.71 N lat, 81° 54’4.25’W long).
Crossbred (Hampshire x Dorset) lambs (60 ± 6 days of age) were weaned, weighed and grazed on perennial tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.) pastures for two weeks, then weighed on two consecutive days. Lambs (n = 30 ewes; n = 60 wethers) blocked for initial body weight (BW) and sex were randomly assigned to one of five finishing systems: grazed alfalfa (ALF) throughout, grazed ryegrass (RG) throughout, grazed alfalfa for 56 d followed by grazed ryegrass for the remainder of the finishing period (ALF/RG), grazed ryegrass for 56 d followed by grazed alfalfa for the remainder of the finishing period (RG/ALF), and limit-fed, corn-based diet fed to achieve a similar rate of gain as the grazed alfalfa treatment (CONC) (3 replicates/system; n = 18 lambs/system). The 56 d switch in forages was set a priori. The amount of concentrate feed offered (Table 1) was adjusted every two weeks to match the rate of gain achieved for the ALF groups for the previous period (Fluharty et al., 1999).

The trial commenced on April 26, 2011 (d0). Lambs were weighed every two weeks. At the initiation of the trial, all animals were treated with Levamisole Hydrochloride (8.11 mg/kg) (Zoetis, Kalamazoo, MI). Fecal egg counts were conducted (Whittlock, 1948) on May 24 (d28), June 21 (d56) and July 19 (d84) to monitor parasite infection (Table 12). Moxidectin (Boehringer Ingelheim Vetmedica, St. Joseph, MO), an identified effective dewormer on the study site, was given (oral drench, 0.2 mg/kg) to all lambs on July 22 (d87).

Pens (3.0 × 4.9 m) that housed the CONC lambs were constructed of expanded metal floors, with metal gates on three sides and a wooden fence line feed bunk (3.0 m
long) on the fourth side with 0.5 m of feed bunk space per lamb. Free access to water was provided via automatic waterers (Ritchie Industries Inc., Conrad, IA).

Six fields (0.66 ha) consisting of soil types Canfield Silt Loam (43.8%), Ravenna Silt Loam (43.7%), and Wooster-Riddles Silt Loam (11.9%) were used for this experiment. The fields were randomly allotted to either perennial ryegrass (*Lolium perenne*, L. cv. Remington) or alfalfa (*Medicago sativa* L. cv. Prolificacy II) and were planted to pure stands the previous August. Lime and fertilizer were incorporated prior to planting based on a current soil test for each field (Appendix C) and Tri-State Fertilizer Recommendations (Vitosh et al., 1995). The forages were planted into a conventionally prepared seedbed. The fields were divided into eight paddocks (0.08 ha) with four paddocks being randomly allotted to each finishing system with a planned equivalent stocking rate of 18 lambs per ha. Lambs were grazed for 7 d on each paddock allowing each paddock a 21 d rest before re-grazing. Each alfalfa paddock was grazed 7±1 (SD) times and each ryegrass paddock was grazed 8±1 times throughout the trial. Paddocks were mowed once during the trial at the initiation of seed head production to keep the forage vegetative. The target residual at mowing was 6 cm and the residue was removed from individual paddocks after the grazing pass starting May 31 (d35, d42, d49 and d56 respectively). Granular urea (46-0-0) was broadcast on each of the ryegrass paddocks at the rate of 33.6 kg N/ha after the residue was removed. Maturity of the alfalfa fields was pre bud and the ryegrass was vegetative throughout the trial. Each paddock was equipped with a water tank and water was available ad libitum. Free choice mineralized salt was provided to all the forage lambs.
In the present system trial, it is noted that forage growth can be limited by the lack of rainfall and temperature during a grazing season (Bransby, 1989; Teague et al., 2009). Forage growth was monitored weekly in the method described below. An a priori management decision was made whereby, if forage growth was less than needed to sustain the initial allocation of lambs per replicate then two random lambs would be pulled out of those respective replicates. Based on the lack of forage growth between grazing rotations, two lambs from each replicate of the RG and ALF/RG finishing system were removed on July 21 (d 86). Rainfall (mm) and maximum temperature (°C), for each 2-week period during the trial are reported in Fig. 6. One lamb in the ALF group died from entanglement in the fence.

**Forage Data**

Total forage dry matter (DM) was measured using a Rising Plate Meter (Filip's Manual Folding Plate Meter, Jenquip, Feilding, New Zealand) at each paddock shift. Calibration of the plate meter was done every two weeks using a 0.1 m² quadrat with 10 clippings per treatment forage (Appendix D). Quadrat clippings were dried in a 100°C oven for 48 h and the dry weight per 0.1 m² was regressed against the respective plate meter reading. Thirty random measurements were taken weekly at each paddock move. Measurements were taken in each paddock from which the animals were removed and the paddocks into which they were entering. The mean of the 30 measurements was used to determine forage mass using the regression equation from current or previous week’s calibration. Every two weeks, all paddocks were measured as described.

**Forage Analysis**
Every two weeks 30 random grab samples were collected for forage analysis in the paddock the lambs were being moved into. The grab samples mimicked the plant parts the lambs had consumed the week before in the previous paddock. The grab samples from each paddock were combined, dried in a 55°C oven and used for analysis of ADF and NDF (using Ankom Technology Method 5 and 6, respectively; Ankom200 Fiber Analyzer, Ankom Technology, Fairport, N.Y.), and CP (macro Kjeldahl N x 6.25).

**Carcass Data**

Lambs were transported (2 hours) the day before slaughter, kept overnight, weighed and slaughtered the next morning at The Ohio State University Meat Science Laboratory when the replicate average reached an approximate target live weight (LW) of 58 kg, or if forage became limiting. To determine final BW, lambs were weighed before feeding on two consecutive days directly before slaughter. Before chilling kidney pelvic heart fat was pulled from the carcasses and weighed. Carcasses were chilled (4°C) for 24 h, and then ribbed between the 12th and 13th ribs. At the 12th-rib interface, back fat (BF) thickness, body wall thickness, and loin eye area (LEA) were measured. Visual lean score, leg score, conformation score, and quality grade (Prime+ = 15; Cull = 1) were estimated according to USDA guidelines (USDA, 1992), using the same technician with no reference between carcass and treatments. Loin pH was recorded using a portable pH meter (H198140, Hanna Instruments, Palermo, Italy) equipped with a glass-tipped pH probe (FC201D, Hanna Instruments) inserted 1 cm deep into the exposed loin eye muscle surface at the 12th- and 13th-rib interface.

**Statistical Analysis**
The experimental design of this study was a randomized complete block design. Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC) (Appendix E).

The model for the forage data was: \( Y_{ijkl} = \mu + p_i + f_j + d_k + g_l + e_{ijkl} \), where \( Y_{ijkl} \) = the response variable; \( \mu \) = the mean; \( p_i \) = the random effect of field (12); \( f_j \) = the fixed effect of forage (alfalfa or rye grass); \( d_k \) = the fixed effect of date; \( g_l \) = the fixed effect of forage by date, and \( e_{ijkl} \) = the experimental error.

Repeated measures were used for forage data and the covariance structure that yielded the smallest Bayesian information criterion was compound symmetric. Simple effects were generated by the SLICE function and mean separation was generated by the PDIFF function in SAS.

The model for the average daily gain data was: \( Y_{ijklmnp} = \mu + p_i + s_j + d_k + f_l + b_m + g_n + h_p + e_{ijklmnp} \), where \( Y_{ijklmnp} \) = the response variable; \( \mu \) = the mean; \( p_i \) = the fixed effect of treatment (5); \( s_j \) = the fixed effect of sex; \( d_k \) = the fixed effect of date; \( f_l \) = the fixed effect of forage (alfalfa or rye grass); \( b_m \) = the random effect of body weight block; \( g_n \) = the fixed effect of sex by treatment; \( h_p \) = the fixed effect of treatment by date; and \( e_{ijklmnp} \) = the experimental error. Repeated measures were used for ADG data and the covariance structure that yielded the smallest Bayesian information criterion was autoregressive order 1. LSMESTIMATE function in SAS was used for mean separation with preplanned contrast comparing the ALF treatment to the other treatments, CONC, ALF/RG, RG/ALF, and RG. Simple effects were generated by the SLICE function in SAS.
The model for the carcass data was: $Y_{ijk} = \mu + b_i + s_j + T_k + e_{ijk}$, where $Y_{ijk}$ = the response variable; $\mu$ = the mean; $b_i$ = the random effect of bodyweight block; $s_j$ = the fixed effect of lamb sex (ewe or wether); $T_k$ = the fixed effect of dietary treatment; and $e_{ijk}$ = the experimental error. LSMESTIMATE function in SAS was used for mean separation with preplanned contrast comparing the ALF treatment to the other finishing system, CONC, ALF/RG, RG/ALF, and RG.

Forage Allowance, based on Sollenberger et al. (2005) was calculated as Forage allowance= $\{(\text{pregraze forage mass/ days in grazing period} + \text{growth}) \times \text{paddock area}\}/[\text{units of animal live weight}]$.

**Results and Discussion**

Minimum and maximum daily temperature ($^\circ$C) followed the 30-year average for the trial (Fig. 6). Rainfall (mm) was more variable for the trial than the 30-year average this may account for the ryegrass growth slowing down, yet still able to maintain four lambs per treatment for the remainder of the trial.

Forage nutritive values are presented in Fig. 7. The LSM for each forage (ALF, ALF/RG, RG/ALF, RG) was calculated from the six replicates. The NDF (Fig. 7, panel 1) was greater for ryegrass than alfalfa throughout the trial ($P < 0.01$), with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$) being detected. The NDF increased as forage plants matured. The increase of NDF in the first three periods reflected the maturation of the respective forages and smaller variation in the remaining periods reflected the vegetative growth (Brink and Casler, 2012).
The ADF (Fig. 7, panel 2) was greater for ryegrass than alfalfa throughout the trial ($P < 0.01$), with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$) being found. The date and forage by date interaction indicated the change in maturity of the respective plants throughout the trial. From previous studies, grasses typically have greater ADF values than alfalfa and as both type of plants mature they have a greater ADF (Fales and Fritz, 2007).

Percent CP (Fig. 7, panel 3) was less for ryegrass than alfalfa ($P < 0.01$), for all periods except July 5 and July 19, with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$) being detected. Part of the increase in CP for ryegrass on June 21 and the corresponding decrease in ADF and NDF, can be explained by the clipping and application of urea following the previous grazing of the respective paddocks. The decrease in alfalfa CP and the corresponding increase in NDF on July 19 were associated with the maturing alfalfa plants. The CP values from the respective forages exceeded the protein requirements for the lamb growth rate during this trial (NRC, 1985).

Forage allowance (Fig. 7, panel 4) expressed as kg DM per kg LW was calculated as described in Sollenberger et al. (2005) and Allen et al. (2011). Forage allowance ($P = 0.04$) was less for ryegrass than alfalfa, for periods May 10, June 21 and July 5, and greater for the periods June 7, August 16 through September 27, with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$). Although forage allowance has not been widely reported, Gibb and Treacher (1976) concluded that intake of herbage is not restricted if the allowance is above three times the daily intake of animals. The trial was designed so that forage was not limiting with estimated intake at 3% of the lambs BW.
Forage growth was measured weekly. Animals were removed from the ryegrass paddocks when forage growth slowed to ensure that forage was not limiting. Since forage was not limiting, this suggest that the associated animal performance results were attributed to the quality of the forage rather than the allowance.

**Animal Performance**

The mean live weights (LW) for each 2-week period are reported in Fig. 8. There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$). By design there was no difference ($P > 0.05$) in the LW between the ALF and CONC lambs. The ALF lambs weighed (LSM ± SE) $3.05 ± 1.22$ kg heavier than the RG lambs on May 24 ($P < 0.05$), with the difference in LW increasing to $13.10 ± 1.22$ kg on September 13 ($P < 0.01$). The ALF lambs were $4.41 ± 1.22$ kg heavier than the RG/ALF lambs on June 7 ($P < 0.01$), with the difference increasing to $8.18 ± 1.22$ kg on September 13 ($P < 0.01$). The difference in the first weigh dates, one weigh period, that the RG and RG/ALF lambs showed statistical differences from the ALF lambs was initially surprising since the RG and RG/ALF lambs were grazing the ryegrass at the time. The RG/ALF lambs did show a trend in lower LW on May 24 ($P = 0.06$). The LW of the ALF lambs was not different ($P > 0.05$) than the ALF/RG lambs while the ALF/RG lambs were grazing alfalfa, through June 21. The LW of the ALF lambs was greater than the ALF/RG lambs starting July 5 ($P < 0.01; 3.69 ± 1.22$ kg) with the difference increasing to $8.70 ± 1.22$ kg on September 13 ($P < 0.01$). The RG lambs did not reach the target slaughter weight of $58$ kg and were slaughtered due to lack of forage growth.
The differences in LW may be further explained by looking at the average daily gain (ADG) for each 2-week weight period. The ADG data for each 2-week period are reported in Fig. 9, with each respective treatment (CONC, RG, RG/ALF, and ALF/RG) plotted with ALF in separate panels. There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$). This follows within other reported results (McClure et al., 1994; Turner et al., 2002; Fraser et al., 2004; Speijers et al., 2004; Borton et al., 2005) where legumes produced greater ADG than grasses.

One period (July 19) ALF ADG was less ($P = 0.04$) than CONC ADG. This was designed; intake of the CONC lamb diet was controlled to achieve the same ADG as that of ALF lambs during the previous period. The main reason for the CONC treatment was to compare carcass differences due to source and not the amount of energy or ADG. Fig. 9, panel 1, was included to indicate the performance in our attempt to limit grain intake to match the ALF gains.

Lambs in the ALF treatment had greater ADG than RG ($P < 0.01$). The majority of the difference occurred in the periods before July 19 (Fig. 9, panel 2). Looking at the nutritive value data (Fig. 7), specifically the greater ADF and NDF values in the RG finishing system, may indicate the greater breakdown of alfalfa during intake and rumination and the faster passage out of the rumen of the alfalfa compared with that of ryegrass (Grenet, 1989; Dewhurst et al., 2003). Because of lesser ADG, the RG lambs took longer to reach target weight (58 kg) and were slaughtered before reaching the target weight due to slow ryegrass growth in late November.
Lambs in the ALF treatment had greater overall ADG ($P < 0.01$) than the RG/ALF lambs. Those differences occurred during the first 56d while the RG/ALF lambs were grazing ryegrass. After the switch in forage, the RG/ALF lambs did not differ in ADG from the ALF lambs. The lambs in the RG/ALF finishing system reached the target weight 4 weeks after the ALF lambs. This difference was due to the lesser ADG in the first 56 d while they were grazing ryegrass.

The lambs in the ALF treatment had greater overall ADG ($P < 0.01$) than the ALF/RG lambs. The differences occurred after the switch to ryegrass on d56. Similar to the RG lambs, it took an additional 10 weeks to reach the target weight of 58 kg. We did not attempt to directly estimate forage intake, which could help explain the differences in ADG.

The uniform decrease in ADG on August 2 and August 16 and the increase in ADG on August 30 was notable. The only nutritive value change at that time was an increase in both alfalfa and ryegrass ADF on August 16 (Fig. 7), which would not fully explain the ADG change in that 6 week period. It may not be associated with any specific treatment effect (Fig. 7). Although not fully understood, that change in performance may be associated with the maximum air temperature (Fig. 6), which increased during that same period.

**Carcass Characteristics**

Days on test (Table 13) was significantly different between finishing system ($P < 0.01$). By design, the ALF lambs and the CONC lambs finished at the same time. The ALF lambs finished 68 ± 9 days earlier than the RG lambs ($P < 0.01$), and 59 ± 9 days
earlier than the ALF/RG lambs \( (P < 0.01) \). There was a trend \( (P = 0.06) \) with the ALF lambs finishing earlier than the RG/ALF lambs. Fraser et al. (2004) and Speijers et al. (2004) based slaughter criteria on body condition scores and found grazing ryegrass required more days to slaughter than grazing alfalfa. Studies that fed an ad libitum concentrate diet and based slaughter on a LW target (Turner et al., 2002; Borton et al., 2005) or estimated fat cover (McClure et al., 1995) suggested that lambs fed concentrate diets spent less days on test than lambs grazing either alfalfa or ryegrass and lambs grazing ryegrass took the longest to finish. Age at slaughter followed the same trend as days on test, with no difference between the ALF and CONC lambs \( (P > 0.05) \).

The lack of forage growth and the removal of 2 lambs per replicate of the RG and ALF/RG treatments means that those treatments only produced 12 lambs per ha compared with the 18 lambs per ha for the ALF and RG/ALF treatments. Economics of different grazing systems can be analyzed in multiple ways and are beyond the scope of this paper.

Final LW was similar between treatments \( (P = 0.17) \); this was similar to Fluharty et al., (1999). This response differed from McClure et al. (1995) who reported that, lambs grazing alfalfa had lesser final LW than those grazing ryegrass or ryegrass followed by alfalfa. McClure et al. (1995) based slaughter criteria on an estimated final BF target and the lambs grazing alfalfa reached that target at a lighter weight. In the current study, final LW was numerically greater for the ALF lambs than the RG lambs because the RG lambs were removed from test early and slaughtered due to lack of forage growth. Other studies who based slaughter on body condition scores found either no difference between final
LW of lambs grazing alfalfa and lambs grazing ryegrass (Fraser et al., 2004) or found lambs grazing ryegrass had lesser final LW than those grazing alfalfa (Speijers et al., 2004).

Even with no difference in ADG and final LW the CONC produced a (3.6 ± 0.9 kg) heavier carcass than the ALF treatment (\( P < 0.01 \)). Fluharty et al. (1999) reported similar results when comparing limit fed concentrates to alfalfa and also found heavier visceral tissue which was likely increasing the maintenance energy and protein requirements for the alfalfa grazed lambs resulting in lighter carcass weights at similar live body weights. In the present trial, the ALF lambs had carcass weights that were not statistically different from the ALF/RG lambs (\( P = 0.75 \)) and the RG/ALF lambs (\( P = 0.11 \)). Results indicate the inclusion of ryegrass as part of the forage grazed would not affect final carcass weights when compared with solely grazing alfalfa, if there were enough forage. The ALF lambs showed a trend for producing heavier carcasses than the RG lambs (\( P = 0.06 \)), a trend that can be partially explained by the differences in final LW.

Dressing percentage was greater for CONC lambs than the ALF lambs (\( P < 0.01 \)). This was similar to Fluharty et al., (1999), who reported a greater dressing percentage for limit fed concentrates verses alfalfa. Dressing percentage of ALF lambs’ was not different than the other grazing treatments, a finding that agrees with reports (Fraser et al., 2004; Speijers et al., 2004) that found no difference in dressing percentage between lambs grazing alfalfa and ryegrass.
Weight of kidney pelvic heart fat (KPH) varied ($P = 0.09$) between finishing systems, with ALF and RG/ALF lambs having numerically less KPH weight and CONC lambs numerically having the greater KPH weight. Expressed as percent of the carcass, KPH for treatments ($P = 0.06$) did not follow the same pattern, whereby percent KPH of ALF lambs lowest and RG lambs had the greatest percent KPH, which agrees with McClure et al. (1995), Fluharty et al. (1999), McClure et al. (2000) and Turner et al. (2002). The difference in hot carcass weight (HCW) can explain the difference between the trends of KPH weight and KPH percentage.

