
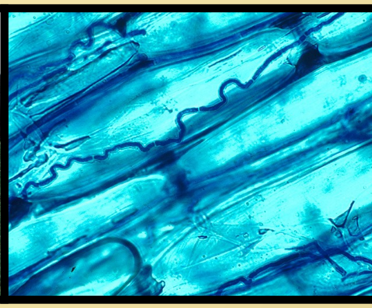

Missouri Beef Value-Added Study

Final report completed for the
Missouri Agricultural & Small Business Development Authority

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UNIVERSITY OF MISSOURI
Extension

Missouri's Value-Added Beef Study – Executive Summary

Missouri ranks within the top 10 U.S. states for beef cow inventory, beef replacement heifers and beef cow operations, based on recent U.S. Department of Agriculture data. Missouri ranked third for beef cow inventory and sixth for beef replacement heifers on Jan. 1, 2015. Additionally, Missouri is the second largest state in the number of beef cow operations in the U.S., according to the latest U.S. Census of Agriculture in 2012.

Missouri has a large beef cow inventory and is a leader in U.S. beef calf production. Currently, Missouri is a major feeder calf exporter; the state sends about 85 percent of its calves to be finished in other Midwestern states. Missouri's slaughter industry only processes a small number of cattle each year. Missouri has a small feedlot industry that ranks 21st in cattle on feed inventory.

The Missouri cattle industry is important to overall Missouri farm income. Relative to cash receipts for other Missouri agricultural commodities, cattle and calves cash receipts ranked second in 2014 and totaled $2 billion.

The Missouri beef industry, livestock slaughter and further livestock processing industries are important to the state's economy. Direct contributions from these industries totaled 45,088 jobs and $1.028 billion in labor income paid during 2014. Total contributions – direct, indirect and induced – from these industries supported 72,566 Missouri jobs and provided $2.081 billion in labor income. Total value added to the state's economy totaled $3.812 billion in 2014. The Missouri beef cattle, livestock slaughter and further livestock processing industries also provided $304 million in state and local taxes and $459 million in federal taxes during 2014.

Many alternative investment ideas have been discussed to ensure the Missouri cattle industry grows and takes full advantage of its economic potential. Increased feeding of cattle in the state has been one area of focus and this report shows that for every 10,000 head of Missouri calves that remain in Missouri to be finished, there is an additional $6 million in value-added to the Missouri economy. Processing cattle in Missouri also adds value to the Missouri economy. Every $100,000 in new beef processing industry sales provides an additional $122,000 to Missouri's economy.

Covered Feeding of Cattle in Missouri

There are several reasons why covered facilities have piqued interest of Missouri beef industry stakeholders. Shelter can protect cattle from weather events, and it may mediate problems like heat stress, cold stress and muddy conditions. Operating a covered cattle production facility can also influence manure characteristics. Maintaining an open feedlot influences manure nutrient capture and value, and the open lot may also create some environmental challenges.

Profitability in growing and finishing beef cattle depends primarily on the cost of producing gain and the value of that gain. The value of gain per pound is the difference between an animal's purchase price and its sales value divided by the gain added during ownership.

Three 400 head covered cattle feeding operations are modeled as examples in this study. Given the assumptions use in the study, all three models would enable producers to operate profitably. Net farm income for backgrounding operations is estimated to total more than $15,000. For operations that finish feeders, net farm income is projected to reach nearly $49,000, and for operators that finish calves net farm income is projected to exceed $52,000.

It is important to understand that purchase prices, selling prices and feed costs are major drivers that influence profitability of backgrounding and finishing beef animals. These models were developed with purchase prices, selling prices and feed costs based on December 2015 market conditions, and efforts were made to match historical cattle weight-price relationships. Market conditions are highly volatile. Unhedged cattle feeding can be very profitable or very unprofitable.

Missouri Cattle Processor Modernization

The Missouri meat processing industry has become increasingly smaller, which creates challenges for livestock producers who need local processors to slaughter and further process animals that they raise. Local processing reduces transportation costs for livestock producers and provides marketing channels for them to develop niche markets.

To operate and serve livestock producers, the processors themselves experience multiple challenges that they must address to make their businesses function well. They include: regulatory burden, HAACP, food safety, operations management, offal sales or disposal.

Large beef processors are located near large fed cattle supplies and have markets for the offal they produce. Despite the challenge of not having these advantages, success stories for small-scale meat processors do exist. It remains critical to provide an atmosphere that allows smaller Missouri processors the chance to serve long-standing local demand and to develop emerging niche markets.

Feed Tracking and Monitoring Technology

The beef industry has several tools available that leverage technology for tracking and monitoring animal behavior and performance. These systems and the data that they collect can be used to indicate whether an animal eats efficiently, grows well, becomes sick and fits in a given marketing group. GrowSafe is the predominant system described for its applicability in research and production environments but many other technologies exist for use in the cattle industry today.

Tall Fescue Toxicosis and Emerging Technologies

Fescue toxicosis has long been recognized as a large negative issue for Missouri cattle producers. Fescue toxicosis reduces reproductive rates and rates of gain in cattle. In Missouri alone, one estimate suggests that toxic fescue annually reduces industry value by $240 million (Harker 2015).

Producers have several technologies and practices available that can reduce fescue toxicosis incidence and its effects. They are: 1) pasture renovation and novel-endophyte fescue, 2) pasture dilution, 3) seed head clipping, 4) herbicide treatment, 5) alternative grazing strategies, 6) diet supplementation, 7) ammoniate hay and 8) genetic testing of cattle.

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Missouri's Value-Added Beef Study