The ALF lambs had a smaller loin eye area (LEA) than the CONC lambs ($P < 0.01; 2.9 \pm 0.54 \text{ cm}^2$). The LEA for ALF lambs trended larger than the RG/ALF lambs ($P = 0.10$) and the ALF/RG lambs ($P = 0.10$), with no statistical difference in LEA between the ALF lambs and RG lambs ($P = 0.80$). The difference between CONC and ALF lamb LEA is similar to findings of Fluharty et al. (1999) and McClure et al. (2000) but contradicts McClure et al. (1994 and 1995) and Turner et al. (2002) who reported no differences in LEA between lambs grazing alfalfa and lambs provided ad libitum access to concentrates. The reason for the contradiction is related to the slaughter decision; McClure et al. (1994 and 1995) based slaughter on BF estimation and Turner et al., (2002) had a 3 kg greater LW target on the grazed lambs. Basing slaughter decisions on BF have produced heavier lambs in the grazing finishing system (McClure et al., 1994 and 1995). The U.S. lamb industry has no defined targets for LEA. Frequently an increase in LEA above 19 cm$^2$ has been suggested to improve consumer acceptance of
lamb. None of the treatments reached that potential LEA target, suggesting a limitation of the sole use of grazed forages in lamb production.

Carcass BF differences among treatments followed only a trend \( (P=0.08) \), whereas the single df contrast indicated CONC lambs had numerically greater BF than the ALF lambs \( (P=0.04; 0.12 \pm 0.05 \text{ cm}) \). Back fat depth was not different when comparing ALF with ALF/RG \( (P=0.97) \), RG/ALF \( (P=0.44) \), and RG \( (P=0.91) \).

Body wall measurements were significantly different \( (P<0.01) \) across treatments. The CONC lambs had a thicker body wall than the ALF lambs \( (P<0.01; 0.6 \pm 0.11 \text{ cm}) \), an observation that follows results reported by Fluharty et al. (1999). The ALF body wall was not significantly different from ALF/RG \( (P=0.18) \), RG/ALF \( (P=0.37) \), and RG \( (P=0.86) \). Body wall measurements were not reported in any previous studies comparing grazing alfalfa or other forages.

Yield grade was calculated based on the BF measurement and followed the same trend as BF. The ALF lambs had a lesser yield grade than CONC lambs \( (P=0.04; 0.5 \pm 0.15) \). The ALF yield grade was not significantly different from ALF/RG \( (P=0.97) \), RG/ALF \( (P=0.44) \) and RG \( (P=0.91) \). Fluharty et al. (1999) used the formula for yield grade that was acceptable before 1992 (USDA), while McClure et al. (1994, 1995, and 2000) and Turner et al. (2002) did not specify the formula used; therefore, valid comparisons to previous research are not possible.

Percent boneless closely trimmed retail cuts (BCTRC) was not significantly different between treatments \( (P=0.22) \). The BCTRC was calculated from the formula in Savell and Smith (2000) and was not reported in any of the previous studies evaluating
grazing alfalfa. With no statistically significant difference found, this suggests results suggest that the difference in HCW among treatments would be more important for a producer direct marketing their product.

The subjective leg score was not significantly different between finishing system ($P = 0.65$). This was similar to McClure et al. (1995), Fluharty et al. (1999) and McClure et al. (2000). Conformation score, also subjective, of ALF lambs was lower than CONC lambs ($P = 0.01; 0.95 \pm 0.23$). The ALF lambs were not significantly different from ALF/RG ($P = 0.55$), RG lambs ($P = 0.41$), or RG/ALF ($P = 0.36$) in conformation score. The subjective lean score was greater for the CONC lambs when compared with the ALF lambs ($P = 0.02; 1.80 \pm 0.32$). The ALF lambs trended lower in lean score compared with the ALF/RG lambs ($P = 0.04$), RG lambs ($P = 0.06$) or the RG/ALF lambs ($P = 0.09$).

The subjective overall quality score, sometimes referred to as marbling score, only showed differences between CONC and ALF lambs, with CONC lambs scoring greater than ALF lambs ($P < 0.01; 1.65 \pm 0.25$). The ALF lambs trended lower overall quality scores than the ALF/RG lambs ($P = 0.09$). The RG ($P = 0.13$), and RG/ALF ($P = 0.40$) lambs were not significantly different in overall quality score from ALF lambs. Based on overall quality scores all treatments were in the Choice range. The discussed industry targets for the U.S. lamb industry are choice and prime overall quality scores.

Ultimate pH, or the pH of the *longissimus dorsi* muscle post rigor (24 h), has been associated with tenderness (Devine et al., 1993) and cooked odor and flavor (Braggins 1996). Ultimate pH in the range of 5.5-5.7 has been demonstrated to result in acceptable lamb tenderness, cooked odor, and flavor (Devine et al., 1993 and Braggins 1996).
Ultimate pH in this trial was between 5.42 - 5.55 and was different between finishing system \((P < 0.01)\), with no difference between the pH of the ALF and CONC lambs \((P = 0.14)\). The ALF lambs trended a greater pH than the RG/ALF lambs \((P = 0.10)\) and had a significantly greater pH than the ALF/RG \((P < 0.01)\) and RG lambs \((P = 0.02)\). Negative effects of pH on tenderness, cooked odor, and flavor observed in previous studies were associated with pH above 5.7. All treatments in the present study were below the pH 5.7 threshold, indicating that all the finishing systems would be likely to produce lamb products with acceptable tenderness, cooked odor, and flavor.

The finding that the pH was similar between the CONC and ALF lambs, indicates they had similar glycogen reserves. Since the CONC lambs were limit-fed to match the gain of the ALF lambs, the finding of greater HCW, LEA, and BF in the CONC lambs compared to the ALF lambs indicates more energy was available in the CONC lambs. Energy source has been shown to have an effect on visceral organ mass (Fluharty et al., 1999; Finegan et al., 2001). Heavier visceral organ mass requires more maintenance energy leaving less energy for muscle growth and fat deposition.

There was no interaction between finishing system and sex of the lamb \((P > 0.05)\). Ewes (Table 14) had greater weight and percentage KPH fat, more BF, a thicker body wall, greater yield grades, lesser BTRC and greater subjective lean and overall quality scores \((P < 0.05)\) when compared with contemporary wethers. Ewes were not different \((P > 0.05)\) than wethers for carcass weight, LEA, subjective leg and conformation scores, or ultimate pH of the loin. Arnold and Meyer (1988) found similar results between ewes and wethers for BF, percentage KPH and leg score, but found that ewes had a greater dressing
percentage and smaller LEA. Likewise, there was no effect of sex ($P = 0.88$), sex by treatment ($P = 0.60$) or sex by period ($P = 0.91$) for ADG (not shown) which was similar to findings of Fraser et al. (2004) and Speijers et al. (2004). Therefore, when making management decisions regarding the need to feed ewes and wethers differently, findings of the present study indicated that sex effects were consistent across forage systems tested and feeding modifications based on sex of the lamb are not likely necessary.

**Implications**

Limit-fed corn to match the same rate of gain in lambs grazing alfalfa resulted in heavier carcasses, with greater muscling and back fat depth. Grazing alfalfa as an alternative to concentrate feeding reduces muscle and fat in the carcass. Leaner carcasses were produced from the grazing programs compared with limit-fed corn. If alfalfa area is limited and lambs cannot be managed solely on alfalfa, then using it later in the finishing phase would produce results closer to grazing alfalfa alone. Grazing ryegrass alone or using it later in the production phase will result in lambs taking longer to reach market weight.

**Literature Cited**


Tables for Chapter 4.

Table 11. Composition of concentrate diet fed during trial.

<table>
<thead>
<tr>
<th>Item</th>
<th>% DM Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground corn</td>
<td>57.75</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>21.50</td>
</tr>
<tr>
<td>Corn gluten meal</td>
<td>15.73</td>
</tr>
<tr>
<td>Urea</td>
<td>0.80</td>
</tr>
<tr>
<td>Limestone</td>
<td>1.20</td>
</tr>
<tr>
<td>Trace mineral salt(^1)</td>
<td>0.45</td>
</tr>
<tr>
<td>Vitamin A, 30,000 IU/g</td>
<td>0.01</td>
</tr>
<tr>
<td>Vitamin D, 3,000 IU/g</td>
<td>0.01</td>
</tr>
<tr>
<td>Vitamin E, 44 IU/g</td>
<td>0.05</td>
</tr>
<tr>
<td>Vitavet selenium, 201 mg of Se/g</td>
<td>0.09</td>
</tr>
<tr>
<td>Lasalocid(^2)</td>
<td>0.01</td>
</tr>
<tr>
<td>A-V Blend(^3)</td>
<td>2.00</td>
</tr>
<tr>
<td>Ammonium chloride</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Analyzed Composition

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein</td>
<td>30.04</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.50</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.44</td>
</tr>
<tr>
<td>NE(_m) Mcal/kg</td>
<td>2.18</td>
</tr>
<tr>
<td>NE(_g) Mcal/kg</td>
<td>1.51</td>
</tr>
</tbody>
</table>

\(^1\)Included 95% NaCl; 0.35% Zn, as ZnO; 0.28% Mn, as MnO\(_2\); 0.175% Fe, as FeCO\(_3\); 0.040% Cu, as Cu\(_2\)O; 0.007% I, as Ca\(_3\)(IO\(_6\))\(_2\); 0.007% Co, as CoCO\(_3\).

\(^2\)Fed to provide 25.5 mg of lasalocid/kg of diet DM (Bovatec, Alpharma Animal Health, Bridgewater, NJ).

\(^3\)Fat supplement (C.F. Zeiler & Co., Inc., Towson, MD)
Table 12. Fecal egg counts for treatment groups.

<table>
<thead>
<tr>
<th>Item</th>
<th>May 24</th>
<th>June 21</th>
<th>July 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALF</td>
<td>283</td>
<td>225</td>
<td>558</td>
</tr>
<tr>
<td>ALF/RG</td>
<td>375</td>
<td>466</td>
<td>508</td>
</tr>
<tr>
<td>RG</td>
<td>533</td>
<td>358</td>
<td>1225</td>
</tr>
<tr>
<td>RG/ALF</td>
<td>492</td>
<td>433</td>
<td>791</td>
</tr>
<tr>
<td>CONC</td>
<td>167</td>
<td>158</td>
<td>8</td>
</tr>
</tbody>
</table>

*Eggs per gram*
Table 13. Carcass characteristics of lambs on five feeding regimes.

<table>
<thead>
<tr>
<th>Item</th>
<th>ALF4</th>
<th>A/R</th>
<th>CON</th>
<th>RG</th>
<th>R/A</th>
<th>SE</th>
<th>F test P value</th>
<th>Contrast P value3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fields/Pen (No. Lambs)</td>
<td>3 (17)</td>
<td>3 (12)</td>
<td>3 (18)</td>
<td>3 (12)</td>
<td>3 (18)</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Days on Test</td>
<td>150.7</td>
<td>209.7</td>
<td>150.7</td>
<td>219</td>
<td>170</td>
<td>6.46</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Age at Slaughter, d</td>
<td>225.9</td>
<td>281.8</td>
<td>223.7</td>
<td>295.0</td>
<td>243.0</td>
<td>6.41</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>LW, kg</td>
<td>59.4</td>
<td>58.5</td>
<td>60.1</td>
<td>55.1</td>
<td>56.6</td>
<td>1.40</td>
<td>0.17</td>
<td>0.64</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>27.3</td>
<td>26.9</td>
<td>30.8</td>
<td>25.1</td>
<td>25.7</td>
<td>0.76</td>
<td>&lt;0.01</td>
<td>0.75</td>
</tr>
<tr>
<td>Dressing Percent KPH weight, kg</td>
<td>46.0</td>
<td>46.0</td>
<td>51.3</td>
<td>45.7</td>
<td>45.5</td>
<td>0.55</td>
<td>&lt;0.01</td>
<td>0.95</td>
</tr>
<tr>
<td>KPH %</td>
<td>0.47</td>
<td>0.58</td>
<td>0.64</td>
<td>0.59</td>
<td>0.48</td>
<td>0.04</td>
<td>0.09</td>
<td>0.13</td>
</tr>
<tr>
<td>LEA, cm²</td>
<td>1.40</td>
<td>12.9</td>
<td>16.9</td>
<td>14.2</td>
<td>13.0</td>
<td>0.72</td>
<td>&lt;0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Back fat, cm</td>
<td>0.4</td>
<td>0.4</td>
<td>0.6</td>
<td>0.4</td>
<td>0.4</td>
<td>0.04</td>
<td>0.08</td>
<td>0.97</td>
</tr>
<tr>
<td>Body Wall, cm</td>
<td>1.6</td>
<td>1.8</td>
<td>2.2</td>
<td>1.6</td>
<td>1.5</td>
<td>0.09</td>
<td>&lt;0.01</td>
<td>0.18</td>
</tr>
<tr>
<td>Yield Grade¹</td>
<td>2.1</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>1.9</td>
<td>0.15</td>
<td>0.08</td>
<td>0.97</td>
</tr>
<tr>
<td>%BCTRC²</td>
<td>48.6</td>
<td>48.2</td>
<td>48.5</td>
<td>49.1</td>
<td>48.7</td>
<td>0.24</td>
<td>0.22</td>
<td>0.20</td>
</tr>
<tr>
<td>Leg Score³</td>
<td>11.5</td>
<td>11.7</td>
<td>11.8</td>
<td>11.5</td>
<td>11.3</td>
<td>0.28</td>
<td>0.65</td>
<td>0.72</td>
</tr>
<tr>
<td>Conformation Score³</td>
<td>11.1</td>
<td>10.5</td>
<td>12.1</td>
<td>10.2</td>
<td>10.9</td>
<td>0.23</td>
<td>0.01</td>
<td>0.55</td>
</tr>
<tr>
<td>Lean Score¹</td>
<td>10.2</td>
<td>11.1</td>
<td>12.0</td>
<td>11.0</td>
<td>10.9</td>
<td>0.32</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Overall Quality Score³</td>
<td>10.5</td>
<td>11.4</td>
<td>12.2</td>
<td>11.1</td>
<td>10.8</td>
<td>0.25</td>
<td>&lt;0.01</td>
<td>0.09</td>
</tr>
<tr>
<td>pH</td>
<td>5.51</td>
<td>5.42</td>
<td>5.55</td>
<td>5.44</td>
<td>5.47</td>
<td>0.03</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

¹Yield grade = 0.4 + (3.94 × BF).
²Percent boneless closely trimmed retail cuts = 49.94 − (0.187 × HCW) − (1.72 × BF) − (1.39 × BW) + (0.38 × LEA).
³Leg score, conformation score, lean score, and marbling score: 1 = cull to 15 = high prime.
⁴Finishing system ALF = alfalfa, A/R = alfalfa for 56 d then ryegrass, CON = limit fed corn, RG = ryegrass, R/A = ryegrass for 56 d then alfalfa.
⁵P values from predetermined contrast A = alfalfa
Table 14. Carcass characteristics of lambs by sex.

<table>
<thead>
<tr>
<th>Item</th>
<th>Ewes</th>
<th>Wethers</th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>EST</td>
<td>SEM</td>
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<td>SEM</td>
<td>P value</td>
</tr>
<tr>
<td><strong>HCW, kg</strong></td>
<td>26.95</td>
<td>0.66</td>
<td>25.40</td>
<td>0.46</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Dressing Percent</strong></td>
<td>52.16</td>
<td>1.07</td>
<td>51.20</td>
<td>0.89</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>KPH weight, kg</strong></td>
<td>0.66</td>
<td>0.04</td>
<td>0.45</td>
<td>0.03</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>KPH %</strong></td>
<td>2.34</td>
<td>0.11</td>
<td>1.68</td>
<td>0.08</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>LEA, cm²</strong></td>
<td>13.52</td>
<td>0.66</td>
<td>13.91</td>
<td>0.56</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>Back fat, cm</strong></td>
<td>0.46</td>
<td>0.03</td>
<td>0.37</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Body Wall, cm</strong></td>
<td>1.73</td>
<td>0.07</td>
<td>1.51</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Yield Grade¹</strong></td>
<td>2.22</td>
<td>0.12</td>
<td>1.85</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>%BCTR²</strong></td>
<td>47.00</td>
<td>0.19</td>
<td>47.74</td>
<td>0.13</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Leg Score³</strong></td>
<td>11.37</td>
<td>0.22</td>
<td>11.22</td>
<td>0.15</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Conformation Score³</strong></td>
<td>11.05</td>
<td>0.18</td>
<td>10.85</td>
<td>0.13</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Lean Score⁵</strong></td>
<td>11.24</td>
<td>0.29</td>
<td>10.63</td>
<td>0.24</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Overall Quality Score³</strong></td>
<td>11.06</td>
<td>0.19</td>
<td>10.69</td>
<td>0.13</td>
<td>0.112</td>
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<tr>
<td><strong>pH</strong></td>
<td>5.51</td>
<td>0.03</td>
<td>5.53</td>
<td>0.02</td>
<td>0.50</td>
</tr>
</tbody>
</table>

¹Yield grade = 0.4 + (3.94 × BF).
²Percent boneless closely trimmed retail cuts = 49.94 – (0.187 × HCW) – (1.72 × BF) – (1.39 × BW) + (0.38 × LEA).
³Leg score, conformation score, lean score, and marbling score: 1 = cull to 15 = high prime.
Figures for Chapter 4.

Figure 6. Mean maximum daily temperature, °C and rainfall, mm for each 2 week period, in 2011 taken from OARDC weather station located 1.6 km south of Wooster OH.
Figure 7. Nutritive values: NDF, ADF, CP, and forage allowance (kg DM kg LW$^{-1}$) from samples collected every two weeks.

Overall LSM for the trial was ALF (NDF 234.3 g kg$^{-1}$, ADF 210.5 g kg$^{-1}$, CP 303.1 g kg$^{-1}$ and forage allowance 1.03 kg DM kg LW$^{-1}$), RG (NDF 554.5 g kg$^{-1}$, ADF 279.5 g kg$^{-1}$, CP 217.2 g kg$^{-1}$ and forage allowance 1.17 kg DM kg LW$^{-1}$). There was an effect of treatment on NDF ADF and CP ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$). There was an effect of treatment on forage allowance ($P = 0.04$), period ($P < 0.01$), and treatment by period ($P < 0.01$).* Date of ryegrass clipping and Urea application after lamb removal from paddock.
Figure 7.
Figure 8. Live weight (kg) of lambs on five treatments for each 2-week weigh period.