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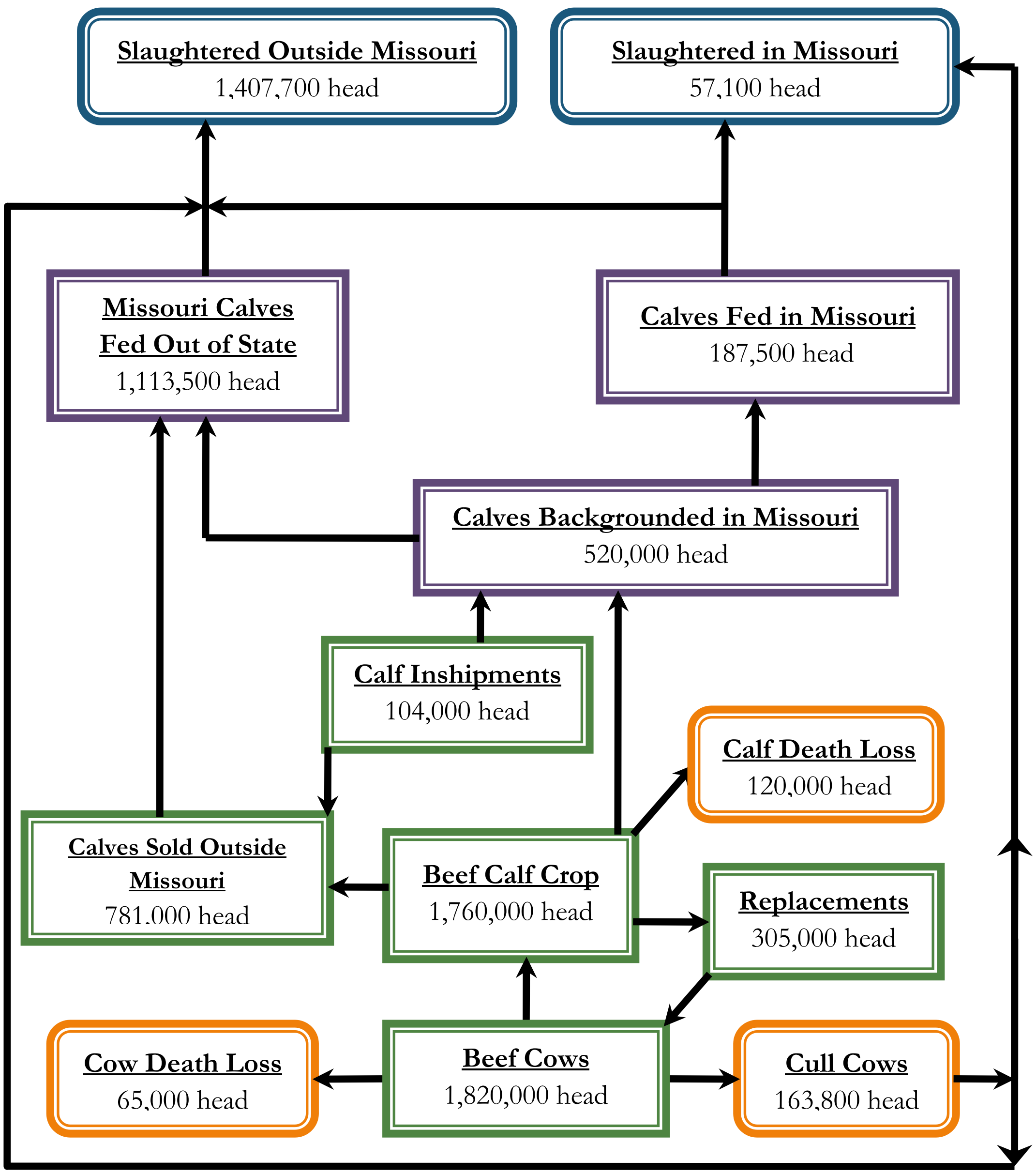
1. Missouri's Beef and Processing Industry

Commercial beef cattle operations are organized into three basic categories: cow-calf, stocker and fed-cattle operations. On Jan. 1, 2015, 80.5 percent of Missouri's total cattle inventory was held by cow-calf operations, 14 percent of the inventory was held as stockers, and less than 2 percent of the inventory was cattle on feed. Dairy cattle – both cows and replacements – made up the remainder of cattle reported, which was an estimated 3.7 percent on Jan. 1, 2015. Exhibit 1.1 details the Missouri cattle flowchart for 2014. The graphic depicts the flow of cattle and calves from Missouri farms into growing, finishing and marketing channels.

Exhibit 1.1 – Missouri Cattle Flowchart, 2014



Source: Horner et al. (2015)

Missouri has a large beef cow inventory and is a leader in U.S. beef calf production. Currently, Missouri is a major feeder calf exporter; the state sends 85 percent of its calves to be finished in other Midwestern states. Missouri's slaughter industry only processes a small number of cattle each year. Larger facilities in the state are dedicated to swine processing. The following sections detail key aspects of the various beef production stages, and more information is shared about Missouri's livestock slaughter and processing industry. Information provided includes historical trends and current conditions affecting these industries.

1.1 Cow-Calf Industry

Missouri ranks within the top 10 U.S. states for beef cow inventory, beef replacement heifers and beef cow operations, based on recent available data. Exhibit 1.1.1 lists the top 20 states for these classifications. Relative to other states, Missouri ranked third for beef cow inventory and sixth for beef replacement heifers on Jan. 1, 2015. Additionally, Missouri represented the second largest state for number of beef cow operations, according to the latest U.S. Census of Agriculture in 2012. Texas held the top place for all three categories.

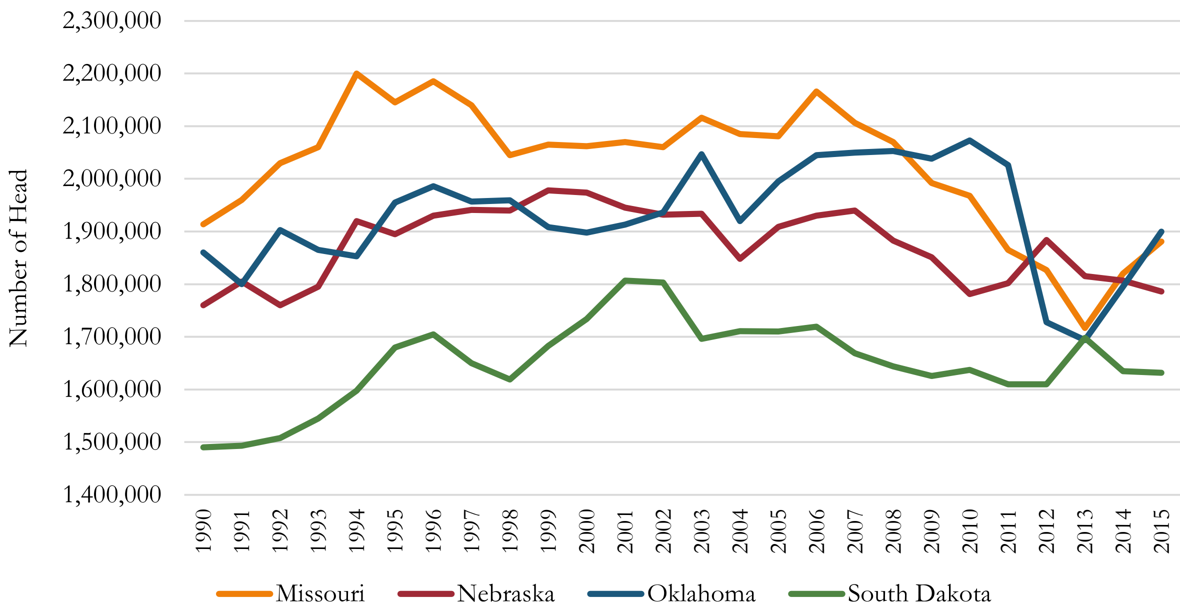
Exhibit 1.1.1 – Beef Cow Inventory, Replacement Heifers Inventory and Beef Cow Operations

Rank	State	Beef Cow Inventory (Jan. 1, 2015)	State	Beef Replacement Heifers (Jan. 1, 2015)	State	Beef Cow Operations (2012)
1	Texas	4,180,000	Texas	710,000	Texas	133,924
2	Oklahoma	1,900,000	Montana	425,000	Missouri	46,161
3	Missouri	1,881,000	Oklahoma	405,000	Oklahoma	44,106
4	Nebraska	1,786,000	Nebraska	390,000	Kentucky	33,823
5	South Dakota	1,632,000	South Dakota	380,000	Tennessee	33,556
6	Montana	1,506,000	Missouri	310,000	Arkansas	23,385
7	Kansas	1,477,000	Kansas	260,000	Kansas	23,272
8	Kentucky	1,007,000	Wyoming	183,000	Alabama	19,685
9	Iowa	920,000	Iowa	170,000	Iowa	19,677
10	Florida	916,000	North Dakota	164,000	Virginia	19,596
11	North Dakota	904,000	Colorado	160,000	Nebraska	19,313
12	Tennessee	883,000	Arkansas	141,000	Florida	18,433
13	Arkansas	863,000	Kentucky	135,000	Ohio	16,922
14	Colorado	745,000	Tennessee	135,000	North Carolina	16,059
15	Wyoming	694,000	Florida	125,000	Georgia	15,175
16	Alabama	672,000	California	120,000	Mississippi	14,644
17	Virginia	637,000	Alabama	110,000	Minnesota	13,547
18	California	600,000	Idaho	110,000	South Dakota	13,327
19	Oregon	525,000	Oregon	110,000	Wisconsin	13,020
20	Georgia	489,000	Virginia	105,000	Illinois	12,646

Source: USDA, National Agricultural Statistics Service

Exhibit 1.1.2 shows beef cow inventory trends for Missouri and other similar beef cow inventory states. Historically, Missouri had been the No. 2 beef cow state behind Texas, but it fell behind other states after 2009. During the observed period, Missouri reached a high of 2.2 million beef cows in 1994 and a low of 1.72 million beef cows in 2013. In the two most recent years, Missouri rebuilt its beef cow inventory to 1.81 million cows and closely follows Oklahoma for beef cow inventory.

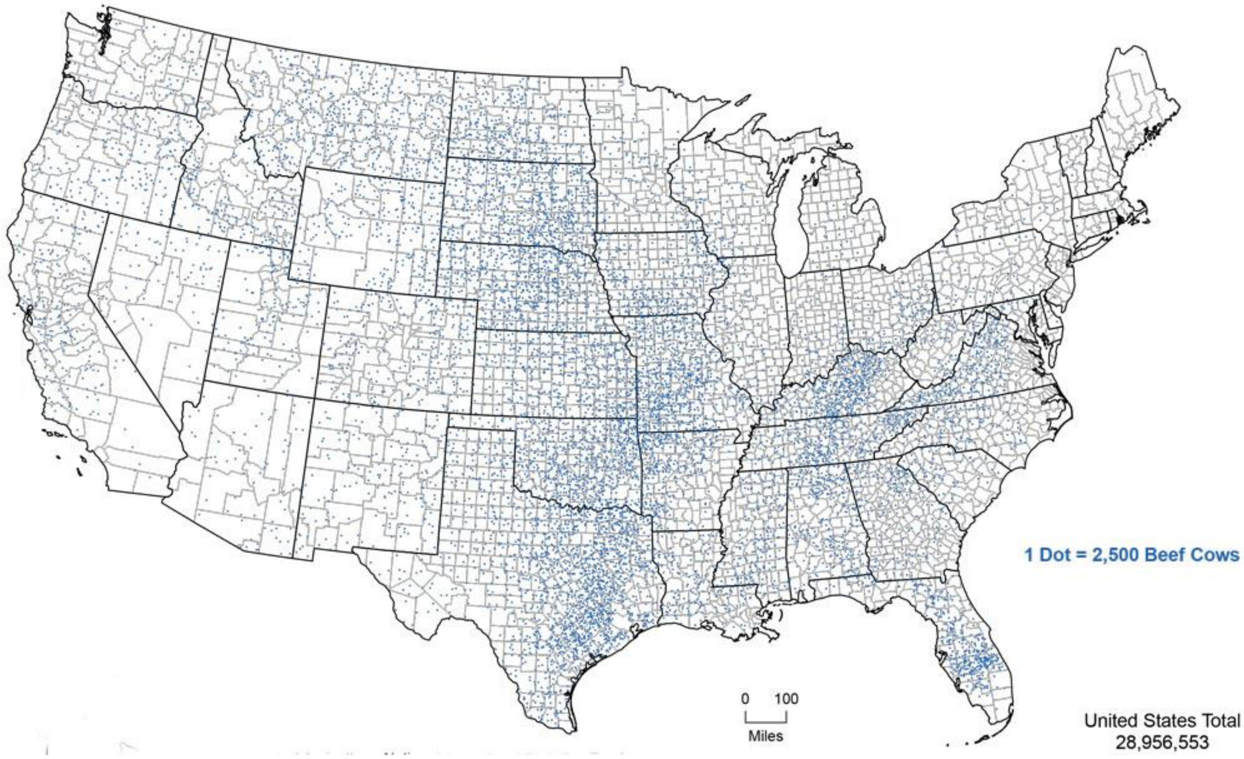
Exhibit 1.1.2 – Beef Cow Inventory, Selected States, 1990 to 2015



Source: USDA, National Agricultural Statistics Service, Census of Agriculture

Beef cows are widely dispersed across the U.S. Exhibit 1.1.3 shows the U.S. beef cow inventory geographically during 2012. Each blue dot reflects a concentration of 2,500 beef cows. The more heavily concentrated areas appear throughout regions of Missouri, Oklahoma and Texas, which are the leading states in total beef cow inventory.

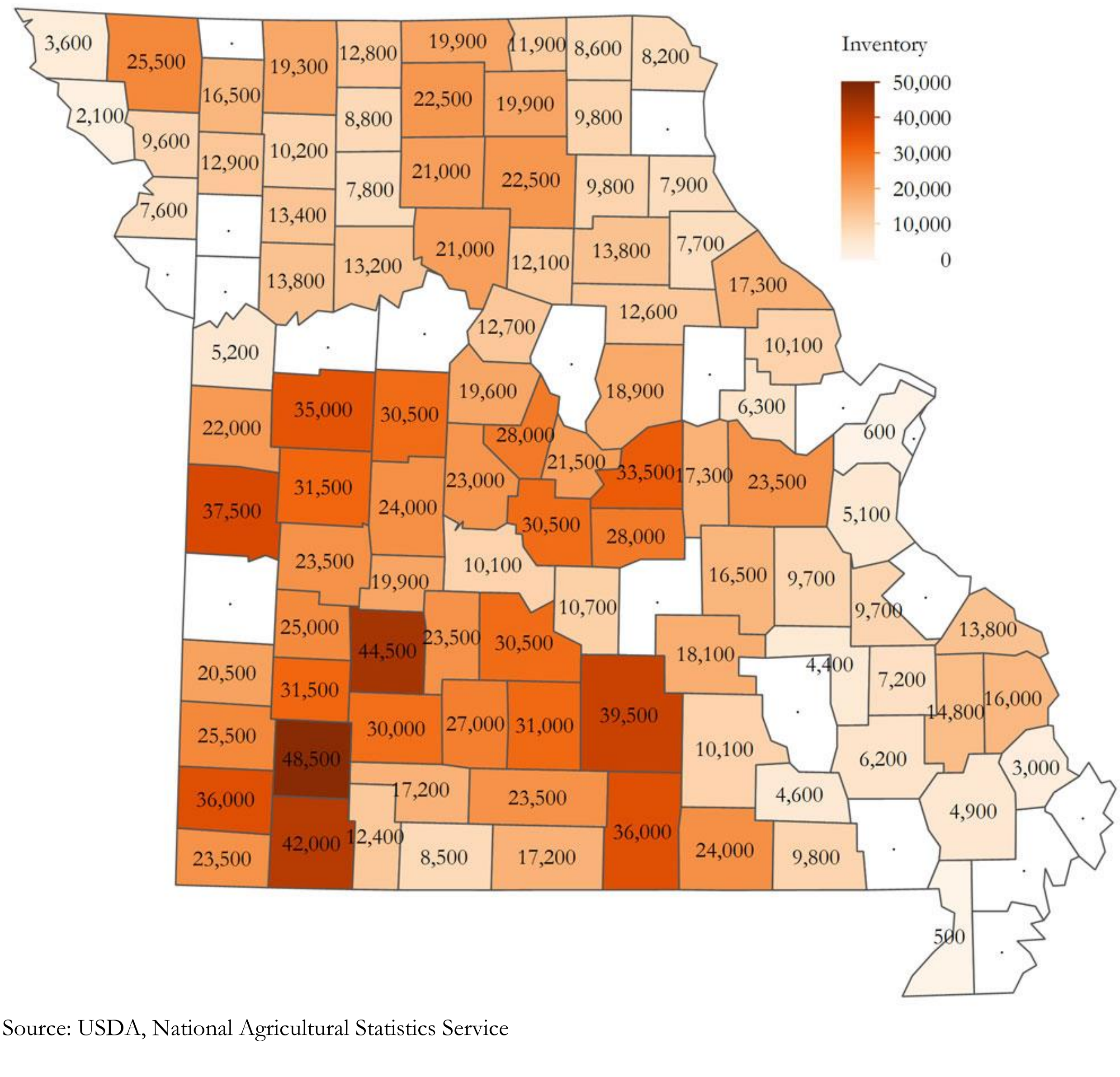
Exhibit 1.1.3 – U.S. Beef Cow Inventory, 2012