There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$).
Figure 9. Average daily gain (kg d\textsuperscript{-1}) by weight period of lambs on different feeding regimes compared with alfalfa.

Overall LSM for the trial was ALF (0.22 kg d\textsuperscript{-1}), CONC (0.24 kg d\textsuperscript{-1}), RG/ALF (0.18 kg d\textsuperscript{-1}), ALF/RG (0.17 kg d\textsuperscript{-1}), and RG (0.14 kg d\textsuperscript{-1}). There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$). * Date of treatment switch.
Figure 9.

Abstract

With lambs, there is a lack of information comparing grazing alfalfa versus other warm season forages, and the effects on lamb growth rate and carcass characteristics. The objective of the study was to compare three forage finishing systems on lamb growth rate and carcass characteristics. Wether (n = 54) lambs blocked by body weight were used to evaluate the effect of finishing systems on rate of growth and carcass composition. Each treatment consisted of three fields of six lambs per field. The finishing systems were grazed alfalfa (ALF), grazed chicory (CHI), and grazed sorghum-sudangrass (SSG).

Forage analysis revealed ALF had lower ADF and NDF content than CHI and SSG throughout the trial (P < 0.05) and greater CP content for all but six weeks (P < 0.05).

Predetermined contrasts between ALF and the other finishing systems were conducted using LSMESTIMATE in PROC MIXED. The slaughter target was predetermined to be the time period when forage became limiting. The SSG lambs were slaughtered 14 d earlier than either the ALF or CHI lambs. The SSG lambs produced lighter carcasses with lower dressing percentages than the ALF lambs (P <0.05). The ALF lambs were not different in carcass weight, loin eye area, and back fat depth from the CHI lambs (P > 0.05). There was a trend for reduced dressing percentage of the ALF lambs when
compared with the CHI lambs \((P = 0.08)\). All three forage treatments produced adequate rate of gain, but would need additional grazing time for lambs to reach adequate carcass weights.

Keywords: Lambs, Alfalfa, Chicory, Sorghum-sudangrass, growth, carcass composition

**Introduction**

Excess fat in US lamb production is a concern of the industry (NRC 2008). Producing finished lamb using grazed forages produces leaner carcasses (McClure et al., 1994; Fluharty et al., 1999; Turner et al., 2002). From previous studies, it was apparent that using alfalfa \((Medicago sativa L.)\) for grazing will produce more lamb weight than using perennial cool-season grasses (McClure et al., 1994; Fraser et al., 2004; Speijers et al., 2004). Other alternative forages exist that may be more suitable for lamb grazing than alfalfa, particularly chicory \((Cichorium intybus L.)\) and sorghum-sudangrass \((Sorghum bicolor L.\ subsp x drummondil)\). Both have nutrient profiles capable of producing adequate live weight gains in lamb during the summer months and are able to be grown on more soil types than alfalfa (Belesky et al., 2000; Fontaneli et al., 2001). However, there have been few studies comparing the growth and carcass characteristics using different summer forages for lamb finishing systems. We hypothesized that growth and carcass characteristics will be the same at the same nutrient intake level regardless of nutrient source. The objective was to determine the effects of three summer forage finishing systems on lamb growth and meat characteristics.
Materials and Methods

All animal procedures were approved by the Agricultural Animal Care and Use Committee of The Ohio State University. The study was conducted at the Sheep Center of the Ohio Research and Development Center, Wooster (40° 43’44.71 N lat, 81° 54’4.25’W long). Rainfall (mm) and maximum daily temperature (°C) for each 2-week weigh period during the trial in 2012 are reported in Fig 9. The fields used for the experiment consisted of soil types Canfield Silt Loam and Ravenna Silt Loam.

Animal management

Crossbred (Hampshire x Dorset) lambs (60 ± 6 days of age) were weaned, weighed and grazed on perennial tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons.) pastures for two weeks, then weighed on two consecutive days. Wether lambs (N = 54, initial BW 24.4 ± 1.6 kg) were used to evaluate the effect of finishing systems on rate of growth and carcass composition in a study that began on June 26, 2012 (d 0) and ended on October 11, 2012 (d 107). Each treatment consisted of three fields of six lambs per field. Lambs were blocked by body weight. The finishing systems were grazed alfalfa (ALF), grazed chicory (CHI), and grazed sorghum-sudangrass (SSG). Lambs were weighed every two weeks. At initiation of the trial, all animals were treated with Moxidectin (Boehringer Ingelheim Vetmedica, St. Joseph, MO) (oral drench, 0.2 mg/kg). Fecal egg counts (FEC) (Table 15) were conducted (Whitlock, 1948) on July 24 (d 28), September 4 (d 70) and October 2 (d 98) to monitor parasite infection. The FEC evaluation processes and time schedule following deworming, were implemented to test anthelmintic effectiveness and coincided with
three-weeks after the lambs, were grazing sections of their respective fields that were previously grazed by dry ewes to keep the respective forage staged. Second Moxidectin (Boehringer Ingelheim Vetmedica, St. Joseph, MO) (oral drench, 0.2 mg/kg) treatments were given to all CHI lambs on September 6 (d 72) and all ALF lambs on October 4 (d 100).

**Field Management**

The fields were randomly allotted to alfalfa (*Medicago sativa* var Consistency 4.10RR), chicory (*Cichorium intybus* var Forage Feast) and sorghum-sudangrass (*Sorghum bicolor subsp x drummondii* var Cow Candy II). Alfalfa and chicory were planted to pure stands the previous August. The sorghum-sudangrass was planted May 29 for one field and June 25 for the second to help ensure proper staging of the forage for grazing. Lime and fertilizer were incorporated prior to planting based on a current soil test (Appendix F) for each field and Tri-State Fertilizer Recommendations (Vitosh et al., 1995). The forages were planted into a conventionally prepared seedbed. The fields 3 for alfalfa, 2 for chicory and 2 for sorghum-sudangrass (0.65 ha) were divided into paddocks (0.02 ha) using temporary electronet. Lambs were grazed for three days on each paddock allowing each paddock a 28 day rest before re-grazing. Alfalfa and chicory paddocks were staged for the beginning of the trial using dry ewes to graze forages to a target residual of 6 cm. Sorghum-sudangrass was mowed to a height of 15 cm after grazing. Nitrogen fertilizer in the form of granular urea (46-0-0) was applied at the rate of 33.6 kg of nitrogen per ha after planting to the sorghum-sudangrass fields and to one chicory field on June 29 to stimulate regrowth. Maturity of the alfalfa fields was pre bud, the chicory
and sorghum-sudangrass was vegetative throughout the trial. Each paddock was equipped with a water tank and water was available ad libitum. Free choice mineralized salt was provided to all the lambs. There were no instances of bloat in the ALF lambs although one lamb died from entanglement in the temporary electric netting.

**Forage Data**

Forage dry matter (DM) was determined every two weeks by taking three, 0.61 m² quadrat clippings per paddock. Clippings were dried in a 100° C oven for 48 hours and the weighed. Every two weeks in each paddock the lambs were entering 30 grab samples were collected from the sward and used for the forage analysis. The grab samples mimicked what was removed or consumed based on the previous paddock. The grab samples from each paddock were combined, dried in a 55° C oven and used for analysis of ADF and NDF (using Ankom Technology Method 5 and 6, respectively; Ankom200 Fiber Analyzer, Ankom Technology, Fairport, N.Y.), and CP (macro Kjeldahl N x 6.25).

**Carcass Data**

Lambs were transported (2 hours) the day before slaughter, kept overnight, weighed and slaughtered the next morning at The Ohio State University Meat Science Laboratory when forage was determined to be limiting. For SSG that was September 27 (d 93) because of high frost potential and the concern of prussic acid build up in the forage. The ALF and CHI were slaughtered on October 11 (d 107) due to limited regrowth of the respective forages. To determine final BW, lambs were weighed on two consecutive days directly before slaughter. Before chilling kidney pelvic heart fat was
removed from the carcass and weighed. Carcasses were chilled (4°C) for 24 h, and then ribbed between the 12th and 13th ribs. At the 12th-rib interface, back fat (BF) thickness, body wall thickness, and loin eye area (LEA) were measured. Visual lean score, leg score, conformation score, and quality grade (Prime+ = 15; Cull = 1) were estimated according to USDA guidelines (USDA, 1992), using the same technician with no reference between carcass and treatments. Loin pH was recorded using a portable pH meter (H198140, Hanna Instruments, Palermo, Italy) equipped with a glass-tipped pH probe (FC201D, Hanna Instruments) inserted 1 cm deep into the exposed LM surface at the 12th- and 13th-rib interface.

**Statistical Analysis**

The experimental design of this study was a randomized complete block design. Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC) (Appendix G).

The model for the forage data was: \( Y_{ijkl} = \mu + p_i + f_j + d_k + g_l + e_{ijkl} \), where \( Y_{ijkl} \) = the response variable; \( \mu \) = the mean; \( p_i \) = the random effect of field (12); \( f_j \) = the fixed effect of forage (alfalfa or ryegrass); \( d_k \) = the fixed effect of date; \( g_l \) = the fixed effect of forage by date; and \( e_{ijkl} \) = the experimental error. Repeated measures were used for forage data where Autoregressive Moving Average, was the covariance structure that yielded the smallest Bayesian information criterion. Simple effects were generated by the SLICE function in SAS.

The model for the average daily gain data was: \( Y_{ijklm} = \mu + p_i + d_j + b_k + g_l + h_m + e_{ijklm} \), where \( Y_{ijklm} \) = the response variable; \( \mu \) = the mean; \( p_i \) = the fixed effect of treatment
(3); \(d_j\) = the fixed effect of date; \(b_k\) = the random effect of block; \(g_i\) = the random effect of pen/paddock; \(h_m\) = the fixed effect of date by treatment; and \(e_{ijklm}\) = the experimental error. Repeated measures were used for ADG data where autoregressive order 1 was the covariance structure that yielded the smallest Bayesian information criterion. Simple effects were generated by the SLICE function in SAS.

The model for the carcass data was: \(Y_{ijk} = \mu + b_i + T_j + e_{ijk}\), where \(Y_{ijk}\) = the response variable; \(\mu\) = the mean; \(b_i\) = the random effect of bodyweight blocks (large, medium or small); \(T_j\) = the fixed effect of dietary treatment; and \(e_{ijk}\) = the experimental error. LSMESTIMATE function in SAS was used for mean separation with preplanned contrast comparing the ALF treatment to the others.

Forage Allowance, based on Sollenberger et al., (2005) was calculated as Forage allowance= \([\text{pregraze forage mass} / \text{days in grazing period} + \text{growth}] \times \text{paddock area} / \text{units of animal live weight}\).

**Results and Discussion**

Forage nutritive values results are presented in Fig. 11. The (Fig. 11, panel 1) was greater for SSG than CHI and ALF throughout the trial \((P < 0.01)\), with an effect for date \((P < 0.01)\) and forage by date interaction \((P < 0.01)\) being detected. Schmidt et al., (2013) and McCutcheon et al., (2014) reported greater NDF values for ALF than were reported here. Schmidt et al., (2013) and Kidane et al., (2010) reported lower NDF values and Parish et al., (2012) reported greater NDF values for CHI than were reported in this study. Differences in reported NDF values may be due to location, or time of year the study was conducted. For example the Schmidt et al., (2013) study was conducted in
South Carolina and Parish et al. (2012) was conducted from April to June in Mississippi. The small variation between the sample dates reflects the vegetative growth of the forage (Brink and Casler, 2012).

The ADF (Fig. 11, panel 2) was greater for CHI and SSG than ALF after the initial sample throughout the trial ($P < 0.01$), with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$) being detected. The decrease in CHI ADF on September 18, may reflect slower growth, because it coincided with a slight decrease in NDF, an increase in CP and a substantial decrease in forage allowance.

The CP (Fig. 11, panel 3) was not different between all three forages for the first three sampling dates ($P > 0.05$). The CP for ALF was greater than SSG and CHI from August 21 throughout the rest of the trial ($P < 0.01$). There was an effect of date ($P < 0.01$) and forage by date interaction ($P < 0.01$). Part of the increase in CP for ALF starting August 7 may be reflective of slower regrowth as evidenced by the decrease in forage allowance starting at the same time. The CP values from the respective forages exceeded the protein requirements for the lamb growth rate during this trial (NRC, 1985).

Forage allowance (Fig. 11, panel 4) expressed as kg DM per kg LW was calculated as described in Sollenberger et al., (2005) and Allen et al., (2011). Forage allowance ($P < 0.01$) was smaller for ALF and CHI than SSG starting July 24 through the end of the trial, with an effect for date ($P < 0.01$) and forage by date interaction ($P < 0.01$). Forage allowance has not been widely reported, Gibb and Treacher (1976) concluded that intake of herbage was not restricted if the allowance was above three times the daily intake of animals. Although forage allowance for this trial was above the
predicted animal intake it was not three times greater. A concern was that forage allowance may have been limiting but previous studies at the same location with lambs grazing ALF reported similar average daily gains at higher forage allowances (McCutcheon et al., 2014). The change in forage allowance for all species is reflective of the growing conditions, since each paddock was set up to give the same area for all replicates. The increase in forage allowance for SSG and its decrease between September 4 and 18, matches the observed growing pattern for the forage.

**Animal Performance**

The mean live weights (LW) for each 2-week period is reported in Fig. 12. There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$). The ALF lambs weighed (LSM ± SE) 2.25 ± 0.92 kg heavier than the CHI lambs only on September 4 ($P < 0.05$). The CHI lambs were heavier than the ALF lambs on August 7 (2.11 ± 0.92 kg), and October 2 (2.48 ± 0.92 kg, $P < 0.05$). The parasite level may have had an impact on the respective weight gain. The CHI lambs had greater FEC than the ALF lambs on September 4 and the ALF lambs had a greater FEC than the CHI lambs on October 2 (Table 15). The ALF lambs were 2.64 ± 0.92 kg heavier than the SSG lambs starting on August 7, ($P < 0.01$), with the difference increasing to 3.99 ± 0.92 kg on September 18 ($P < 0.01$).

The differences in LW may be further explained by looking at the average daily gain (ADG) for each 2-week weight period. The ADG data for each 2-week period are reported in Table 16. There was an effect of treatment ($P = 0.04$), period ($P < 0.01$), and treatment by period ($P < 0.01$).
In only one period was ALF ADG greater \((P < 0.01)\) than CHI ADG, August 7. The ALF lambs had greater ADG than the SSG during two weight periods August 7 and 21 respectively \((P = 0.01, P < 0.01)\). The CHI lambs had greater ADG than the ALF lambs during 2 weight periods, July 24 and September 18 \((P < 0.01)\). The SSG trended greater ADG than the ALF lambs during 2 weight periods, July 24 and September 18 \((P = 0.07)\). The parasite loads (Table 15) could explain some of the variation in the ALF and CHI lambs ADG but that does not account for the change in July 24 period.

**Carcass Data**

Carcass data is presented in Table 17. As described earlier the SSG lambs were slaughtered 14 d before either the ALF and CHI lambs due to frost. All lambs were lighter than the projected weight target based on the history of the farm, but the slaughter decision was based on forage availability and not a lamb measurement. Days on test account for the differences in final live weight (LW) and hot carcass weight (HCW) with ALF lambs being heavier in both than SSG lambs \((P < 0.01)\). The CHI lambs were not statistically different than the ALF lambs in either LW or HCW \((P > 0.05)\). The trend in SSG lambs having smaller loin eye area (LEA) \((P = 0.07)\) and thinner body wall measurements \((P = 0.09)\) could also be associated with the earlier slaughter dates. There was a statistical difference in the dressing percentage (DP) with the ALF lambs having a greater DP than the SSG lambs. This would not be associated with slaughter weight, Santos-Silva et al. (2002) showed no difference in DP between 24 kg and 30 kg lambs, regardless of feeding regime. Schmidt et al. (2013) reported greater DP for steers grazed on ALF and CHI than those that grazed bermudagrass (*Cynodon dactylon* L. Pers.) or
steers that grazed pearl millet (*Pennisetum glaucum* L.). It may be due to the weight of the gastrointestinal tract and the digestibility of the feed. Ingalls et al. (1966) found that sheep fed ALF and birdsfoot trefoil (*Lotus corniculatus* L.) had greater intake and lower retention time compared with sheep fed bromegrass (*Bromus inermis* L.) and reed canarygrass (*Phalaris arundinacea* L.). Robles et al. (1981) reported greater dry matter intake and less retention time in wethers fed orchardgrass (*Dactylis glomerata* L.) with ALF leaves than orchardgrass at different maturity stages with all forages ground to pass a 13mm screen. More digestible feeds results in lighter gastrointestinal tract weights that require less energy for maintenance (Fluharty et al., 1999). There was also a trend for a greater DP in the CHI lambs compared with the ALF lambs (*P* =0.08). This may also be due to the digestibility of the feed. Turner et al., (1999) found no difference in NDF in vitro disappearance rate between orchardgrass-chicory swards and orchardgrass-alfalfa swards, but showed a greater in vitro organic matter disappearance for pure chicory than pure alfalfa swards.

The percentage kidney pelvic heart fat (KPH) showed a trend (*P* = 0.08) with the SSG lambs having a greater percentage KPH than the ALF lambs (*P* <0.03). It is not known if energy produced from the different forages in this experiment affect the site of fat deposition. The trend is not clear. It is similar to other studies comparing carcasses from lambs grazing ALF and those grazing perennial ryegrass (*Lolium perenne* L.), with lambs grazing ALF having a lesser KPH than lambs grazing ryegrass (Turner et al., 2002) while McClure et al., (1994) found no difference in percent KPH from lambs grazing ALF and those grazing ryegrass or orchardgrass. Schmidt et al., (2013) found steers
grazing pearl millet had a smaller percent KPH than those grazing ALF or CHI. There was no difference in back fat measurements between the ALF, CHI and SSG lambs \((P = 0.17)\).

The trend in percent boneless closely trimmed retail cuts (BCTRC) was not apparent from the contrast between ALF and CHI or SSG \((P > 0.05)\) and not enough to overcome a lighter weight carcass. The subjective Leg, Conformation, Lean, and Overall Quality Scores were not different between treatments \((P > 0.05)\). All would fall into the Good category. This is lower than what is desired by the industry (NRC 2008) and indicates that May born lambs grazed on these forages after weaning would need additional forage to graze when the forage species used in this study stop growing or the lambs would need to be placed on feed or harvested forages to reach acceptable carcass targets.

**Implications**

Alfalfa, chicory and sorghum-sudangrass produced similar gains in weaned lambs grazing during the summer months and are options to be included in a forage based system. There were minor differences in carcass characteristics when different slaughter dates are taken into account. All forages stopped growing before the lambs reached desirable carcass targets. Lambs on a forage based finishing system would need additional forage.
Literature Cited


Tables for Chapter 5.

Table 15. Fecal egg counts for treatment groups.