Source: USDA, National Agricultural Statistics Service, Census of Agriculture

Beef cows are located in a majority of Missouri counties. Counties with the highest beef cow concentrations are in the state's southwest and south central regions. Exhibit 1.1.4 shows the distribution of Missouri beef cow inventory by county on Jan. 1, 2015. The three Missouri counties with the greatest inventories were Lawrence County, 48,500 head; Polk County, 44,500 head; and Barry County, 42,000 head.

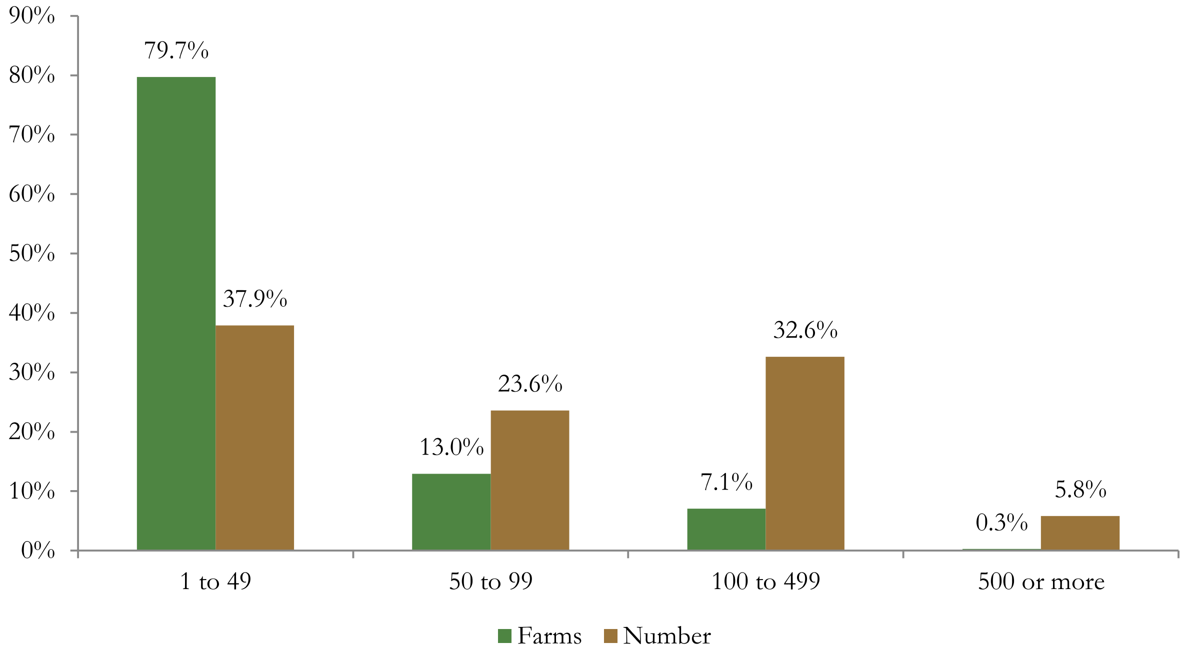
Exhibit 1.1.4 – Missouri Beef Cow Inventory, by County, Jan. 1, 2015



Source: USDA, National Agricultural Statistics Service

Exhibit 1.1.5 displays Missouri's beef cow operations and the share of beef cow inventory that they maintained in 2012. According to the U.S. Census of Agriculture, Missouri had 46,161 farms that reported owning beef cows in 2012. A majority of these farms had fewer than 50 head. Operations with 1 to 49 head represented nearly 80 percent of total farms, but they controlled just 38 percent of the Missouri beef cow inventory. Missouri only had 122 operations (0.3 percent) that had at least 500 head in 2012, but these large operations held about 6 percent of the state's beef cow inventory.

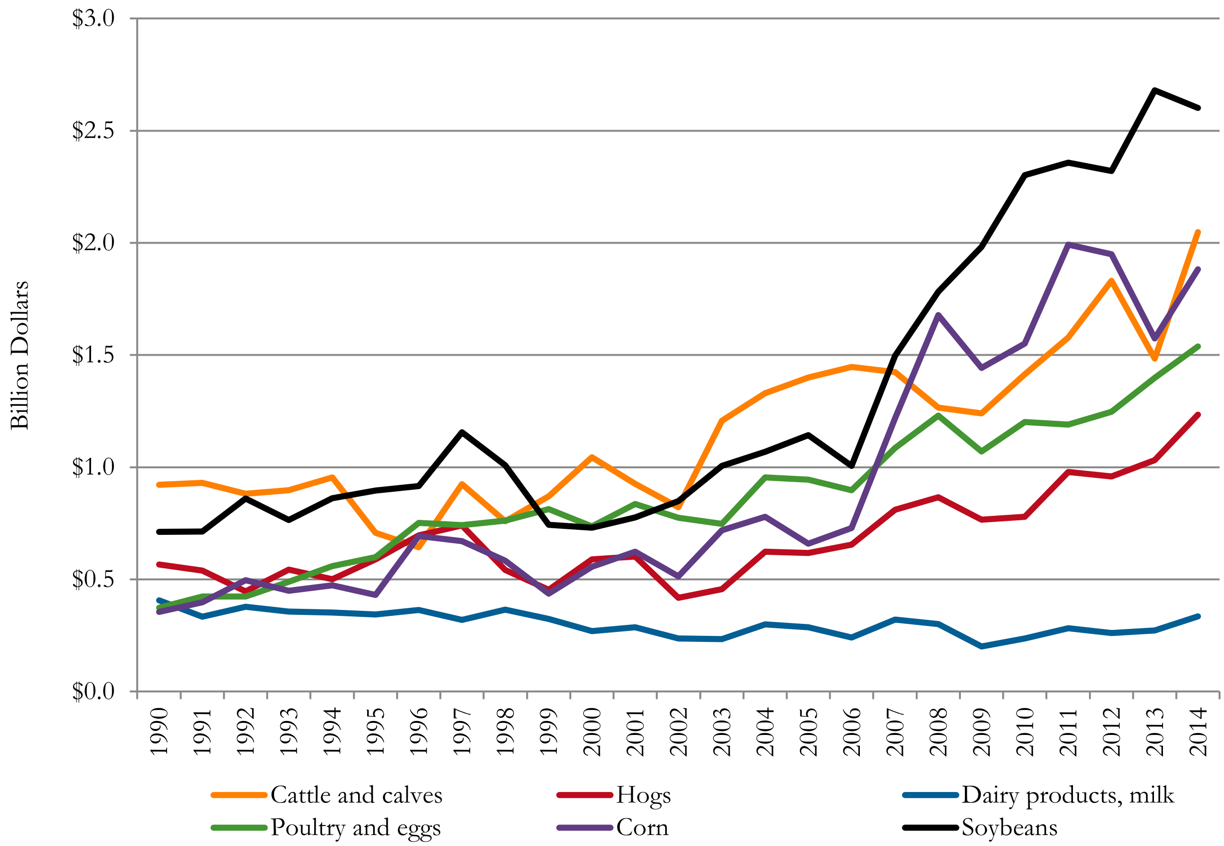
Exhibit 1.1.5 – Missouri Beef Cow Operations by Size and Inventory, 2012