<table>
<thead>
<tr>
<th>Item</th>
<th>July 24 EPG</th>
<th>September 4 EPG</th>
<th>October 2 EPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>0</td>
<td>3</td>
<td>1561</td>
</tr>
<tr>
<td>Chicory</td>
<td>4</td>
<td>4352</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum Sudangrass</td>
<td>1</td>
<td>0</td>
<td>---</td>
</tr>
</tbody>
</table>

*Eggs per gram*
Table 16. Average daily gain (kg/d) by period of lambs on different feeding regimes.

<table>
<thead>
<tr>
<th>Period End Date</th>
<th>Alfalfa</th>
<th>Chicory</th>
<th>Sorghum - Sudangrass</th>
<th>SE</th>
<th>A vs C</th>
<th>A vs SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fields (No. lambs)</td>
<td>3 (17)</td>
<td>3 (18)</td>
<td>3 (18)</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>10 – July</td>
<td>0.19</td>
<td>0.16</td>
<td>0.22</td>
<td>0.04</td>
<td>0.26</td>
<td>0.13</td>
</tr>
<tr>
<td>24 – July</td>
<td>0.14</td>
<td>0.31</td>
<td>0.17</td>
<td>0.04</td>
<td>&lt;0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>7 – August</td>
<td>0.40</td>
<td>0.16</td>
<td>0.24</td>
<td>0.04</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>21 – August</td>
<td>0.28</td>
<td>0.21</td>
<td>0.09</td>
<td>0.04</td>
<td>0.27</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>4 – Sept.</td>
<td>0.08</td>
<td>0.15</td>
<td>0.18</td>
<td>0.04</td>
<td>0.26</td>
<td>0.13</td>
</tr>
<tr>
<td>18 – Sept.</td>
<td>0.17</td>
<td>0.44</td>
<td>0.29</td>
<td>0.04</td>
<td>&lt;0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>2 – October</td>
<td>0.28</td>
<td>0.31</td>
<td>---</td>
<td>0.04</td>
<td>0.60</td>
<td>---</td>
</tr>
<tr>
<td>Overall</td>
<td>0.22</td>
<td>0.25</td>
<td>0.20</td>
<td>0.01</td>
<td>0.07</td>
<td>0.55</td>
</tr>
</tbody>
</table>
Table 17. Carcass characteristics of lambs on different feeding regimes.

<table>
<thead>
<tr>
<th>Item</th>
<th>Alfalfa</th>
<th>Chicory</th>
<th>Sorghum - Sudangrass</th>
<th>SE</th>
<th>F test</th>
<th>Contrast P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fields (No. Lambs)</td>
<td>3(17)</td>
<td>3(18)</td>
<td>3(18)</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Days on test</td>
<td>107</td>
<td>107</td>
<td>93</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Final LW, kg</td>
<td>38.66</td>
<td>38.60</td>
<td>32.79</td>
<td>1.58</td>
<td>0.02</td>
<td>0.97  0.01</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>20.08</td>
<td>20.92</td>
<td>14.74</td>
<td>1.01</td>
<td>&lt;0.01</td>
<td>0.42 &lt;0.01</td>
</tr>
<tr>
<td>Dressing Percent</td>
<td>51.91</td>
<td>54.12</td>
<td>44.78</td>
<td>0.83</td>
<td>&lt;0.01</td>
<td>0.08 &lt;0.01</td>
</tr>
<tr>
<td>KPH weight, kg</td>
<td>0.16</td>
<td>0.20</td>
<td>0.09</td>
<td>0.02</td>
<td>0.08</td>
<td>0.32  0.11</td>
</tr>
<tr>
<td>KPH %</td>
<td>0.67</td>
<td>0.71</td>
<td>0.79</td>
<td>0.02</td>
<td>0.07</td>
<td>0.34  0.03</td>
</tr>
<tr>
<td>LEA, cm²</td>
<td>12.99</td>
<td>13.18</td>
<td>10.25</td>
<td>0.75</td>
<td>0.07</td>
<td>0.85  0.05</td>
</tr>
<tr>
<td>Back fat, cm</td>
<td>0.15</td>
<td>0.22</td>
<td>0.15</td>
<td>0.02</td>
<td>0.17</td>
<td>0.11  0.93</td>
</tr>
<tr>
<td>Body Wall, cm</td>
<td>1.04</td>
<td>1.12</td>
<td>0.73</td>
<td>0.09</td>
<td>0.09</td>
<td>0.56  0.08</td>
</tr>
<tr>
<td>Yield Grade¹</td>
<td>0.99</td>
<td>1.25</td>
<td>0.98</td>
<td>0.09</td>
<td>0.17</td>
<td>0.11  0.93</td>
</tr>
<tr>
<td>%BCTRC²</td>
<td>49.42</td>
<td>49.11</td>
<td>49.81</td>
<td>0.17</td>
<td>0.10</td>
<td>0.26  0.18</td>
</tr>
<tr>
<td>Leg Score³</td>
<td>9.11</td>
<td>9.25</td>
<td>8.72</td>
<td>0.27</td>
<td>0.45</td>
<td>0.74  0.38</td>
</tr>
<tr>
<td>Conformation Score³</td>
<td>9.11</td>
<td>9.25</td>
<td>8.72</td>
<td>0.23</td>
<td>0.37</td>
<td>0.70  0.32</td>
</tr>
<tr>
<td>Lean Score³</td>
<td>9.22</td>
<td>9.19</td>
<td>8.72</td>
<td>0.21</td>
<td>0.30</td>
<td>0.92  0.18</td>
</tr>
<tr>
<td>Overall Quality Score³</td>
<td>9.11</td>
<td>9.18</td>
<td>8.67</td>
<td>0.20</td>
<td>0.28</td>
<td>0.81  0.21</td>
</tr>
<tr>
<td>pH</td>
<td>5.66</td>
<td>5.66</td>
<td>5.57</td>
<td>0.03</td>
<td>0.16</td>
<td>0.99  0.10</td>
</tr>
</tbody>
</table>

1Yield grade = 0.4 + (3.94 × BF).
2Percent boneless closely trimmed retail cuts = 49.94 – (0.187 × HCW) – (1.72 × BF) – (1.39 × BW) + (0.38 × LEA).
3Leg score, conformation score, lean score, and marbling score: 1 = cull to 15 = high prime.
Figures for Chapter 5.

Figure 10. Mean maximum daily temperature, °C and rainfall, mm for each 2-week period during 2012, taken from OARDC weather station located 1.6 km south of Wooster OH.
Figure 11. Forage quality values: NDF g kg$^{-1}$, ADF g kg$^{-1}$, CP g kg$^{-1}$, and forage allowance (kg DM kg LW$^{-1}$) from samples collected every 2-weeks.

Overall LSM for the trial was ALF (NDF 258.8 g kg$^{-1}$, ADF 224.0 g kg$^{-1}$, CP 235.6 g kg$^{-1}$ and forage allowance 0.1 kg DM kg LW$^{-1}$), CHI (NDF 366.3 g kg$^{-1}$, ADF 303.8 g kg$^{-1}$, CP 191.8 g kg$^{-1}$ and forage allowance 0.09 kg DM kg LW$^{-1}$), and SS (NDF 529.5 g kg$^{-1}$, ADF 287.7 g kg$^{-1}$, CP 194.3 g kg$^{-1}$ and forage allowance 0.26 kg DM kg LW$^{-1}$). There was an effect of treatment on NDF, ADF, CP, and forage allowance ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$).
Figure 11.
Figure 12. Live weight (kg) of lambs on different treatments for each 2-week weigh period.

There was an effect of treatment ($P < 0.01$), period ($P < 0.01$), and treatment by period ($P < 0.01$).
Chapter 6: Integration of Sheep Grazing Into an Organic Crop Production System
to Control Weeds

Abstract

Two experiments were conducted to determine the efficacy of using sheep to control weeds in an organic crop production system. In experiment 1, mature ewes were grazed on weeds following crop removal in 2012 in five established organic crop fields with each growing as part of a five-year rotation of red clover (*Trifolium pratense* L.), corn (*Zea mays* L.), soybeans (*Glycine max* (L.) Merr.), oats (*Avena* L.) and barley (*Hordeum* L.). Results showed that ewes can be used to remove weeds from organic fields after crop harvest. They will eat most weeds present in crop fields including; giant ragweed (*Ambrosia trifida* L.), lambsquarter (*Chenopodium album* L.), foxtails (*Setaria spp.* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), and woodsorrel (*Oxalis* L). The amount they eat increases and dietary choices decrease at higher stocking densities. In experiment 2, giant ragweed, lambsquarter, and sudangrass (*Sorghum bicolor subsp. drummondii*, var. Promax) were hand harvested each morning, and used in a cafeteria study after ewes had been fed to meet their maintenance requirements, to determine preference in ewes that had been introduced to all three plants. All three plants were consumed at a high rate (> 95%). Consumption increased in Day 2 for all except the forage sorghum. Giant ragweed was consumed the least of the
three \((P < 0.05)\). Since the ewes were fed to meet their maintenance each day the results indicate that both lambsquarter and giant ragweed are palatable to mature ewes.

Keywords: sheep, weed control, organic cropping systems

**Introduction**

There is a deficiency of scientific investigation regarding organic meat production as well as the efficacy of integrating organic cropping systems with organic livestock production. A major limitation to organic sheep production is control of gastrointestinal parasites, since the USDA’s National Organic Standards prohibit the use of parasiticides (anthelmintics) in any meat animal from the last third of gestation through slaughter. Grazing sheep in annual crop fields may provide excellent nutrition for the animals and may break up the parasite life cycle and reduce the need for anthelmintics. This leads to the possibility of using sheep in an integrated organic annual cropping and pasture farming system, as grazing sheep may help manage the weed pressure typically found under organic cropping conditions. In addition, the growing demand for lamb and goat in ethnic markets in many areas of the country, including Ohio (Inwood, 2004), offers economic diversity opportunities to organic farmers.

By integrating animal and plant resources to utilize complementary and synergistic relationships, flexibility, and economic viability of an agroecosystem should be improved (Parker, 1990). Sheep and goats are natural livestock choices for a sustainable organic system. They are small, tend to be hardy and are easily handled. Their needs are minimal; shelter and fencing are the primary up-front costs, so capital
cost of entry is relatively low. They can be managed on a grazing system, with minimal grain supplementation, and used to glean post-harvest crop fields. Historically, sheep were commonly used to keep fields free from weeds (Parker, 1990). Sheep primarily consume forages, but they are known to eat 90% of weed species and are increasingly being used as biological tools for resource management to control weeds, for example, for grazing under power lines and for leafy spurge control (*Euphoriba esula* L.) (Parker, 1990). Sheep have been studied for weed control in western rangelands and were effective for control of spotted knapweed (*Centaurea stoebe* L.) (Ganguli et al., 2010) and medusahead (*Taeniatherum caput-medusae* L.) (DiTomaso et al., 2008). Sheep have been studied for control of common weeds present in dryland grain production (Hatfield et al., 2007). To our knowledge, only one study has evaluated using sheep for control of weeds common to Midwest crop production and it was focused on weeds in established forages (Marten and Andersen, 1975). In that study they found giant ragweed (*Ambrosia trifida* L.) unpalatable by sheep. One of the biggest challenges facing organic producers is weed pressure (Waltz, 2004). In Ohio, giant ragweed is a concern for both conventional and organic grain farmers (Loux and Berry, 1991; personal communication). Animut et al. (2005) did a comprehensive study to evaluate the performance and forage selectivity of sheep and goats co-grazing grass/forb pastures at different stocking rates in Oklahoma. Common ragweed (*Ambrosia artemisiifolia* L.) was part of this study, but not giant ragweed. In year 2, the preference value for common ragweed was lower for sheep versus goats but increased linearly with increasing stocking rate of both sheep and goats. At the highest stocking rate, grazing pressure was high
enough and forage availability adequately limited to lessen forb selectivity against common ragweed to a point at which the contribution to forbs in the sward pre- and post-grazing was similar for ragweed and other forbs (Animut et al., 2005). Taken together, these studies suggest that defining the stage of growth and the stocking rate that will result in weed consumption by livestock needs to be defined for the use of small ruminants for weed control in organic farming systems.

Animals are a desirable component in an organic farming system. They help maintain biological diversity, as well as adding financial diversity. Their feces and urine return a majority of the nutrients consumed in forage to the soil and help improve soil fertility. By integrating animal and plant resources to utilize complementary and synergistic relationships, flexibility and economic viability of an agro ecosystem should be improved (Parker, 1990). Sheep are a natural livestock choice for a sustainable organic system. They are small, tend to be hardy and are easily handled. Their needs are minimal; shelter and fencing are the primary up-front costs, so capital cost of entry is relatively low. Sheep can be managed on a grazing system, with minimal grain supplementation, and can be used to glean post-harvest crop fields. Furthermore, sheep have been shown to have some potential as a means of weed control, depending on stocking rate (Animut et al., 2005, 2006) and species of weed present. Differences in the nutritive value and palatability of various weed species have been reported (Marten and Andersen, 1975).

The objective of this study was to determine if sheep would eat weeds growing in organic crop fields after crop harvest, and specifically if they would eat giant ragweed.
The hypothesis was that ewes grazing weeds after crop harvest would eat a variety of weeds, including giant ragweed, and that stocking density would increase the weeds consumed.

Methods

Experiment 1

Experiment 1 was conducted at the West Badger Farm (40° 46’53.75” N, 81° 50’55.43” W ) on the campus of the Ohio Agricultural Research and Development Center. The farm has been certified organic since 2001. The plot consisted of five equal sized fields (0.77 ha) that were in a five year rotation consisting of red clover (Trifolium pratense L.), corn (Zea mays L.), soybeans (Glycine max (L.) Merr.), oats (Avena L.) and barley (Hordeum L.). Each of the five fields were subdivided into nine paddocks (0.08 ha each) using temporary electric fencing. The treatments were high stocking rate (HS) at six ewes per paddock, a low stocking rate (LS) at three ewes per paddock, and a control with no animals. The treatments were randomly assigned within three blocks.

Animals used were dry ewes grazing permanent pasture at the Sheep Center of the Ohio Research and Development Center, Wooster. The ewes were randomly sorted from the ewe flock maintained at the Center. The ewes were weighed, trailered to West Badger and randomly placed in appropriate paddocks. Water and a mineral salt block were provided at all times. After grazing the animals were trailered back to the Sheep Center and weighed.

Herbage mass sampling was done using three, 0.61 m² quadrat clippings per paddock before and after grazing. Clippings were dried in a 100° C oven for 48 hours.
and the weighed. Plant counts were done before and after grazing using a transect rope running from the SW to NW corners of the paddocks. Three knots were randomly placed in the rope before the start of the trial and used as sampling points. At each knot a 0.61 m$^2$ quadrat was placed over the vegetation. Plants were counted within the quadrat.

Grazing in 2012 took place in three events. The first was a month following barley harvest for 3 days. The second was a month later after weed regrowth in the barley and oat fields for 3 days. The final was in the corn, soybean and clover fields in early October for 7 days.

**Experiment 2**

A cafeteria study was conducted in September 2013 at the Sheep Center of the Ohio Research and Development Center, Wooster, OH. Dry ewes ($n = 42$) were used in 21 pens (two ewes per pen). Pens ($1.5 \times 4.9$ m) were on expanded metal floors, and each ewe had access to at least 0.75 m of feed bunk space.

Ewes were pulled off permanent pasture, weighed and randomly placed in pens. In the bunks 1.81 kg of all three forages (giant ragweed, lambsquarter, and sudangrass) was placed in the bunks the first day. The next two days ewes were fed 2.04 kg of alfalfa meal pellets at 8:00 a.m. to meet their maintenance requirements. At 12:00 p.m. 1.81 kg of respective wet forage was placed in the bunk. After three hours refusals were weighed back. An additional 1.81 kg of each forage was placed in separate feed bunks and weighed back at the end of the session to determine moisture loss during the feeding period.
Giant ragweed, lambsquarter, and sudangrass were hand harvested each morning from locations within 16 km of the Sheep Center. The giant ragweed and lambsquarter were harvested from crop fields with the branches only being harvested leaving the stem behind. The sudangrass was planted for another trial and the top 50.8 cm was harvested. Grab samples were pulled from each forage and dried in a 55°C and used for analysis of ADF and NDF (using Ankom Technology Method 5 and 6, respectively; Ankom200 Fiber Analyzer, Ankom Technology, Fairport, N.Y.), and CP (macro Kjeldahl N x 6.25).

**Statistical Analysis**

The experimental design of this study was a randomized complete block design. For the field trial, data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). The model for the weed consumption data included the random effect of replicate block (3), the fixed effect of stocking density (high, low or none), the random effect of weeds by stocking density; the fixed effect of date (3), the random effect field (5), and the random effect initial weed count (35). The DIFF function with the ‘none’ treatment as control was used for mean separation. The model for the Dry Matter (DM) consumption data included the random effect of replicate block (3), the fixed effect stocking density (high, low or none); the random effect of date (3), the random effect of field (5), and the random effect of initial weed DM (35). The DIFF function with the ‘none’ treatment as control was used for mean separation. The model for the cafeteria trial data included the the random effect of replicate block (3), the fixed effect of feed (giant ragweed, lambsquarter, or sorghum sudangrass), the fixed effect of day (2), and and the fixed effect
of feed by day; and the random effect of pen (21). The DIFF function was used for mean separation.

Results and Discussion

Dry ewes were grazed on weeds following crop removal in 2012 in five established organic crop fields with each growing as part of the five-year rotation of red clover, corn, soybeans, oats and barley. Based on quadrat samples the weeds species present at each grazing and the contribution of individual species to the total population were not consistent at initiation of each grazing period (Table 18). For this analysis and discussion we focus on the weeds present at larger percentages in all 3 periods, those include giant ragweed (*Ambrosia trifida*), Pennsylvania smartweed (*Polygonum pensylvanicum*), lambs quarter (*Chenopodium album*), wood sorrel (*Oxalis acetosella*), and foxtails (*Setaria* spp.). Those five weeds were similar to what Loux and Berry (1991) found based on a survey of Ohio growers with foxtails, giant ragweed, lambsquarter, and Pennsylvania smartweed identified in the 10 most severe weed problems by farmers. Ewes were stocked at a density of 75 ewes/ha (4,840 kg/ha) for the HS groups and 38 ewes/ha (2,355 kg/ha) for the LS groups. As expected the HS groups ate more weeds (Table 19). The percentage consumption of the HS groups implies a preference order of giant ragweed = lambsquarter > foxtails = Pennsylvania smartweed = wood sorrel (P < 0.05). The percentage of the LS groups does not follow the same pattern with giant ragweed being consumed greater than the others (P < 0.05). This contradicts Marten and Andersen (1975) who found both giant foxtail and giant ragweed unpalatable to sheep. The difference in the findings can be explained by the fact they included an oat boarder, a
food the ewes were familiar with, and our study did not include a familiar food. Offering a familiar food can influence consumption of a new food and mature animals do not accept new foods as well as young animals (Arnold and Maller, 1977).

The amount of weeds available at initial turn in also influenced the amount consumed. Since there were more species than the five we choose to look at, we also calculated the change in the weeds contribution to the total population sampled (Table 20). There was no significant difference between the weeds presented here ($P > 0.05$). All five constituted a smaller percentage of the final population at both stocking densities. There was an effect of stocking density with the HS showing a greater reduction in the weeds presented, except for lambsquarter. The larger numerical reduction in lambsquarter at the LS may indicate a preference for lambsquarter.

Based on Tables 19 and 20 there was an effect of stocking density. Considering total DM consumed makes that effect clearer (Table 21). The HS groups consumed more DM ($P < 0.01$). That was not surprising as others have found the same thing (Animut et al., 2006; Shaw et al., 2006). Animut et al., (2006) used stocking densities of 40, 60, and 80 ewes/ha, while Shaw et al., (2006) found the same results at greater stocking densities of 1,333 and 5,715 ewes/ha. When we consider using dry ewes for weed control greater stocking densities will accomplish the task.

The effect on the animal also needs considered. The ewes were dry and only needed to maintain their bodyweight (NRC, 1985). This was a concern as sheep exhibit decreased intake of novel foods at a novel environment (Burritt and Provenza, 1997). Table 22 shows the weight change of the ewes during each grazing event. There were
differences in stocking rates \( (P < 0.01) \) and date \( (P < 0.01) \). Intake was adequate in July and the LS in August to gain weight. The weight loss in the October grazing event may be due to the fact the October grazing event lasted 7 days compared with 3 days for the other two dates. Intake decreases the more days sheep are in a paddock (Shaw et al., 2006). This suggests that moving frequently would keep intake adequate for ewes on maintenance diet. Weight loss in the dry production phase is permissible (NRC, 1985) and the HS group lost less than 5% of their BW in October. Decreasing BW in some production phases, pre-breeding and gestation can decrease the production of the ewe (NRC, 1985) and would need monitored if grazing during those phases.

A cafeteria trial was also conducted to determine if ewes would eat giant ragweed and lambsquarter. Those two weeds were selected due to space limitations. Forage Sorghum was used as a control because the flock had experience grazing it. Table 23 list the forage analysis values for each plant used in the cafeteria trial. The forage sorghum had the most moisture, ADF, NDF, and CP. All three plants were consumed at a high rate (> 95%) (Table 24). Consumption increased in Day 2 for all except the forage sorghum. Giant ragweed was consumed the least of the three \( (P <0.05) \). Since the ewes were fed to meet their maintenance each day the results indicate that both lambsquarter and giant ragweed are palatable to mature ewes.

**Conclusion**

Dry ewes can be used to remove weeds from organic fields after crop harvest. They will eat most weeds present in crop fields including; giant ragweed, lambsquarter,
foxtails, Pennsylvania smartweed, and woodsorrel. The amount they eat increases and dietary choices decrease at higher stocking densities.

**Literature Cited**


Tables for Chapter 6.

Table 18. Percentage of weeds present in all samples at the beginning of each grazing period in Experiment 1.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>30-Jul</th>
<th>26-Aug</th>
<th>8-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giant Ragweed</td>
<td><em>Ambrosia trifida</em> L.</td>
<td>3.12%</td>
<td>3.18%</td>
<td>7.38%</td>
</tr>
<tr>
<td>Common Ragweed</td>
<td><em>Ambrosia artemisiifolia</em> L.</td>
<td>4.53%</td>
<td>5.42%</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania Smartweed</td>
<td><em>Polygonum pensylvanicum</em> L.</td>
<td>16.15%</td>
<td>13.62%</td>
<td>0.27%</td>
</tr>
<tr>
<td>Lambs Quarter</td>
<td><em>Chenopodium album</em> L.</td>
<td>17.56%</td>
<td>16.40%</td>
<td>22.68%</td>
</tr>
<tr>
<td>Pigweed</td>
<td><em>Abutilon theophrasti</em> L.</td>
<td>1.42%</td>
<td>3.32%</td>
<td>0.94%</td>
</tr>
<tr>
<td>Wood sorrel</td>
<td><em>Oxalis acetoella</em> L.</td>
<td>18.98%</td>
<td>13.14%</td>
<td>11.88%</td>
</tr>
<tr>
<td>Common Purslane</td>
<td><em>Portulaca oleracea</em> L.</td>
<td>9.35%</td>
<td>1.36%</td>
<td>0.13%</td>
</tr>
<tr>
<td>Hairy Galinsoga</td>
<td><em>Galinsoga ciliate</em> L.</td>
<td>4.53%</td>
<td>3.12%</td>
<td>0.20%</td>
</tr>
<tr>
<td>Foxtails</td>
<td><em>Setaria spp.</em> L.</td>
<td>19.55%</td>
<td>35.16%</td>
<td>20.27%</td>
</tr>
<tr>
<td>Thistles</td>
<td><em>Cirsium arvense</em> L.</td>
<td>0.85%</td>
<td>3.59%</td>
<td>11.81%</td>
</tr>
<tr>
<td>Burdocks</td>
<td><em>Arctium minus</em> L.</td>
<td>0.57%</td>
<td>0.41%</td>
<td>0.74%</td>
</tr>
<tr>
<td>Horsenettle</td>
<td><em>Solanum carolinense</em> L.</td>
<td>0.85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marestail</td>
<td><em>Conyza Canadensis</em> L.</td>
<td>1.42%</td>
<td>0.27%</td>
<td></td>
</tr>
<tr>
<td>Nutsedge</td>
<td><em>Cyperus esculentus</em> L.</td>
<td>0.28%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shepherds Purse</td>
<td><em>Capsella bursa-pastoris</em> L.</td>
<td>0.88%</td>
<td>23.29%</td>
<td></td>
</tr>
<tr>
<td>Aster</td>
<td><em>Aster pilosus</em> L.</td>
<td>0.14%</td>
<td>0.07%</td>
<td></td>
</tr>
<tr>
<td>Plantain</td>
<td><em>Plantago major</em> L.</td>
<td>0.07%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velvetleaf</td>
<td><em>Abutilon theophrasti</em> L.</td>
<td>0.20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Nightshade</td>
<td><em>Solanum nigrum</em> L.</td>
<td>0.07%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 19. Percentage of weeds consumed in three separate grazing events in Experiment 1.

<table>
<thead>
<tr>
<th>Stocking Density</th>
<th>Giant Ragweed</th>
<th>Foxtails</th>
<th>Lambs Quarter</th>
<th>Pennsylvania Smartweed</th>
<th>Woodsorrel</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>72.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.57&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Low</td>
<td>52.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.53&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Percentages with different superscripts within rows differ \( (P < 0.05) \).

<sup>1</sup> Overall differences in percentage of plants consumed were \( P < 0.001 \), with an effect of stocking density \( P < 0.0001 \) and a plant by stocking density interaction \( P = 0.0002 \).
Table 20. Percentage reduction in weed contribution to total weed population present in Experiment 1.

<table>
<thead>
<tr>
<th>Stocking Density</th>
<th>Giant Ragweed</th>
<th>Foxtails</th>
<th>Lambs Quarter</th>
<th>Pennsylvania Smartweed</th>
<th>Woodsorrel</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>10.17</td>
<td>16.09</td>
<td>3.22</td>
<td>7.87</td>
<td>15.24</td>
</tr>
<tr>
<td>Low</td>
<td>9.07</td>
<td>10.00</td>
<td>10.61</td>
<td>6.22</td>
<td>5.40</td>
</tr>
</tbody>
</table>

1 Percent of weed in beginning population – percent of weed in ending population
2 Overall differences in percentage of plant population change were $P = 0.8879$, with an effect of stocking density $P = 0.0086$ and a plant by stocking density interaction $P = 0.2475$. 
Table 21. Difference in consumption of available dry matter compared with control in Experiment 1.

<table>
<thead>
<tr>
<th>Stocking Density</th>
<th>Percentage consumed above control(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>63.03</td>
</tr>
<tr>
<td>Low</td>
<td>16.83</td>
</tr>
</tbody>
</table>

\(^1\) \(P = 0.0093\).
Table 22. Ewe weight change during grazing event in Experiment 1.

Weight change (kg) for each Grazing Period\textsuperscript{1,2}

<table>
<thead>
<tr>
<th>Stocking Density</th>
<th>July</th>
<th>August</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>4.69 (0.93)</td>
<td>-1.04 (0.88)\textsuperscript{a}</td>
<td>-3.86 (1.90)</td>
</tr>
<tr>
<td>Low</td>
<td>5.14 (1.14)</td>
<td>3.10 (0.94)\textsuperscript{b}</td>
<td>-2.60 (2.12)</td>
</tr>
</tbody>
</table>

\textsuperscript{a,b} Percentages with different superscripts within rows differ \((P < 0.05)\).
\textsuperscript{1} Initial weight – ending weight, LSM (SE).
\textsuperscript{2} Overall differences in ewe weight change by stocking density were \(P < 0.001\), with an effect of date \(P < 0.0001\) and a date by stocking density interaction \(P = 0.0008\).
Table 23. Forage analysis of species used in cafeteria trial.

<table>
<thead>
<tr>
<th>Plant</th>
<th>% DM</th>
<th>ADF g kg⁻¹</th>
<th>NDF g kg⁻¹</th>
<th>CP g kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambs quarter</td>
<td>30.28</td>
<td>308.9</td>
<td>420.6</td>
<td>126.7</td>
</tr>
<tr>
<td>Giant Ragweed</td>
<td>33.61</td>
<td>354.0</td>
<td>372.8</td>
<td>129.9</td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>20.38</td>
<td>367.3</td>
<td>588.8</td>
<td>137.5</td>
</tr>
</tbody>
</table>
Table 24. Percentage forage consumed in cafeteria trial on a dry matter basis.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Day 1</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage consumed</td>
<td>Percentage consumed</td>
</tr>
<tr>
<td>Lambs quarter</td>
<td>98.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>99.55&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Giant Ragweed</td>
<td>95.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>98.17&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>99.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>99.35&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup><sup>b</sup> Percentages with different superscripts within columns differ \( (P < 0.05) \).

<sup>1</sup> Overall differences in percentage of plant consumed were \( P < 0.001 \), with an effect of day \( P = 0.008 \) and a plant by day interaction \( P = 0.0453 \).
Appendix A: Producer survey used
Assessing production, economics, and marketing of meat from forage-based systems

Producer survey Spring 2010

This project was funded in part by USDA-NIFA cooperative agreement no. OHO01059-SS, Ohio Agricultural Research & Development Center, Ohio State University Extension, and the Small Farm Institute.

Figure 13. Survey instrument used in Chapters 2 and 3.
Please answer the following questions and return this survey in the enclosed postage paid envelop.
1. Which of these best describes your livestock management? (select one)

- confinement animal feeding (grain-based)
- pasture based with some grain
- totally forage based, no harvested forage
- totally forage based, including harvested forage

2. What are the components of your current livestock rearing system?
(check all that apply)

- total confinement/no pasture
- improved pasture
- native pasture
- grazing crop residue
- grazing annual forages

3. How frequently do you feed the following to your livestock?

<table>
<thead>
<tr>
<th></th>
<th>Never (1)</th>
<th>Sometimes (2)</th>
<th>Often (3)</th>
<th>Always (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Grain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. By products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[e.g., distillers grain, soy hulls, corn gluten]</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. Hay</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. Baleage</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. Silage</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 13. Continued
4. To what extent are the following factors important to your farm management system?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important (1)</th>
<th>A little important (2)</th>
<th>Sometimes important (3)</th>
<th>Important (4)</th>
<th>Very important (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. balance forage supply with forage demand to minimize haying livestock in normal periods of forage shortage [e.g. late summer dry period] ...</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>b. use a variety of forages to complement different seasonal growth patterns</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c. rotational grazing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. maintain uniform plant height in pastures/paddocks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e. maintain livestock in excellent body condition</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>f. run a diverse livestock operation by using a variety of livestock species at different stages of production</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>g. minimize livestock impacts to riparian zones/streams</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>h. produce high quality products to meet market demand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>i. livestock holding facilities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>j. feed storage</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>k. feeding equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>l. manure management structure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>m. manure handling equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>n. fencing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>o. access to stream</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>p. pasture watering infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>q. financing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>r. soil types</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>s. topography</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>t. competition for land</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>u. access to viable livestock markets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>v. profit margin on livestock</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 13. Continued
5. Are livestock an important enough part of your operation to borrow money for feed, grazing, or facilities?
   ■ yes  ■ no

6. Do you currently use a grazing based system to manage your livestock?
   ■ yes  ■ no

   If yes, why? (check all that apply)
   ■ a. Profitability
   ■ b. Market Potential
   ■ c. My land is more suited to native pasture rather than row crops
   ■ d. My land is more suited to improved pasture rather than row crops
   ■ e. I manage grazing for back grounding [e.g. cow-calf stocker; ewe-lambs]
   ■ f. I manage grazing for finishing animals
   ■ g. Environmental benefits
   ■ h. Family/lifestyle reasons
   ■ i. Efficient use of time
   ■ j. Animal welfare
   ■ k. Lower capital investment

   If no, why have you not moved to a grass based system? (check all that apply)
   ■ a. Profitability
   ■ b. Market Potential
   ■ c. My land is more suited to row crops
   ■ d. Don’t have pasture infrastructure
   ■ e. Environmental risk
   ■ f. Family/lifestyle reasons
   ■ g. Efficient use of time
   ■ h. Animal welfare
   ■ i. Capital investment in land
   ■ j. Capital investment in fencing
   ■ k. Capital investment in water supply
   ■ l. Concern over predators

Figure 13. Continued
7. In your opinion, to what extent do these factors influence a decision to move to a grass-based grazing system from a grain and harvest forage system?

<table>
<thead>
<tr>
<th>Factor</th>
<th>No influence (1)</th>
<th>Some influence (2)</th>
<th>Moderate influence (3)</th>
<th>High influence (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. available livestock breeds</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. type of current livestock</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. desired genetics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. handling facilities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. access to land</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>f. suitability of land</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>g. labor availability</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>h. equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>i. fencing/watering infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>j. knowledge of grass/forage management</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>k. niche marketing opportunities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

8. Please indicate your opinion on each of the following statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree (1)</th>
<th>Disagree (2)</th>
<th>No opinion (3)</th>
<th>Agree (4)</th>
<th>Strongly agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I would rather take an off farm job than start a grass-fed livestock enterprise</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>b. I don’t want to start something new</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c. I don’t know the markets for grass-based livestock</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. I am not convinced about demand for grass-based livestock</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e. I am uncomfortable trying to market directly to consumers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>f. I don’t have sufficient business development experience to manage the supply chain of processing storing and marketing of grass based products</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>g. I believe start up costs for conversion to grass based system are too high</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>h. I am too busy with my current farm operation to get involved doing something different</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>i. I believe the commodity program is a safety net that grass-based livestock production lacks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>j. I believe banks are reluctant to provide financing for grass based livestock production</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 13. Continued
9. In your opinion how do these factors influence consumer acceptance of grass-fed animal products?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all (1)</th>
<th>A little (2)</th>
<th>Moderate (3)</th>
<th>Strong (4)</th>
<th>Very strong (5)</th>
<th>Don’t know (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. meat flavor intensity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>b. off flavor of meat</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>c. cooked aroma of meat</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>d. types of meat cuts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>e. meat tenderness</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>f. meat juiciness</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>g. fat color in the retail case</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>h. lean color in the retail case</td>
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<td>3</td>
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</tr>
<tr>
<td>i. meat shelf-life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
</tr>
<tr>
<td>j. packaging design</td>
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<td>2</td>
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</tr>
<tr>
<td>k. packaging type</td>
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<td>2</td>
<td>3</td>
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<td>6</td>
</tr>
<tr>
<td>l. labeling</td>
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<td>2</td>
<td>3</td>
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<td>6</td>
</tr>
<tr>
<td>m. price</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
</tr>
<tr>
<td>n. frozen meat precuts</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>o. fresh/refrigerated meat products</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</table>

10. In your opinion how do these factors influence consumer acceptance of grain-fed animal products?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all (1)</th>
<th>A little (2)</th>
<th>Moderate (3)</th>
<th>Strong (4)</th>
<th>Very strong (5)</th>
<th>Don’t know (6)</th>
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</thead>
<tbody>
<tr>
<td>a. meat flavor intensity</td>
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<td>2</td>
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<td>6</td>
</tr>
<tr>
<td>b. off flavor of meat</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tr>
<tr>
<td>c. cooked aroma of meat</td>
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<td>2</td>
<td>3</td>
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</tr>
<tr>
<td>d. types of meat cuts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
</tr>
<tr>
<td>e. meat tenderness</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>f. meat juiciness</td>
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<tr>
<td>g. fat color in the retail case</td>
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<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
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<td>i. meat shelf-life</td>
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<td>4</td>
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</tr>
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<td>j. packaging design</td>
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<td>k. packaging type</td>
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</tr>
<tr>
<td>l. labeling</td>
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<td>6</td>
</tr>
<tr>
<td>m. price</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>n. frozen meat precuts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</tr>
<tr>
<td>o. fresh/refrigerated meat products</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 13. Continued
11. Of the traits mentioned in Questions 9 & 10, list the top 3 in order of the highest priority for repeat purchase of meat based animal products you sell.

1. 

2. 

3. 

12. How do these factors influence a producer’s ability to direct market animal products?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all (1)</th>
<th>A little (2)</th>
<th>Moderate (3)</th>
<th>Strong (4)</th>
<th>Very strong (5)</th>
<th>Don’t know (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. finding customers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>b. dealing with customers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>c. finding a meat processor to cut the way customer requests'</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>d. communicating and scheduling with processors</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>e. educating consumers about meat preparation &amp; cooking</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>f. dealing with Ohio Department of Agriculture regulations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>g. dealing with health department retail sales regulations (e.g. farmer’s markets)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>h. dealing with USDA requirements</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>i. packaging &amp; storage</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>j. advertising</td>
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<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
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<td>l. pricing</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>m. product transport</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>n. seasonality of consumer meat demand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
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<tr>
<td>o. long term storage of product</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>p. product liability</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

13. How many animals did you direct market in 2009?
14. In your mind, how well do these markets fit grass fed meat products?