Source: USDA, National Agricultural Statistics Service, Census of Agriculture

A majority of beef economic transactions occur in the cow-calf sector. Cattle and calf production leads to cash sales for farmers, and it provides income to pay expenses and generate returns. Relative to cash receipts for other Missouri agricultural commodities, cattle and calves cash receipts ranked second in 2014 and totaled $2 billion. Soybean cash receipts topped the list representing 19 percent of total 2014 Missouri commodity cash receipts. Exhibit 1.1.6 presents historical cash receipts for Missouri commodities. Between 1990 and 2014, Missouri cattle and calves cash receipts increased by 122 percent.

Exhibit 1.1.6 – Missouri Cash Receipts by Commodity, 1990 to 2014



Source: USDA, Economic Research Service

1.2 Stocker/Backgrounding Industry

Exhibit 1.2.1 estimates the number of stocker calves in Missouri and presents state-by-state stocker inventory rankings based on Jan. 1, 2015, inventory estimates. Missouri ranked seventh in the U.S. for stocker calf inventory on Jan. 1, 2015. At the time, Missouri had an estimated 560,000 stocker calves. Texas, Kansas and Nebraska were the three top stocker calf states based on this analysis.

Estimating stocker inventory requires taking a few steps and using cattle inventory data available from the USDA National Agricultural Statistics Service. This analysis estimates stocker inventory by adding inventory for steers and non-replacement heifers that weigh at least 500 pounds. Then, the number of cattle/calves already on feed is subtracted. This stocker calculation assumes that stocker calves represent all calves that weigh at least 500 pounds on Jan. 1 and that are not kept for breeding or are not already in feedlots. These animals may be on pasture or in dry lot systems.

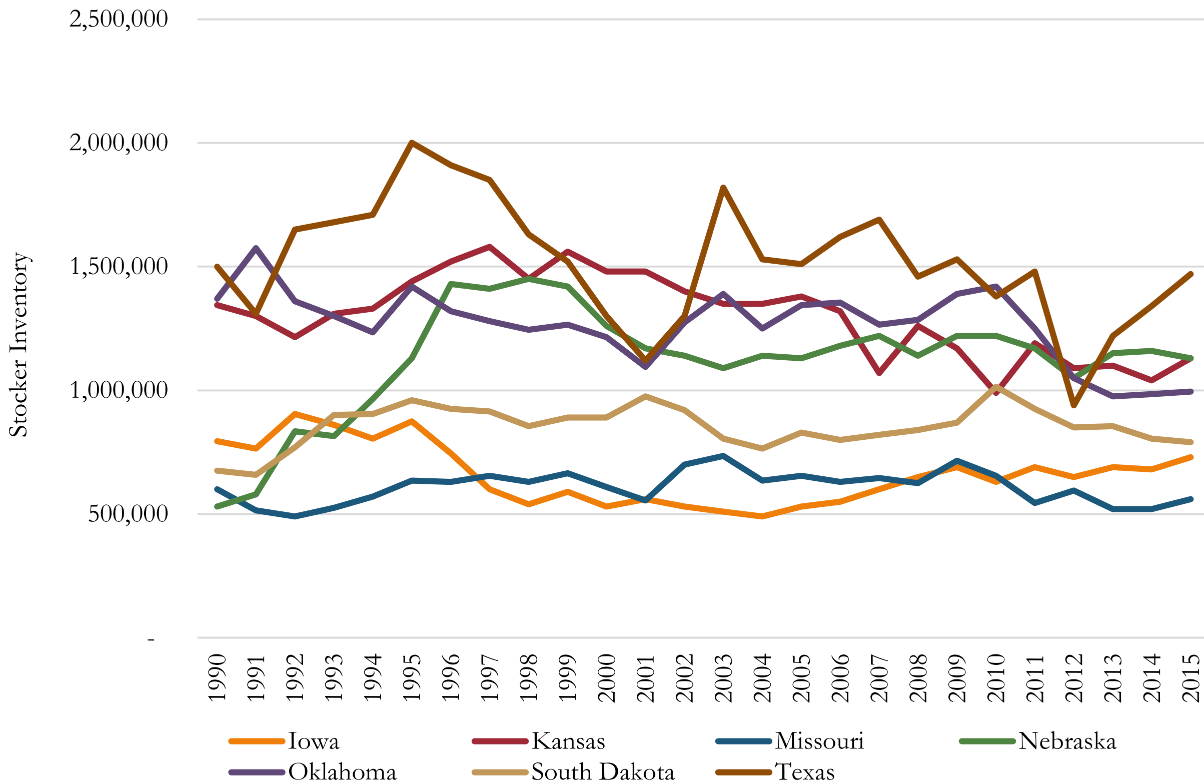
Exhibit 1.2.1 – Non-Replacement Heifers, Steers and Stocker Inventory, Jan. 1, 2015

Rank	State	Non-Replacement Heifer Inventory 500+ lbs.	State	Steer Inventory 500+ lbs.	State	Stocker Inventory
1	Texas	1,480,000	Texas	2,500,000	Texas	1,470,000
2	Kansas	1,380,000	Nebraska	2,360,000	Kansas	1,130,000
3	Nebraska	1,300,000	Kansas	1,930,000	Nebraska	1,130,000
4	Iowa	640,000	Iowa	1,310,000	Oklahoma	995,000
5	South Dakota	495,000	Oklahoma	870,000	South Dakota	790,000
6	Colorado	490,000	Colorado	790,000	Iowa	730,000
7	Oklahoma	390,000	South Dakota	680,000	Missouri	560,000
8	Missouri	230,000	California	570,000	Ohio	425,000
9	Montana	198,000	Minnesota	500,000	North Dakota	356,000
10	Idaho	190,000	Missouri	400,000	Oregon	355,000
11	North Dakota	185,000	Wisconsin	375,000	Colorado	350,000
12	California	180,000	Idaho	290,000	Montana	333,000
13	Minnesota	165,000	Arizona	275,000	California	325,000
14	Wyoming	152,000	Illinois	220,000	Kentucky	295,000
15	Washington	136,000	North Dakota	215,000	Minnesota	280,000
16	Kentucky	110,000	Kentucky	200,000	Idaho	235,000
17	Oregon	105,000	Ohio	200,000	Wyoming	212,000
18	Illinois	101,000	Washington	180,000	Tennessee	185,000
19	New Mexico	80,000	Michigan	175,000	Virginia	182,000
20	Tennessee	70,000	Montana	175,000	Wisconsin	170,000

Source: USDA, National Agricultural Statistics Service

Historical trends for top stocker state rankings are shown in Exhibit 1.2.2. Presently, the top three states in terms of stocker inventory are Kansas, Nebraska and Oklahoma. Missouri's stocker inventory didn't vary much during the observed period. It reached a high of 735,000 head in 2003 and a low of 490,000 head in 1992. Nebraska stocker numbers sharply increased from 1990 to 1996. On a year-to-year basis, Texas has observed much volatility in its stocker inventory.