<table>
<thead>
<tr>
<th></th>
<th>No fit</th>
<th>Some fit</th>
<th>Good fit</th>
<th>Excellent fit</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
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<tr>
<td>a. organic</td>
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<td>2</td>
<td>3</td>
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</tr>
<tr>
<td>b. natural</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>c. local</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. freezer meat [beef/lamb]</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e. farmers’ markets</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>f. restaurant/institutional</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>g. auction</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>h. contract</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tbody>
</table>

15. How do these factors influence market timing?

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>somewhat</th>
<th>moderately</th>
<th>a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>a. animal age</td>
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<td>4</td>
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<tr>
<td>b. animal weight</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. finish</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. adequate feed resources</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. consumer preference [ethnic &amp; niche markets]</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</tbody>
</table>

16. What percent of your animal harvest occurs in each month? [should total 100%]

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tr>
<td>January</td>
<td>_____%</td>
<td>July</td>
<td>_____%</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>_____%</td>
<td>August</td>
<td>_____%</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>_____%</td>
<td>September</td>
<td>_____%</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>_____%</td>
<td>October</td>
<td>_____%</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>_____%</td>
<td>November</td>
<td>_____%</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>_____%</td>
<td>December</td>
<td>_____%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 13. Continued
17. How do you market your meat products? (check all that apply)
   ___ a. live sale
   ___ b. live sale, then custom harvest for buyer
   ___ c. sale after harvest in carcass form
   ___ d. sale after harvest in wholesale cut form
   ___ e. sale after harvest in retail cut form
   ___ f. sale after harvest, fresh
   ___ g. sale after harvest, frozen
   ___ h. sale after harvest, cooked/prepared

18. Estimate the percent in which your total animal products are sold [should total 100%]
   Fresh ________ %       whole carcasses ________ %
   Frozen ________ %      half carcasses ________ %
   Cooked/prepared ________ % pieces/cuts ________ %
   100 %                         100%  

19. What impacts do you think pasture-based livestock management has on water quality?
   no threat (1)   some threat (2)   a lot of threat (3)   don’t know (4)
   1      2      3      4

20. Have you applied for or received money for the following conservation practices? (check all that apply)
   ___ a. grassed water ways
   ___ b. fencing
   ___ c. heavy use paths
   ___ d. manure storage facility
   ___ e. chemical loading facility
   ___ f. no

Figure 13. Continued
21. To what extent do you use cover crops, in conjunction with row crop production, as livestock forage?

<table>
<thead>
<tr>
<th>not at all</th>
<th>some</th>
<th>a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

22. How satisfied are you that conservation measures on your farm are adequate? (check only one)

- [ ] Think we’re doing a really good job
- [ ] Think we’re doing an ok job
- [ ] Not concerned
- [ ] Think there is room for improvement
- [ ] Think there is lots of room for improvement

23. How do you deal with livestock mortality? (check all that apply)

- [ ] a. composting
- [ ] b. incineration
- [ ] c. rendering
- [ ] d. burial

24. Who do you share farm management decisions with? (check all that apply)

- [ ] Self only
- [ ] Spouse
- [ ] Family members: (Brother, sister, father, mother, cousins)
- [ ] Non family partner

25. What portion of your neighbors are finishing animals on grass? (check only one)

- [ ] None
- [ ] less than 5%
- [ ] 5-10%
- [ ] 11-25%
- [ ] 26-50%
- [ ] 51-75%
- [ ] 76-100 %

Figure 13. Continued
26. Which of the following organizations do you belong to?

- Ohio Farm Bureau
- Ohio Cattlemen's Association
- Ohio Sheep Improvement Association
- Ohio Forage & Grassland Council
- Ohio Ecological Food & Farm Association (OEFFA)
- Water shed group/alliance
- Service/fraternal organization (Lions, Kiwanis, etc)
- Recreation group (bowling league, gardening club, card club, softball, etc)
- Farmer Cooperative
- Church related
- Political/civic groups (PTA, historical society, local development group, library, etc)
- Nature Conservancy
- Ducks unlimited
- Turkey Federation
- Other (Specify)

27. To what extent are these an important part of your farm management

<table>
<thead>
<tr>
<th>Activity</th>
<th>Not important (1)</th>
<th>A little important (2)</th>
<th>Sometimes important (3)</th>
<th>Important (4)</th>
<th>Very important (5)</th>
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</thead>
<tbody>
<tr>
<td>a. Helping friends and neighbors with farm tasks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>b. Sharing equipment with friends and neighbors</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c. Sharing knowledge and results of on farm experiments with others</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. Planning with other landowners to establish practices that will protect our watershed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e. Putting long term conservation of farm resources before short term profits</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 13. Continued
28. To what extent do you get your information about livestock management and best management practices from the following sources?

<table>
<thead>
<tr>
<th>Source</th>
<th>Never (1)</th>
<th>Sometimes (2)</th>
<th>Often (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Relatives/Neighbors/friends</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b. Other farmers</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>c. OSU Extension Educators</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>d. OSU Extension print materials</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>e. OSU web sites</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>f. OSU/OARDC faculty</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>g. Field days and conferences</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>h. Soil &amp; Water Conservation District newsletters/web sites</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>j. Newspaper</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>k. Farm association newsletter/website</td>
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<td>3</td>
</tr>
<tr>
<td>l. Farm magazines</td>
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<td>2</td>
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<tr>
<td>m. TV, radio</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>n. Internet searches</td>
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<td>3</td>
</tr>
<tr>
<td>o. Veterinarians</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>p. Other university’s web sites</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>q. Non-university web sites</td>
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<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

29. Please indicate the number of the type of livestock you managed in 2009

- Beef cows
- Feeder calves
- Finished cattle/market ready
- Ewes
- Market lambs
  - less 90 pounds
  - 91-120 pounds
  - greater than 121 pounds

Figure 13. Continued
30. How many acres do you own and/or rent?

Total acres owned _______  Total acres rented _______

Acres owned in hay or pasture _______  Acres rented in hay or pasture _______

Acres owned in row crops _______  Acres rented in row crops _______

31. How many years experience do you have raising sheep? _______

32. How many years experience do you have raising beef cattle? _______

33. What is your age? _______

34. Are you (check one)  ___ male  ___ female

35. Please check the category that best represents your total net household income (including farm and off-farm income) for 2009

___ Less than $2,500
___ $2,500-$9,999
___ $10,000-$19,999
___ $20,000-$34,999
___ $35,000-$49,999
___ $50,000-$74,999
___ $75,000-$99,999
___ $100,000 or more

Figure 13. Continued
Thank you for your help. Please place this survey in the self-addressed, stamped envelop and return to:

Jeff McCutcheon  
Morrow County Extension  
871 West Marion Road  
Suite 102  
Mt. Gilead  
Ohio 43338-1088

This project was funded in part by USDA NIFA cooperative agreement no. OHO01059-88, Ohio Agricultural Research & Development Center, Ohio State University Extension, and the Small Farm Institute.

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Keith L. Smith, Associate Vice President for Agricultural Administration; Associate Dean, College of Food, Agricultural, and Environmental Sciences; Director, Ohio State University Extension and Gist Chair in Extension Education and Leadership. TDD No. 800-589-8292 (Ohio only) or 614-292-1868.

Figure 13. Continued
Appendix B: SAS programs used for producer survey
SAS Data Program (used in Chapter 2)

data new;set Afri.producer;

/*age grouping*/
if Q33_age = . then age = 'na';
if Q33_age < 40 then age = '20&30s';
if Q33_age > 39 and Q33_age < 50 then age = '40s';
if Q33_age > 49 and Q33_age < 60 then age = '50s';
if Q33_age > 59 and Q33_age < 70 then age = '60s';
if Q33_age > 69 and Q33_age < 80 then age = '70s';
if Q33_age > 79 then age = '80&90s';

/*experience grouping*/
if Q31_years_sheep = . then sheepexp = '0';
if Q31_years_sheep > 0 and Q31_years_sheep < 6 then sheepexp = '1';
if Q31_years_sheep > 5 and Q31_years_sheep < 16 then sheepexp = '6';
if Q31_years_sheep > 15 and Q31_years_sheep < 26 then sheepexp = '16';
if Q31_years_sheep > 25 and Q31_years_sheep < 36 then sheepexp = '26';
if Q31_years_sheep > 35 and Q31_years_sheep < 46 then sheepexp = '36';
if Q31_years_sheep > 45 and Q31_years_sheep < 56 then sheepexp = '46';
if Q31_years_sheep > 55 and Q31_years_sheep < 66 then sheepexp = '56';
if Q31_years_sheep > 65 then sheepexp = '65';

if Q32_years_beef = . then beefexp = '0';
if Q32_years_beef > 0 and Q32_years_beef < 6 then beefexp = '1';
if Q32_years_beef > 5 and Q32_years_beef < 16 then beefexp = '2';
if Q32_years_beef > 15 and Q32_years_beef < 26 then beefexp = '16';
if Q32_years_beef > 25 and Q32_years_beef < 36 then beefexp = '26';
if Q32_years_beef > 35 and Q32_years_beef < 46 then beefexp = '36';
if Q32_years_beef > 45 and Q32_years_beef < 56 then beefexp = '46';
if Q32_years_beef > 55 and Q32_years_beef < 66 then beefexp = '56';
if Q32_years_beef > 65 then beefexp = '65';

/*sheep grouping*/
if totalsheep = . then sheep = 0;
if totalsheep > 0 and totalsheep < 20 then sheep = 1;
if totalsheep > 19 and totalsheep < 31 then sheep = 2;
if totalsheep > 30 and totalsheep < 51 then sheep = 3;
if totalsheep > 50 and totalsheep < 76 then sheep = 4;
if totalsheep > 75 and totalsheep < 101 then sheep = 5;
if totalsheep > 100 and totalsheep < 201 then sheep = 6;
if totalsheep > 200 then sheep = 7;

/*beef grouping*/
if totalbeef = . then beef = 0;
if totalbeef > 0 and totalbeef < 20 then beef = 1;
if totalbeef > 19 and totalbeef < 31 then beef = 2;
if totalbeef > 30 and totalbeef < 51 then beef = 3;
if totalbeef > 50 and totalbeef < 76 then beef = 4;
if totalbeef > 75 and totalbeef < 201 then beef = 5;
if totalbeef > 200 then beef = 6;
/*raising sheep*/
if Q31_years_sheep > 0 then hadsheep = 'yes';
if Q31_years_sheep < 1 then hadsheep = 'no';
if totalsheep > 0 then currentsheep = 'yes';
if totalsheep < 1 then currentsheep = 'no';

/*raising beef*/
if Q32_years_beef > 0 then hadbeef = 'yes';
if Q32_years_beef < 1 then hadbeef = 'no';
if totalbeef > 0 then currentbeef = 'yes';
if totalbeef < 1 then currentbeef = 'no';

if hadsheep = 'yes' and hadbeef = 'yes' then both = 'yes';
else both = 'no';

if hadsheep = 'yes' then species3 = 'sheep';
if hadbeef = 'yes' then species3 = 'beef';
if both = 'yes' then species3 = 'both';

if currentbeef = 'yes' then species = 1;
if currentsheep = 'yes' then species = 2;
if currentsheep = 'yes' and currentbeef = 'yes' then currentboth = 'yes';
else currentboth = 'no';

if currentsheep = 'yes' then currentsheep = 'sheep';
if currentbeef = 'yes' then currentbeef = 'beef';
if currentboth = 'yes' then currentboth = 'yes';

/*direct marketing*/
if Q13_Direct > 0 then direct = 1;
else direct = 0;

/*if Q13_Direct = . then groupdirect = '0';*/
if Q13_Direct = 1 then groupdirect = 1;
if Q13_Direct = 2 then groupdirect = 2;
if Q13_Direct = 3 then groupdirect = 3;
if Q13_Direct = 4 then groupdirect = 4;
if Q13_Direct = 5 then groupdirect = 5;
if Q13_Direct > 5 and Q13_Direct < 8 then groupdirect = 6;
if Q13_Direct > 7 and Q13_Direct < 10 then groupdirect = 7;
if Q13_Direct = 10 then groupdirect = 8;
if Q13_Direct > 10 and Q13_Direct < 15 then groupdirect = 9;
if Q13_Direct > 14 and Q13_Direct < 20 then groupdirect = 10;
if Q13_Direct > 19 and Q13_Direct < 25 then groupdirect = 11;
if Q13_Direct > 24 and Q13_Direct < 30 then groupdirect = 12;
if Q13_Direct > 29 and Q13_Direct < 35 then groupdirect = 13;
if Q13_Direct > 34 and Q13_Direct < 40 then groupdirect = 14;
if Q13_Direct > 39 and Q13_Direct < 50 then groupdirect = 15;
if Q13_Direct > 49 and Q13_Direct < 100 then groupdirect = 16;
if Q13_Direct >99 and Q13_Direct <200 then groupdirect = 17;
if Q13_Direct >199 then groupdirect = 18;

/*acreage groupings*/
Total_acreage = SUM (q30_total_ac_own, q30_total_rent);

if Total_acreage = . then acre = '0';
if Total_acreage >1 and Total_acreage <101 then acre = '1';
if Total_acreage >100 and Total_acreage <300 then acre = '2';
if Total_acreage >299 and Total_acreage <500 then acre = '3';
if Total_acreage >499 and Total_acreage <800 then acre = '5';
if Total_acreage >799 and Total_acreage <1300 then acre = '8';
if Total_acreage >1299 then acre = '9';

Total_hay = SUM (q30_owned_ac_hay, q30_rent_hay);

if Total_hay = . then Hay = '0';
if Total_hay >1 and Total_hay <101 then Hay = '1';
if Total_hay >100 and Total_hay <300 then Hay = '2';
if Total_hay >499 and Total_hay <800 then Hay = '5';
if Total_hay >799 and Total_hay <1300 then Hay = '8';
if Total_hay >1299 then Hay = '9';

Total_Crops = SUM (q30_owned_ac_crops, q30_rent_crops);

if Total_Crops = . then Crops = '0';
if Total_Crops >1 and Total_Crops <101 then Crops = '1';
if Total_Crops >100 and Total_Crops <300 then Crops = '2';
if Total_Crops >499 and Total_Crops <800 then Crops = '5';
if Total_Crops >799 and Total_Crops <1300 then Crops = '8';
if Total_Crops >1299 then Crops = '9';

/*Q9 recode for Don't Know*/
if Q9_a_flavor = 1 then q9_flavor = 1;
if Q9_a_flavor = 2 then q9_flavor = 2;
if Q9_a_flavor = 3 then q9_flavor = 3;
if Q9_a_flavor = 4 then q9_flavor = 4;
if Q9_a_flavor = 5 then q9_flavor = 5;
if Q9_a_flavor = 6 then q9_flavor = .;
if Q9_a_flavor = 6 then q9adk = 2;
if Q9_a_flavor < 6 then q9adk = 1;

if Q9_b_off_flavor = 1 then q9_off = 1;
if Q9_b_off_flavor = 2 then q9_off = 2;
if Q9_b_off_flavor = 3 then q9_off = 3;
if Q9_b_off_flavor = 4 then q9_off = 4;
if Q9_b_off_flavor = 5 then q9_off = 5;
if Q9_b_off_flavor = 6 then q9_off = .;
if Q9_b_off_flavor = 6 then q9bdk = 2;
if Q9_b_off_flavor < 6 then q9bdk = 1;

if Q9_c_aroma = 1 then Q9_aroma = 1;
if Q9_c_aroma=2 then Q9_aroma=2;
if Q9_c_aroma=3 then Q9_aroma=3;
if Q9_c_aroma=4 then Q9_aroma=4;
if Q9_c_aroma=5 then Q9_aroma=5;
if Q9_c_aroma=6 then Q9_aroma=6;
if Q9_c_aroma<6 then q9cdk = 2;
if Q9_c_aroma=6 then q9cdk = 1;

if Q9_d_type_cuts=1 then Q9_cuts=1;
if Q9_d_type_cuts=2 then Q9_cuts=2;
if Q9_d_type_cuts=3 then Q9_cuts=3;
if Q9_d_type_cuts=4 then Q9_cuts=4;
if Q9_d_type_cuts=5 then Q9_cuts=5;
if Q9_d_type_cuts=6 then Q9_cuts=6;
if Q9_d_type_cuts<6 then q9ddk = 2;
if Q9_d_type_cuts=6 then q9ddk = 1;

if Q9_e_tenderness=1 then Q9_tender=1;
if Q9_e_tenderness=2 then Q9_tender=2;
if Q9_e_tenderness=3 then Q9_tender=3;
if Q9_e_tenderness=4 then Q9_tender=4;
if Q9_e_tenderness=5 then Q9_tender=5;
if Q9_e_tenderness=6 then Q9_tender=6;
if Q9_e_tenderness<6 then q9edk = 2;
if Q9_e_tenderness=6 then q9edk = 1;

if Q9_f_juiciness=1 then Q9_juice=1;
if Q9_f_juiciness=2 then Q9_juice=2;
if Q9_f_juiciness=3 then Q9_juice=3;
if Q9_f_juiciness=4 then Q9_juice=4;
if Q9_f_juiciness=5 then Q9_juice=5;
if Q9_f_juiciness=6 then Q9_juice=6;
if Q9_f_juiciness<6 then q9fdk = 2;
if Q9_f_juiciness=6 then q9fdk = 1;

if Q9_g_fat_color=1 then Q9_fat=1;
if Q9_g_fat_color=2 then Q9_fat=2;
if Q9_g_fat_color=3 then Q9_fat=3;
if Q9_g_fat_color=4 then Q9_fat=4;
if Q9_g_fat_color=5 then Q9_fat=5;
if Q9_g_fat_color=6 then Q9_fat=6;
if Q9_g_fat_color<6 then q9gdk = 2;
if Q9_g_fat_color=6 then q9gdk = 1;

if Q9_h_lean_color=1 then Q9_lean=1;
if Q9_h_lean_color=2 then Q9_lean=2;
if Q9_h_lean_color=3 then Q9_lean=3;
if Q9_h_lean_color=4 then Q9_lean=4;
if Q9_h_lean_color=5 then Q9_lean=5;
if Q9_h_lean_color=6 then Q9_lean=6;
if Q9_h_lean_color<6 then q9hdk = 2;
if Q9_h_lean_color=6 then q9hdk = 1;

if Q9_i_shelf_life=1 then Q9_shelf=1;
if Q9_i_shelf_life=2 then Q9_shelf=2;
if Q9_i_shelf_life=3 then Q9_shelf=3;
if Q9_i_shelf_life=4 then Q9_shelf=4;
if Q9_i_shelf_life=5 then Q9_shelf=5;
if Q9_i_shelf_life=6 then Q9_shelf=5;
if Q9_i_shelf_life<6 then q9idk =2;
if Q9_i_shelf_life<6 then q9idk =1;
if Q9_j_pack_design=1 then Q9_pack=1;
if Q9_j_pack_design=2 then Q9_pack=2;
if Q9_j_pack_design=3 then Q9_pack=3;
if Q9_j_pack_design=4 then Q9_pack=4;
if Q9_j_pack_design=5 then Q9_pack=5;
if Q9_j_pack_design=6 then Q9_pack=5;
if Q9_j_pack_design<6 then q9jdk =2;
if Q9_j_pack_design<6 then q9jdk =1;
if Q9_k_pack_type=1 then Q9_design=1;
if Q9_k_pack_type=2 then Q9_design=2;
if Q9_k_pack_type=3 then Q9_design=3;
if Q9_k_pack_type=4 then Q9_design=4;
if Q9_k_pack_type=5 then Q9_design=5;
if Q9_k_pack_type=6 then Q9_design=5;
if Q9_k_pack_type<6 then q9kdk =2;
if Q9_k_pack_type<6 then q9kdk =1;
if Q9_l_label=1 then Q9_label=1;
if Q9_l_label=2 then Q9_label=2;
if Q9_l_label=3 then Q9_label=3;
if Q9_l_label=4 then Q9_label=4;
if Q9_l_label=5 then Q9_label=5;
if Q9_l_label=6 then Q9_label=5;
if Q9_l_label<6 then q9ldk =2;
if Q9_l_label<6 then q9ldk =1;
if Q9_m_price=1 then Q9_price=1;
if Q9_m_price=2 then Q9_price=2;
if Q9_m_price=3 then Q9_price=3;
if Q9_m_price=4 then Q9_price=4;
if Q9_m_price=5 then Q9_price=5;
if Q9_m_price=6 then Q9_price=5;
if Q9_m_price<6 then q9mdk =2;
if Q9_m_price<6 then q9mdk =1;
if Q9_n_frozen=1 then Q9_frozen=1;
if Q9_n_frozen=2 then Q9_frozen=2;
if Q9_n_frozen=3 then Q9_frozen=3;
if Q9_n_frozen=4 then Q9_frozen=4;
if Q9_n_frozen=5 then Q9_frozen=5;
if Q9_n_frozen=6 then Q9_frozen=5;
if Q9_n_frozen<6 then q9ndk =2;
if Q9_n_frozen<6 then q9ndk =1;
if Q9_o_Fresh=1 then Q9_Fresh=1;
if Q9_o_Fresh=2 then Q9_Fresh=2;
if Q9_o_Fresh=3 then Q9_Fresh=3;
if Q9_o_Fresh=4 then Q9_Fresh=4;
if Q9_o_Fresh=5 then Q9_Fresh=5;
if Q9_o_Fresh=6 then Q9_Fresh=6;
if Q9_o_Fresh<6 then q9odk =2;

if Q9_o_Fresh=6 then q9odk =2;
if Q9_o_Fresh<6 then q9odk =1;

/*Q10 recode for Don’t Know*/
if Q10_a_flavor =1 then q10_flavor =1;
if Q10_a_flavor =2 then q10_flavor =2;
if Q10_a_flavor =3 then q10_flavor =3;
if Q10_a_flavor =4 then q10_flavor =4;
if Q10_a_flavor =5 then q10_flavor =5;
if Q10_a_flavor =6 then q10_flavor =6;
if Q10_a_flavor <6 then q10adk =2;
if Q10_a_flavor =6 then q10adk =1;

if Q10_b_off_flavor=1 then q10_off=1;
if Q10_b_off_flavor=2 then q10_off=2;
if Q10_b_off_flavor=3 then q10_off=3;
if Q10_b_off_flavor=4 then q10_off=4;
if Q10_b_off_flavor=5 then q10_off=5;
if Q10_b_off_flavor<6 then q10bdk =2;
if Q10_b_off_flavor =6 then q10bdk =1;

if Q10_c_aroma=1 then Q10_aroma=1;
if Q10_c_aroma=2 then Q10_aroma=2;
if Q10_c_aroma=3 then Q10_aroma=3;
if Q10_c_aroma=4 then Q10_aroma=4;
if Q10_c_aroma=5 then Q10_aroma=5;
if Q10_c_aroma=6 then Q10_aroma=6;
if Q10_c_aroma<6 then q10cdk =2;
if Q10_c_aroma=6 then q10cdk =1;

if Q10_d_type_cuts=1 then Q10_cuts=1;
if Q10_d_type_cuts=2 then Q10_cuts=2;
if Q10_d_type_cuts=3 then Q10_cuts=3;
if Q10_d_type_cuts=4 then Q10_cuts=4;
if Q10_d_type_cuts=5 then Q10_cuts=5;
if Q10_d_type_cuts=6 then Q10_cuts=6;
if Q10_d_type_cuts<6 then q10ddk =2;
if Q10_d_type_cuts =6 then q10ddk =1;

if Q10_e_tenderness=1 then Q10_tender=1;
if Q10_e_tenderness=2 then Q10_tender=2;
if Q10_e_tenderness=3 then Q10_tender=3;
if Q10_e_tenderness=4 then Q10_tender=4;
if Q10_e_tenderness=5 then Q10_tender=5;
if Q10_e_tenderness=6 then Q10_tender=6;
if Q10_e_tenderness<6 then q10edk =2;
if Q10_e_tenderness=6 then q10edk =1;
if Q10_f_juiciness = 1 then Q10_juice = 1;
if Q10_f_juiciness = 2 then Q10_juice = 2;
if Q10_f_juiciness = 3 then Q10_juice = 3;
if Q10_f_juiciness = 4 then Q10_juice = 4;
if Q10_f_juiciness = 5 then Q10_juice = 5;
if Q10_f_juiciness = 6 then Q10_juice = .;
if Q10_f_juiciness = 6 then q10fdk = 2;
if Q10_f_juiciness < 6 then q10fdk = 1;

if Q10_g_fat_color = 1 then Q10_fat = 1;
if Q10_g_fat_color = 2 then Q10_fat = 2;
if Q10_g_fat_color = 3 then Q10_fat = 3;
if Q10_g_fat_color = 4 then Q10_fat = 4;
if Q10_g_fat_color = 5 then Q10_fat = 5;
if Q10_g_fat_color = 6 then Q10_fat = .;
if Q10_g_fat_color = 6 then q10gdk = 2;
if Q10_g_fat_color < 6 then q10gdk = 1;

if Q10_h_lean_color = 1 then Q10_lean = 1;
if Q10_h_lean_color = 2 then Q10_lean = 2;
if Q10_h_lean_color = 3 then Q10_lean = 3;
if Q10_h_lean_color = 4 then Q10_lean = 4;
if Q10_h_lean_color = 5 then Q10_lean = 5;
if Q10_h_lean_color = 6 then Q10_lean = .;
if Q10_h_lean_color = 6 then q10hdk = 2;
if Q10_h_lean_color < 6 then q10hdk = 1;

if Q10_i_shelf_life = 1 then Q10_shelf = 1;
if Q10_i_shelf_life = 2 then Q10_shelf = 2;
if Q10_i_shelf_life = 3 then Q10_shelf = 3;
if Q10_i_shelf_life = 4 then Q10_shelf = 4;
if Q10_i_shelf_life = 5 then Q10_shelf = 5;
if Q10_i_shelf_life = 6 then Q10_shelf = .;
if Q10_i_shelf_life = 6 then q10idk = 2;
if Q10_i_shelf_life < 6 then q10idk = 1;

if Q10_j_pack_design = 1 then Q10_pack = 1;
if Q10_j_pack_design = 2 then Q10_pack = 2;
if Q10_j_pack_design = 3 then Q10_pack = 3;
if Q10_j_pack_design = 4 then Q10_pack = 4;
if Q10_j_pack_design = 5 then Q10_pack = 5;
if Q10_j_pack_design = 6 then Q10_pack = .;
if Q10_j_pack_design = 6 then q10jdk = 2;
if Q10_j_pack_design < 6 then q10jdk = 1;

if Q10_k_pack_type = 1 then Q10_design = 1;
if Q10_k_pack_type = 2 then Q10_design = 2;
if Q10_k_pack_type = 3 then Q10_design = 3;
if Q10_k_pack_type = 4 then Q10_design = 4;
if Q10_k_pack_type = 5 then Q10_design = 5;
if Q10_k_pack_type = 6 then Q10_design = .;
if Q10_k_pack_type = 6 then q10kdk = 2;
if Q10_k_pack_type < 6 then q10kdk = 1;
if Q10_l_label=1 then Q10_label=1;
if Q10_l_label=2 then Q10_label=2;
if Q10_l_label=3 then Q10_label=3;
if Q10_l_label=4 then Q10_label=4;
if Q10_l_label=5 then Q10_label=5;
if Q10_l_label=6 then Q10_label=6;
if Q10_l_label<6 then q10ldk =2;
if Q10_l_label<6 then q10ldk =1;
if Q10_m_price=1 then Q10_price=1;
if Q10_m_price=2 then Q10_price=2;
if Q10_m_price=3 then Q10_price=3;
if Q10_m_price=4 then Q10_price=4;
if Q10_m_price=5 then Q10_price=5;
if Q10_m_price=6 then Q10_price=6;
if Q10_m_price<6 then q10mdk =2;
if Q10_m_price<6 then q10mdk =1;
if Q10_n_frozen=1 then Q10_frozen=1;
if Q10_n_frozen=2 then Q10_frozen=2;
if Q10_n_frozen=3 then Q10_frozen=3;
if Q10_n_frozen=4 then Q10_frozen=4;
if Q10_n_frozen=5 then Q10_frozen=5;
if Q10_n_frozen=6 then Q10_frozen=6;
if Q10_n_frozen<6 then q10ndk =2;
if Q10_n_frozen<6 then q10ndk =1;
/*Q12 recode for Don't Know*/
if Q12_a_finding_customers=1 then Q12_findC=1;
if Q12_a_finding_customers=2 then Q12_findC=2;
if Q12_a_finding_customers=3 then Q12_findC=3;
if Q12_a_finding_customers=4 then Q12_findC=4;
if Q12_a_finding_customers=5 then Q12_findC=5;
if Q12_a_finding_customers=6 then Q12_findC=6;
if Q12_a_finding_customers<6 then q12adk =2;
if Q12_a_finding_customers<6 then q12adk =1;
if Q12_b_dealing_cust=1 then Q12_deal=1;
if Q12_b_dealing_cust=2 then Q12_deal=2;
if Q12_b_dealing_cust=3 then Q12_deal=3;
if Q12_b_dealing_cust=4 then Q12_deal=4;
if Q12_b_dealing_cust=5 then Q12_deal=5;
if Q12_b_dealing_cust=6 then Q12_deal=6;
if Q12_b_dealing_cust<6 then q12bdk =2;
if Q12_b_dealing_cust<6 then q12bdk =1;
if Q12_c_find_processor=1 then Q12_findpro=1;
if Q12_c_find_processor=2 then Q12_findpro=2;
if Q12_c_find_processor=3 then Q12_findpro=3;
if Q12_c_find_processor=4 then Q12_findpro=4;
if Q12_c_find_processor=5 then Q12_findpro=5;
if Q12_c_find_processor=6 then Q12_findpro=.
if Q12_c_find_processor=6 then q12cdk =2;
if Q12_c_find_processor<6 then q12cdk =1;

if Q12_d_Communicate=1 then Q12_Communicate=1;
if Q12_d_Communicate=2 then Q12_Communicate=2;
if Q12_d_Communicate=3 then Q12_Communicate=3;
if Q12_d_Communicate=4 then Q12_Communicate=4;
if Q12_d_Communicate=5 then Q12_Communicate=5;
if Q12_d_Communicate=6 then Q12_Communicate=.
if Q12_d_Communicate=6 then q12ddk =2;
if Q12_d_Communicate<6 then q12ddk =1;

if Q12_e_educate=1 then Q12_educate=1;
if Q12_e_educate=2 then Q12_educate=2;
if Q12_e_educate=3 then Q12_educate=3;
if Q12_e_educate=4 then Q12_educate=4;
if Q12_e_educate=5 then Q12_educate=5;
if Q12_e_educate=6 then Q12_educate=.
if Q12_e_educate=6 then q12edk =2;
if Q12_e_educate<6 then q12edk =1;

if Q12_f_ODA=1 then Q12_ODA=1;
if Q12_f_ODA=2 then Q12_ODA=2;
if Q12_f_ODA=3 then Q12_ODA=3;
if Q12_f_ODA=4 then Q12_ODA=4;
if Q12_f_ODA=5 then Q12_ODA=5;
if Q12_f_ODA=6 then Q12_ODA=.
if Q12_f_ODA=6 then q12fdk =2;
if Q12_f_ODA<6 then q12fdk =1;

if Q12_g_Health_Dept=1 then Q12_HEALTHDEPT=1;
if Q12_g_Health_Dept=2 then Q12_HEALTHDEPT=2;
if Q12_g_Health_Dept=3 then Q12_HEALTHDEPT=3;
if Q12_g_Health_Dept=4 then Q12_HEALTHDEPT=4;
if Q12_g_Health_Dept=5 then Q12_HEALTHDEPT=5;
if Q12_g_Health_Dept=6 then Q12_HEALTHDEPT=.
if Q12_g_Health_Dept=6 then q12gdk =2;
if Q12_g_Health_Dept<6 then q12gdk =1;

if Q12_h_USDA=1 then Q12_USDA=1;
if Q12_h_USDA=2 then Q12_USDA=2;
if Q12_h_USDA=3 then Q12_USDA=3;
if Q12_h_USDA=4 then Q12_USDA=4;
if Q12_h_USDA=5 then Q12_USDA=5;
if Q12_h_USDA=6 then Q12_USDA=.
if Q12_h_USDA=6 then q12hdk =2;
if Q12_h_USDA<6 then q12hdk =1;
if Q12_i_storage=1 then Q12_STORAGE=1;
if Q12_i_storage=2 then Q12_STORAGE=2;
if Q12_i_storage=3 then Q12_STORAGE=3;
if Q12_i_storage=4 then Q12_STORAGE=4;
if Q12_i_storage=5 then Q12_STORAGE=5;
if Q12_i_storage=6 then Q12_STORAGE=6;
if Q12_i_storage<6 then q12idk = 2;
if Q12_i_storage = 6 then q12idk = 1;

if Q12_j_advertise=1 then Q12_ADVERTISE=1;
if Q12_j_advertise=2 then Q12_ADVERTISE=2;
if Q12_j_advertise=3 then Q12_ADVERTISE=3;
if Q12_j_advertise=4 then Q12_ADVERTISE=4;
if Q12_j_advertise=5 then Q12_ADVERTISE=5;
if Q12_j_advertise=6 then Q12_ADVERTISE=6;
if Q12_j_advertise<6 then q12jdk = 2;
if Q12_j_advertise = 6 then q12jdk = 1;

if Q12_l_price=1 then Q12_price=1;
if Q12_l_price=2 then Q12_price=2;
if Q12_l_price=3 then Q12_price=3;
if Q12_l_price=4 then Q12_price=4;
if Q12_l_price=5 then Q12_price=5;
if Q12_l_price=6 then Q12_price=6;
if Q12_l_price<6 then q12ldk = 2;
if Q12_l_price = 6 then q12ldk = 1;

if Q12_m_transport=1 then Q12_TRANSPORT=1;
if Q12_m_transport=2 then Q12_TRANSPORT=2;
if Q12_m_transport=3 then Q12_TRANSPORT=3;
if Q12_m_transport=4 then Q12_TRANSPORT=4;
if Q12_m_transport=5 then Q12_TRANSPORT=5;
if Q12_m_transport=6 then Q12_TRANSPORT=6;
if Q12_m_transport<6 then q12mdk = 2;
if Q12_m_transport = 6 then q12mdk = 1;

if Q12_n_season=1 then Q12_SEASON=1;
if Q12_n_season=2 then Q12_SEASON=2;
if Q12_n_season=3 then Q12_SEASON=3;
if Q12_n_season=4 then Q12_SEASON=4;
if Q12_n_season=5 then Q12_SEASON=5;
if Q12_n_season=6 then Q12_SEASON=6;
if Q12_n_season<6 then q12ndk = 2;
if Q12_n_season = 6 then q12ndk = 1;

if Q12_o_long_store=1 then Q12_LONG_STORE=1;
if Q12_o_long_store=2 then Q12_LONG_STORE=2;
if Q12_o_long_store=3 then Q12_LONG_STORE=3;
if Q12_o_long_store=4 then Q12_LONG_STORE=4;
if Q12_o_long_store=5 then Q12_LONG_STORE=5;
if Q12_o_long_store=6 then Q12_LONG_STORE=6;
if Q12_o_long_store<6 then q12odk = 2;
if Q12_o_long_store = 6 then q12odk = 1;
if Q12_p_liability = 1 then Q12_LIABILITY = 1;
if Q12_p_liability = 2 then Q12_LIABILITY = 2;
if Q12_p_liability = 3 then Q12_LIABILITY = 3;
if Q12_p_liability = 4 then Q12_LIABILITY = 4;
if Q12_p_liability = 5 then Q12_LIABILITY = 5;
if Q12_p_liability = 6 then Q12_LIABILITY = 6;

if Q12_p_liability = 6 then q12pdk = 2;
if Q12_p_liability < 6 then q12pdk = 1;

/* Q14 recode for Don’t Know */
if Q14_a_organic = 1 then Q14_ORGANIC = 1;
if Q14_a_organic = 2 then Q14_ORGANIC = 2;
if Q14_a_organic = 3 then Q14_ORGANIC = 3;
if Q14_a_organic = 4 then Q14_ORGANIC = 4;
if Q14_a_organic = 5 then Q14_ORGANIC = 5;
if Q14_a_organic < 5 then Q14adk = 1;
if Q14_a_organic = 5 then q14adk = 0;

if Q14_b_natural = 1 then Q14_NATURAL = 1;
if Q14_b_natural = 2 then Q14_NATURAL = 2;
if Q14_b_natural = 3 then Q14_NATURAL = 3;
if Q14_b_natural = 4 then Q14_NATURAL = 4;
if Q14_b_natural = 5 then Q14_NATURAL = 5;
if Q14_b_natural < 5 then q14bdk = 1;
if Q14_b_natural = 5 then q14bdk = 0;

if Q14_c_local = 1 then Q14_LOCAL = 1;
if Q14_c_local = 2 then Q14_LOCAL = 2;
if Q14_c_local = 3 then Q14_LOCAL = 3;
if Q14_c_local = 4 then Q14_LOCAL = 4;
if Q14_c_local = 5 then Q14_LOCAL = 5;
if Q14_c_local < 5 then q14cdk = 1;
if Q14_c_local = 5 then q14cdk = 0;

if Q14_d_freezer = 1 then Q14_FREEZER = 1;
if Q14_d_freezer = 2 then Q14_FREEZER = 2;
if Q14_d_freezer = 3 then Q14_FREEZER = 3;
if Q14_d_freezer = 4 then Q14_FREEZER = 4;
if Q14_d_freezer = 5 then Q14_FREEZER = 5;
if Q14_d_freezer < 5 then q14ddk = 1;
if Q14_d_freezer = 5 then q14ddk = 0;

if Q14_e_farmers_market = 1 then Q14_FARMERS_MARKET = 1;
if Q14_e_farmers_market = 2 then Q14_FARMERS_MARKET = 2;
if Q14_e_farmers_market = 3 then Q14_FARMERS_MARKET = 3;
if Q14_e_farmers_market = 4 then Q14_FARMERS_MARKET = 4;
if Q14_e_farmers_market = 5 then Q14_FARMERS_MARKET = 5;
if Q14_e_farmers_market < 5 then q14edk = 1;
if Q14_e_farmers_market = 5 then q14edk = 0;

if Q14_f_institution = 1 then Q14_INSTITUTION = 1;
if Q14_f_institution = 2 then Q14_INSTITUTION = 2;
if Q14_f_institution = 3 then Q14_INSTITUTION = 3;
if Q14_f_institution=4 then Q14_INSTITUTION=4;
if Q14_f_institution=5 then Q14_INSTITUTION=.
if Q14_f_institution=5 then q14fdk =1;
if Q14_f_institution<5 then q14fdk =0;

if Q14_g_auction=1 then Q14_AUCTION=1;
if Q14_g_auction=2 then Q14_AUCTION=2;
if Q14_g_auction=3 then Q14_AUCTION=3;
if Q14_g_auction=4 then Q14_AUCTION=4;
if Q14_g_auction=5 then Q14_AUCTION=.
if Q14_g_auction=5 then q14gdk =1;
if Q14_g_auction<5 then q14gdk =0;

if Q14_h_contract=1 then Q14_CONTRACT=1;
if Q14_h_contract=2 then Q14_CONTRACT=2;
if Q14_h_contract=3 then Q14_CONTRACT=3;
if Q14_h_contract=4 then Q14_CONTRACT=4;
if Q14_h_contract=5 then Q14_CONTRACT=.
if Q14_h_contract=5 then q14hdk =1;
if Q14_h_contract<5 then q14hdk =0;