Exhibit 1.2.2 – Top States for Stocker Inventory, 1990 to 2015



Source: USDA, National Agricultural Statistics Service

Backgrounding involves growing stocker steers and heifers from weaning until they are ready to enter a feedlot. Calves generally gain 100 pounds to 400 pounds during backgrounding. Gain depends on cattle condition, forages and supplemental ration provided and feeding period.

There are many types of backgrounding systems. Some of the more popular systems involve buying calves either in the fall or spring and selling them four months to six months later. A backgrounding system can be built into a cow-calf operation or be part of a finishing program. Some backgrounders buy and sell throughout the year. Buying and selling skills are very important in a backgrounding business as roughly 50 percent to 65 percent of the weight sold must be initially purchased. A calf's purchase price greatly affects profit potential. Additionally, a backgrounder needs to have the necessary facilities and the ability to diagnose and treat sick animals.

Successful Missouri backgrounding operations typically follow one of two strategies with regard to procuring and marketing calves. They either use a traditional strategy or an emerging value-added alliance strategy. A profitable business can be built using either strategy, but the means of creating and capturing value can vary quite significantly between the two strategies.

A. Traditional Strategy: Profits are made when the cattle are bought.

Procurement:

- Buy lower cost, commingled calves from small lots of unknown genetic merit.
- Buy calves during weather-related dips in market prices or seasonal low-price periods.
- Purchase lower cost cattle from southeastern states and background them in Missouri before shipping west for finishing.

Value Creation:

- Dehorning, castrating and tagging with similar tags in series.
- Sort according to breed, weight, color and condition.
- Vaccinate cattle, precondition them, and feed them to gain, but maintain a body condition that looks adequate, not fat.

Value Capture:

- Feed low-cost co-products, home-raised pasture, hay or silage to produce low-cost gains.
- Use hedging, options, forward contracting or insurance to manage risk.
- Market the cattle as "trouble-free" commodity calves, and sell them directly to a feedlot that buys in tractor-trailer lots.

B. Emerging Value-Added Alliance Strategy: Marketing quality pays.

Procurement:

- Buy only calves from known herds of genetic merit with regard to traits that enhance finishing profits and slaughter value.
- Create relationships with cow-calf producers producing these types of consistent calves, and offer them either a premium over market prices or a percentage of retained ownership through the backgrounding and finishing stages.

Value Creation:

- Maintain age and source verification data with the calves using an individual calf identification system preferred by the final buyer.
- Maintain rapid calf growth to finish at a young age.
- Vaccinate cattle, precondition them, and attach performance and carcass data to them and future lots of similar cattle.

Value Capture:

- Feed the calves an optimal diet for rapid growth.
- Market the cattle through a value-based alliance where premiums are captured either at sale to the feedlot or at slaughter.
- Use known cattle production and carcass qualities to negotiate.

1.3 Feedlot Industry

Missouri has a small cattle feedlot industry. Exhibit 1.3.1 reports the U.S. state ranking in recent years for cattle on feed inventory (Jan. 1, 2015) and cattle on feed operations (2012). According to these data, Missouri ranked 21st in cattle on feed inventory. Nebraska, Texas and Kansas were the major states with a large feedlot industry. They maintained 55 percent of total U.S. cattle on feed inventory. Number of cattle on feed operations is much different. Based on 2012 data, Iowa, Minnesota and Wisconsin had the most operations. These data would suggest that leading cattle on feed inventory states have much larger feedlot operations than other states.

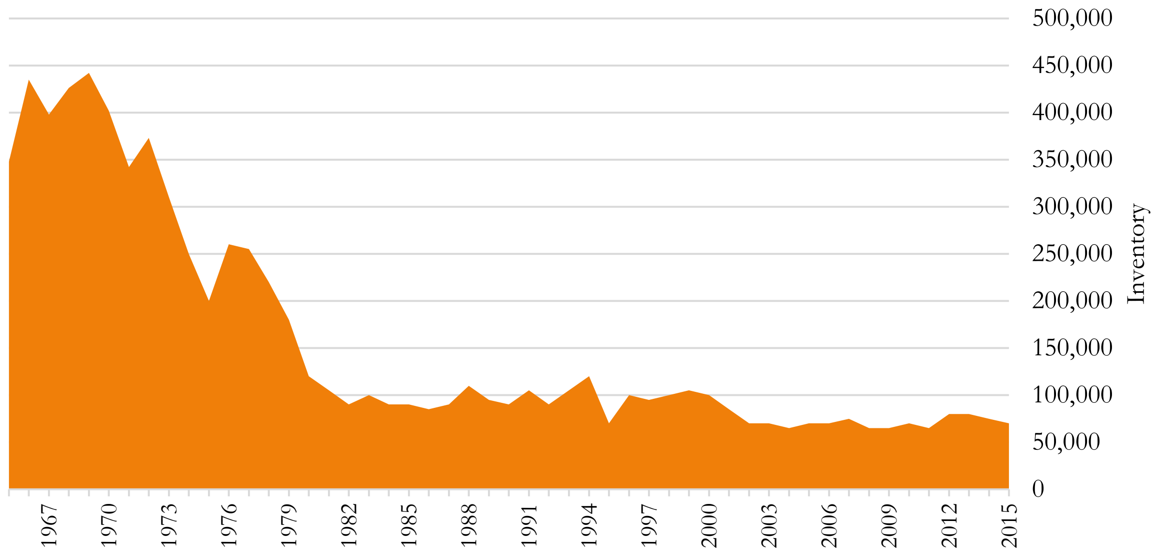
Exhibit 1.3.1 – Cattle on Feed, Inventory (Jan. 1, 2015) and Operations (2012)

Rank	State	Cattle on Feed Inventory	State	Cattle on Feed Operations
1	Nebraska	2,530,000	Iowa	5,368
2	Texas	2,510,000	Minnesota	3,790
3	Kansas	2,180,000	Wisconsin	2,789
4	Iowa	1,220,000	Illinois	1,976
5	Colorado	930,000	Nebraska	1,777
6	California	425,000	Pennsylvania	1,527
7	Minnesota	385,000	Ohio	1,517
8	South Dakota	385,000	South Dakota	1,263
9	Oklahoma	265,000	Michigan	1,017
10	Wisconsin	260,000	Indiana	919
11	Arizona	252,000	Kansas	714
12	Idaho	245,000	Missouri	687
13	Illinois	230,000	Kentucky	437
14	Washington	210,000	Texas	375
15	Ohio	170,000	Virginia	328
16	Michigan	160,000	North Dakota	292
17	Indiana	100,000	New York	273
18	Pennsylvania	90,000	Colorado	244
19	Oregon	85,000	Oklahoma	227
20	Wyoming	75,000	Idaho	163
21	Missouri	70,000	Utah	132
22	North Dakota	44,000	Montana	128
23	Montana	40,000	Maryland	115
24	New York	26,000	Oregon	109
25	Utah	24,000	California	97

Source: USDA, National Agricultural Statistics Service

Exhibit 1.3.2 shows the trend in Jan. 1 cattle on feed inventory in Missouri from 1965 to 2015. Since 2002, Missouri's cattle on feed inventory has not fluctuated much. On Jan. 1, 2015, Missouri's cattle on feed inventory totaled 70,000 head. During the past 25 years, Missouri averaged approximately 82,000 cattle on feed per year.

Exhibit 1.3.2 – Missouri Cattle on Feed Inventory, Jan. 1, 1965, to Jan. 1, 2015



Source: USDA, National Agricultural Statistics Service

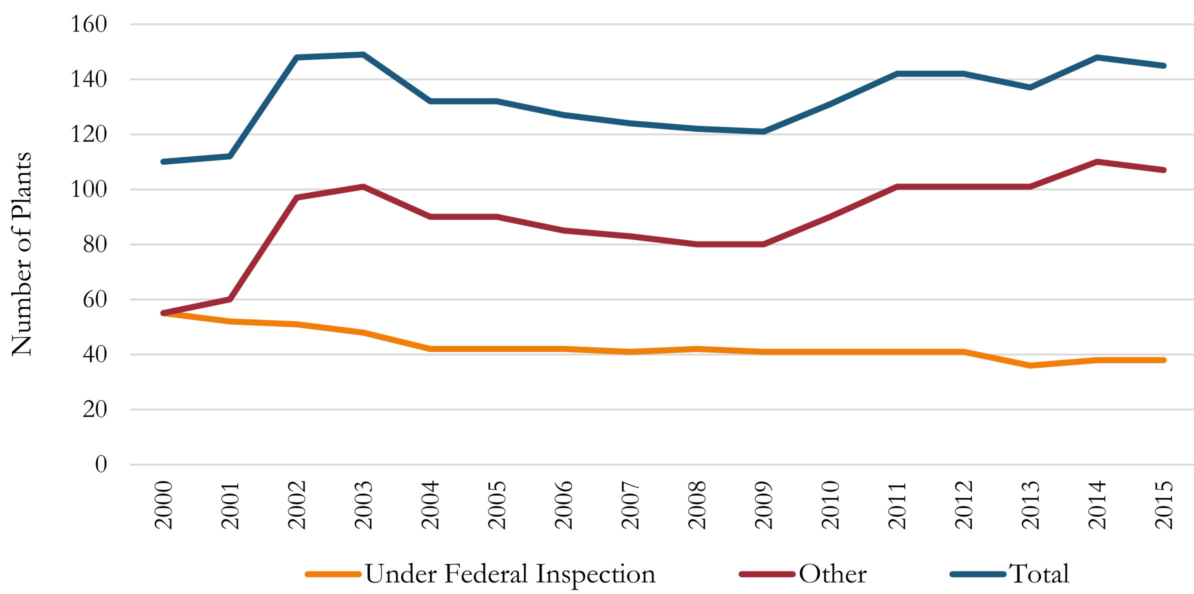
Historically, Missouri has not built many large-scale beef feedlots. According to the Missouri Department of Natural Resources (DNR), there are only 7 beef operations in Missouri that have an operating permit as of January 2016. Operating permits are required for confined beef operations greater than 1,000 head, can be required for operations that have had a notice of violation(s) or operations may voluntarily apply for a permit regardless of size. Most of the current U.S. feedlot industry has developed in Kansas, Iowa and Nebraska; these areas have close proximity to the U.S. slaughtering industry. Major problems associated with Missouri open feedlots can be attributed to high rainfall, which leads to runoff that can pollute streams, and muddy dirt lots, which reduce animal performance and feed efficiency. Additionally, long distances to slaughtering facilities and massive competition from existing large western feedlots are barriers to feeding cattle in Missouri.

1.4 Missouri Slaughter and Processing Industries

Many livestock slaughter and processing plants operate in Missouri. State or federal representatives periodically inspect such slaughtering facilities and meat processors to ensure that the facilities follow safe practices. Plants are classified by type depending on their commerce and animal ownership. Federally inspected plants may sell and transport products interstate, and they are subject to federal inspection to ensure compliance with USDA standards. Non-federally inspected plants sell and transport products, including online sales and mail orders, only within the origin state. These plants are subject to state inspection by the Missouri Meat and Poultry Inspection Program to ensure compliance with Missouri state standards. If plants do not sell meat and just operate on a custom basis, then they can be classified as custom-exempt plants. Custom-exempt products must be marked "not for sale" and raised and delivered by the customer. Custom-exempt plants are only subject to sanitary inspection by the state.

Exhibit 1.4.1 shows the correlation between federally inspected slaughter plants and other slaughter plants in Missouri during the past 15 years. On Jan. 1, 2015, Missouri was estimated to have 145 total plants. Of those, 38 were subject to federal inspection, and 107 were classified as other slaughter plants. Other slaughter plants, which include state-inspected and custom-exempt plants, have seen more fluctuation since 2000. The number of federally inspected slaughter plants in Missouri has declined slightly since 2000 but has remained relatively constant since 2004. State-inspected and custom-exempt slaughter plants make up the majority of Missouri slaughter plants.

Exhibit 1.4.1 – Missouri Livestock Slaughter Plants, Jan. 1, 2000, to Jan. 1, 2015



Source: USDA, National Agricultural Statistics Service

Missouri also has a significant meat processing industry. Some of the existing livestock slaughter plants are engaged in the processing industry. This processing industry primarily purchases boxed meat and further cuts and packages it into value-added products. Exhibit 1.4.2 details all federally inspected Missouri establishments that produce meat, poultry and/or egg products. Ninety-one plants identified their activities as processing alone, and 42 plants indicated that they offered slaughtering and processing. A majority of federally inpected plants – 72 percent – registered as handling both meat and poultry products.

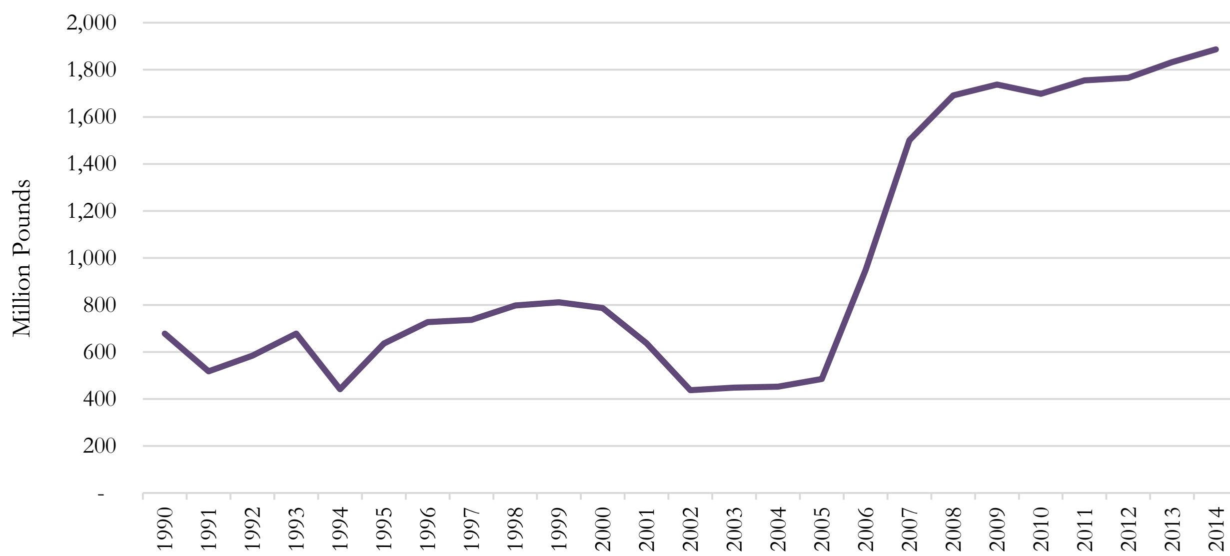
Exhibit 1.4.2 – Missouri Federally Inspected Meat, Poultry and Egg Product Establishments, November 2015