/*grouping Q11*/
if Q11_1 = 'flavor' or Q11__2 = 'flavor' or Q11__3 = 'flavor' then
  flavor = 'yes';
else flavor = 'no';
if Q11_1 = 'tenderness' or Q11__2 = 'tenderness' or Q11__3 =
  'tenderness' then tenderness = 'yes';
else tenderness = 'no';
if Q11_1 = 'price' or Q11__2 = 'price' or Q11__3 = 'price' then price =
  'yes';
else price = 'no';
if Q11_1 = 'juiciness' or Q11__2 = 'juiciness' or Q11__3 = 'juiciness'
  then juiciness = 'yes';
else juiciness = 'no';

/*Q1 combine 3&4*/
if Q1_Operation_type = 1 then Operation = 1;
if Q1_Operation_type = 2 then Operation = 2;
if Q1_Operation_type = 3 or Q1_Operation_type = 4 then Operation = 3;

/*Factor creation*/
Q4_pasture = SUM (Q4_a_balance, Q4_b_variety, Q4_c_rotation, 
  Q4_n_fence, Q4_p_pasture);
Q4_equipment = SUM (Q4_i_facilities, Q4_j_storage, Q4_k_equipment, 
  Q4_l_structure, Q4_m_handling);
Q4_Market = SUM (Q4_h_quality, Q4_u_market, Q4_v_profit);
Q4_resource = Sum (Q4_q_finance, Q4_r_soil, Q4_s_topo, Q4_t_land);
Q12_customers = SUM (Q12_findC, Q12_deal, Q12_findpro, Q12_communicate, 
  Q12_educate, Q12_ADVERTISE, Q12_price);
Q12_regulate = SUM (Q12_ODA, Q12_HEALTHDEPT, Q12_USDA, Q12_STORAGE);
Q12_logistics = SUM (Q12_TRANSPORT, Q12_SEASON, Q12_LONG_STORE, 
  Q12 LIABILITY);
Q7_infrastructure = SUM (Q7_d_facilities, Q7_e_access, Q7_f_suit, 
Q7_g_labor, Q7_h_equipment, Q7_i_fence); 
Q7_genetics = SUM (Q7_a_breeds, Q7_b_type, Q7_c_genetics); 
Q7_management = Sum (Q7_j_know, Q7_k_niche); 
Q8_desire = SUM (Q8_a_off_farm, Q8_b_start, Q8_d_demand, Q8_h_busy); 
Q8_knowledge = SUM (Q8_c_markets, Q8_e_uncomfortable, Q8_f_chain); 
Q8_financial = SUM (Q8_g_start_up, Q8_i_safety_net, Q8_j_banks); 

/*recode for grazing*/ 
If totalsheep > 0 then sheep = 1; else sheep = 0; 
if totalbeef > 0 then beef = 1; else beef = 0; 
if Q1_Operation_type = 1 then Grassbase = 0; 
if Q1_Operation_type = 2 then Grassbase = 0; 
if Q1_Operation_type = 3 then Grassbase = 1; 
if Q1_Operation_type = 4 then Grassbase = 1; 
if Q6_grazing = 1 then graze = 1; else graze = 0; 
if Q6_Yes_a_profit = 1 then Grassprofit = 1; else grassprofit = 0; 
if Q6_Yes_b_market= 1 then Grassmarket = 1; else Grassmarket = 0; 
if Q6_Yes_c_native = 1 then Grassnative = 1; else grassnative = 0; 
if Q6_Yes_d_improved = 1 then Grassimproved = 1; else grassimproved = 0; 
if Q6_Yes_e_background = 1 then Grassback = 1; else grassback = 0; 
if Q6_Yes_f_finishing = 1 then Grassfinish = 1; else grassfinish = 0; 
if Q6_Yes_g_environment = 1 then Grassenviro = 1; else grassenviro = 0; 
if Q6_Yes_h_family = 1 then Grassfam = 1; else grassfam = 0; 
if Q6_Yes_i_time = 1 then Grasstime = 1; else grasstime = 0; 
if Q6_Yes_j_welfare = 1 then Grasswel = 1; else grasswel = 0; 
if Q6_Yes_k_capitol = 1 then Grasscap = 1; else grasscap = 0; 
if Q6_No_a_profit = 1 then Grainprofit = 1; else Grainprofit = 0; 
if Q6_No_b_market= 1 then Grainmarket = 1; else Grainmarket = 0; 
if Q6_No_c_crops= 1 then Graincrop = 1; else graincrop = 0; 
if Q6_No_d_pasture= 1 then Grainpast = 1; else grainpast = 0; 
if Q6_No_e_risk = 1 then Grainrisk = 1; else grainrisk = 0; 
if Q6_No_f_family= 1 then Grainfam = 1; else grainfam = 0; 
if Q6_No_g_time = 1 then Graintime = 1; else graintime = 0; 
if Q6_No_h_welfare= 1 then Grainwel = 1; else grainwel = 0; 
if Q6_No_i_land= 1 then Grainland = 1; else grainland = 0; 
if Q6_No_j_fence= 1 then Grainfence= 1; else grainfence = 0; 
if Q6_No_k_water= 1 then Grainwater= 1; else grainwater = 0; 
if Q6_No_l_predators= 1 then Grainpred = 1; else grainpred = 0; 
if Q2_confine = 1 then confine = 1; else confine = 0; 
if Q2_Improved = 1 then improved = 1; else improved = 0; 
if Q2_native = 1 then native = 1; else native = 0; 
if Q2_residue = 1 then residue = 1; else residue = 0; 
if Q2_annuals = 1 then annuals = 1; else annuals = 0; 
if Q5_important = 1 then important = 1; else important = 0; 
if Q16_Jan =. then Q16_Jan = 0; 
if Q16_Feb =. then Q16_Feb = 0;
if Q16_Mar = . then Q16_Mar = 0;
if Q16_Ap = . then Q16_Ap = 0;
if Q16_May = . then Q16_May = 0;
if Q16_June = . then Q16_June = 0;
if Q16_July = . then Q16_July = 0;
if Q16_Aug = . then Q16_Aug = 0;
if Q16_Sep = . then Q16_Sep = 0;
if Q16_Oct = . then Q16_Oct = 0;
if Q16_Nov = . then Q16_Nov = 0;
if Q16_Dec = . then Q16_Dec = 0;
if Q16_Jan > 0 then Jan = 1;
if Q16_Feb > 0 then Feb = 1;
if Q16_Mar > 0 then Mar = 1;
if Q16_Ap > 0 then Ap = 1;
if Q16_May > 0 then May = 1;
if Q16_June > 0 then June = 1;
if Q16_July > 0 then July = 1;
if Q16_Aug > 0 then Aug = 1;
if Q16_Sep > 0 then Sep = 1;
if Q16_Oct > 0 then Oct = 1;
if Q16_Nov > 0 then Nov = 1;
if Q16_Dec > 0 then Dec = 1;

if Q18_Fresh = . then Q18_Fresh = 0;
if Q18_Frozen = . then Q18_Frozen = 0;
if Q18_cooked = . then Q18_cooked = 0;
if Q18_whole = . then Q18_whole = 0;
if Q18_half = . then Q18_half = 0;
if Q18_cuts = . then Q18_cuts = 0;
if Q18_Fresh > 0 then Fresh = 1;
else fresh = 0;
if Q18_Frozen > 0 then Frozen = 1;
else frozen = 0;
if Q18_cooked > 0 then cooked = 1;
else cooked = 0;
if Q18_whole > 0 then whole = 1;
else whole = 0;
if Q18_half > 0 then half = 1;
else half = 0;
if Q18_cuts > 0 then cuts = 1;
else cuts = 0;

if Q17_a_live = 1 then q17live = 1; else q17live = 0;
if Q17_b_custom = 1 then Q17Custom = 1; else Q17custom = 0;
if Q17_c_carass = 1 then q17carass = 1; else q17carass = 0;
if Q17_d_wolesale = 1 then Q17wholesale = 1; else Q17wholesale = 0;
if Q17_e_retail = 1 then Q17retail = 1; else q17retail = 0;
if Q17_f_fresh = 1 then q17fresh = 1; else q17fresh = 0;
if Q17_g_frozen = 1 then q17frozen = 1; else q17frozen = 0;
if Q17_h_cooked = 1 then q17cook = 1; else q17cook = 0;

Winter = SUM (Q16_Dec , Q16_Jan , Q16_Feb) ;
Spring = SUM (Q16_Mar , Q16_Ap , Q16_May) ;

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Summer = SUM (Q16_June, Q16_July, Q16_Aug) ;
Fall = SUM (Q16_Sep, Q16_Oct, Q16_Nov) ;

run;

SAS program for principle component analysis

PROC FACTOR SIMPLE METHOD=PRIN PRIORS=ONE MINEIGEN=1 SCREE
ROTATE=VARIMAX FLAG=.35 ;
var Q4_a_balance
Q4_b_vardty
Q4_c_rotation
Q4_d_quality
Q4_e_facilities
Q4_f_storag
Q4_g_equipment
Q4_h_structure
Q4_i_handling
Q4_j_fence
Q4_k_pastur
Q4_l_finance
Q4_m_soil
Q4_n_topo
Q4_o_land
Q4_p_market
Q4_q_profit;
run;

PROC FACTOR SIMPLE METHOD=PRIN PRIORS=ONE MINEIGEN=1 SCREE
ROTATE=VARIMAX FLAG=.35 ;
VAR Q7_a_breeds
Q7_b_type
Q7_c_genetics
Q7_d_facilities
Q7_e_access
Q7_f_suit
Q7_g_labo
Q7_h_equipment
Q7_i_fence
Q7_j_know
Q7_k_niche;
run;

PROC FACTOR SIMPLE METHOD=PRIN PRIORS=ONE MINEIGEN=1 SCREE
ROTATE=VARIMAX FLAG=.35 ;
VAR Q8_a_off_farm
Q8_b_start
Q8_c_markets
Q8_d_demand
Q8_e_uncomfortable
Q8_f_chain
Q8_g_start_up
Q8_h_buys
Q8_i_safety_net

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Q8_j_banks;
run;

PROC FACTOR SIMPLE METHOD=PRIN PRIORS=ONE MINEIGEN=1 SCREE
ROTATE=VARIMAX FLAG=.35 ;
var Q12_findc
Q12_deal
Q12_findpro
Q12_Communicate
Q12_educate
Q12_ODA
Q12_HealthDept
Q12_USDA
Q12_storage
Q12_advertise
Q12_price
Q12_transport
Q12_season
Q12_long_store
Q12_liability;
run;

SAS program used in analysis of factor scores between management
systems

PROC Glm;
class Operation;
model Q4_pasture= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class operation;
model Q4_equipment= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class operation;
model Q4_Market= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class currentspecies operation;
model Q4_resource= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class operation;
model Q12_customers= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class currentspecies operation;
model Q12_regulate= operation;
lsmeans operation/stderr pdiff;
run;
PROC Glm;
class operation;

model Q12_logistics= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class operation;
model Q7_infrastructure= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class operation;
model Q7_genetics= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class operation;
model Q7_management= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class operation;
model Q8_desire= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class operation;
model Q8_knowledge= operation;
lsmeans operation/stderr pdiff;
run;

PROC Glm;
class currentspecies operation;
model Q8_financial= operation;
lsmeans operation/stderr pdiff;
run;
Appendix C: Soil test values for 2011 perennial trial
Table 25. Soil test data for the field plots at the OARDC Sheep Center in Wooster, OH. Samples were taken August 2010, prior to the establishment of alfalfa and perennial ryegrass used in the trial.

<table>
<thead>
<tr>
<th>Field</th>
<th>Forage</th>
<th>pH</th>
<th>LTI</th>
<th>P (ug/g)</th>
<th>K (ug/g)</th>
<th>Ca (ug/g)</th>
<th>Mg (ug/g)</th>
<th>% organic Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Alfalfa</td>
<td>4.9</td>
<td>64</td>
<td>24</td>
<td>212</td>
<td>1217</td>
<td>248</td>
<td>3.5</td>
</tr>
<tr>
<td>S</td>
<td>Ryegrass</td>
<td>5.3</td>
<td>66</td>
<td>12</td>
<td>153</td>
<td>1092</td>
<td>240</td>
<td>3.7</td>
</tr>
<tr>
<td>T</td>
<td>Ryegrass</td>
<td>5.4</td>
<td>66</td>
<td>27</td>
<td>179</td>
<td>954</td>
<td>179</td>
<td>3.9</td>
</tr>
<tr>
<td>U</td>
<td>Ryegrass</td>
<td>5.2</td>
<td>66</td>
<td>25</td>
<td>220</td>
<td>941</td>
<td>199</td>
<td>3.1</td>
</tr>
<tr>
<td>V</td>
<td>Alfalfa</td>
<td>5.8</td>
<td>68</td>
<td>27</td>
<td>237</td>
<td>1092</td>
<td>196</td>
<td>3.2</td>
</tr>
<tr>
<td>W</td>
<td>Alfalfa</td>
<td>5.4</td>
<td>66</td>
<td>11</td>
<td>174</td>
<td>908</td>
<td>176</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Appendix D: Regression equations used in 2011 alfalfa/ryegrass study
Figure 14. Regression equations used in calibration of rising plate meter for alfalfa during the 2011 perennial forage trial.
Figure 14. Continued
Figure 15. Regression equations used in calibration of rising plate meter for ryegrass during the 2011 perennial forage trial.
Figure 15. Continued
Appendix E: SAS programs used for 2011 alfalfa/ryegrass field study
SAS program for forage data.

Proc mixed;
class Field date Forage;
model Allowance = forage|date/DDFM=KR;
Random field;
Repeated date/ type=AR (1) subject=field R Rcorr;
lsmeans forage|date/ slice=date;
run;

SAS program for ADG data

proc mixed ;
class Group block sex treat date forage;
model ADGkg = Treat|date sex sex*treat/DDFM=KR;
random block;
repeated date/type=cs subject=group;
LSMEANS Treat;
lsmestimate treat
"DL vs alf" -1 0 1 0 0 ,
"Alf vs Rye" 1 0 0 -1 0,
"alf vs Alfearly" 1 -1 0 0 0,
"alf vs Alflate" 1 0 0 0 -1;
lsmeans treatment|date/ slice=date ;
Run;

SAS program for carcass data

proc mixed ;
class diet sex block;
model trueHCW = diet sex;
random block ;
lsmeans diet;
lsmestimate diet
"DL vs alf" -1 0 1 0 0 ,
"Alf vs Rye" 1 0 0 -1 0 ,
"alf vs Alfearly" 1 -1 0 0 0,
"alf vs Alflate" 1 0 0 0 -1;
Lsmeans sex;
Appendix F: Soil test data for fields used in 2012 summer forage trial
Table 26. Soil test data for the field plots at the OARDC Sheep Center in Wooster, OH. Samples were taken August 2011, prior to the establishment of alfalfa and chicory used in the trial.

<table>
<thead>
<tr>
<th>Field</th>
<th>Forage</th>
<th>pH</th>
<th>LTI</th>
<th>P (ug/g)</th>
<th>K (ug/g)</th>
<th>Ca (ug/g)</th>
<th>Mg (ug/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Sorghum</td>
<td>6.60</td>
<td>70.0</td>
<td>15.0</td>
<td>162.16</td>
<td>46.31</td>
<td>181.48</td>
</tr>
<tr>
<td>C</td>
<td>Sorghum</td>
<td>6.29</td>
<td>69.5</td>
<td>33.7</td>
<td>165.65</td>
<td>37.83</td>
<td>164.09</td>
</tr>
<tr>
<td>D</td>
<td>Chicory</td>
<td>6.00</td>
<td>68.5</td>
<td>47.5</td>
<td>166.19</td>
<td>37.49</td>
<td>175.35</td>
</tr>
<tr>
<td>E</td>
<td>Chicory</td>
<td>6.23</td>
<td>67.0</td>
<td>57.0</td>
<td>348.04</td>
<td>71.28</td>
<td>356.53</td>
</tr>
<tr>
<td>F</td>
<td>Alfalfa</td>
<td>6.13</td>
<td>67.3</td>
<td>70.9</td>
<td>403.31</td>
<td>75.10</td>
<td>372.05</td>
</tr>
<tr>
<td>G</td>
<td>Alfalfa</td>
<td>5.72</td>
<td>67.4</td>
<td>46.7</td>
<td>307.89</td>
<td>40.42</td>
<td>182.36</td>
</tr>
<tr>
<td>H</td>
<td>Alfalfa</td>
<td>6.54</td>
<td>70.0</td>
<td>40.1</td>
<td>232.64</td>
<td>29.74</td>
<td>133.72</td>
</tr>
</tbody>
</table>
Appendix G: SAS programs used for 2011 alfalfa/ryegrass field study
SAS program for forage data.

**Proc mixed;**
class Field date Forage;
model Allowance = forage|date/DDFM=KR;
Random field;
Repeated date/ type=AR (1) subject=field R Rcorr;
lsmeans forage|date/ slice=date;
run;

SAS program for ADG data

**proc mixed ;**
class Group block treat date forage;
model ADGkg = Treat|date /DDFM=KR;
random block;
repeated date/type=cs subject=group;
LSMEANS Treat;
lsmestimate treat
"Alf vs Chic" -1 1 0,
"alf vs SSG" -1 0 1 ;
lsmeans treatment|date/ slice=date;
Run;

SAS program for carcass data

**proc mixed ;**
class diet block;
model trueHCW = diet;
random block;
lsmeans diet;
lsmestimate diet
"Alf vs Chic" -1 1 0,
"alf vs SSG" -1 0 1 ;
Run;
Bibliography


quality assurance program.


Culture & Agriculture. 27: 92-98.


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