Type of Operation	Number of Plants
Slaughter, Processing	42
Processing	91
ID Warehouse	4
Not Listed	18
Total	**155**

Source: USDA, Food Safety and Inspection Service

Commercial red meat production in Missouri has increased during the past three decades. Red meat production is classified as the carcass weight after slaughter condemnation, and it includes beef, veal, pork and lamb and mutton in its total. Commercial production includes slaughter and meat production in federally inspected and other plants (state-inspected and custom-exempt plants), but it excludes animals slaughtered on farms. The pound measurements are based on packers' dressed weights. Exhibit 1.4.3 shows a significant increase in red meat production starting in 2006 and continuing to 2014. In 2014, Missouri produced 1.887 billion pounds of commercial red meat.

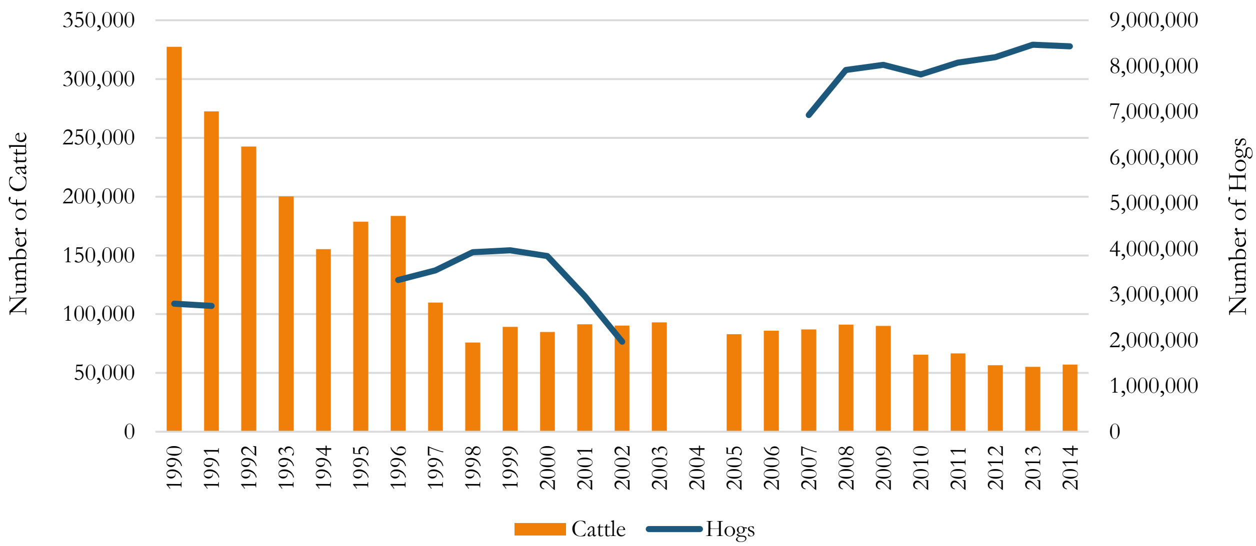
Exhibit 1.4.3 – Missouri Commercial Red Meat Production, Pounds, 1990 to 2014



Source: USDA, National Agricultural Statistics Service

Red meat production in Missouri primarily originates from the hog industry. Exhibit 1.4.4 details commercial cattle and hog slaughter since 1990. As the major federally inspected slaughter plants – Triumph Foods in St. Joseph and Smithfield Farmland Corp. in Milan – began operations, Missouri hog slaughter rapidly increased. In 2013, the state recorded the highest hog slaughter during the observed period with 8.468 million head slaughtered. Commercial cattle slaughter has generally decreased over time. It totaled 57,100 head in 2014. Other animal categories in Missouri such as calves and sheep/lambs have seen smaller quantities slaughtered. In 2014, Missouri's commercial calf slaughter totaled 200 head, and commercial sheep/lamb slaughter totaled 9,400 head.

Exhibit 1.4.4 – Missouri Commercial Cattle and Hog Slaughter, Head, 1990 to 2014



Source: USDA, National Agricultural Statistics Service

How does Missouri's slaughter industry compare to other U.S. states? Exhibit 1.4.5 shows state rankings by number of commercial cattle, hog and sheep/lamb slaughtered during 2014. Missouri ranked 17th among U.S. states in commercial cattle slaughter; the state's output represented 0.2 percent of total U.S commercial cattle slaughter. Most facilities that process beef cattle in Missouri are smaller plants. Large Midwestern beef plants operate near existing cattle feedlots. Leading cattle slaughter states include Nebraska, Kansas and Texas, and their combined market share is nearly 60 percent of the U.S. total. During 2014, Missouri ranked fourth and 20th in commercial hog slaughter and commercial sheep/lamb slaughter, respectively.

Exhibit 1.4.5 – Commercial Cattle, Hog, Sheep and Lamb Slaughter, Number of Head, 2014

Rank	State	Cattle	State	Hogs	State	Sheep & Lamb
1	Nebraska	6,683,700	Iowa	28,644,700	Colorado	945,100
2	Kansas	5,907,500	Illinois	10,437,700	California	290,200
3	Texas	5,322,000	Minnesota	9,708,400	Michigan	198,600
4	Colorado	2,464,900	Missouri	8,429,700	Illinois	146,800
5	California	1,360,100	Indiana	8,206,200	New Jersey	120,700
6	Wisconsin	1,327,300	Nebraska	7,139,000	Texas	109,400
7	Washington	1,059,000	Oklahoma	4,845,300	Pennsylvania	71,800
8	Pennsylvania	962,200	Pennsylvania	2,829,500	New York	51,700
9	Minnesota	664,200	California	2,344,700	Indiana	51,600
10	Utah	563,700	Ohio	909,700	Maryland	47,400
11	Arizona	523,200	Tennessee	713,800	New Hampshire	37,200
12	Michigan	522,800	Wisconsin	613,100	Oregon	33,600
13	South Carolina	169,400	Texas	261,800	Ohio	16,200
14	Ohio	103,900	Michigan	184,000	North Carolina	15,600
15	North Carolina	70,500	Oregon	164,500	Kentucky	14,700
16	Oregon	66,000	Idaho	129,300	Tennessee	13,500
17	Missouri	57,100	New Jersey	104,400	Georgia	12,300
18	Tennessee	53,400	Georgia	70,900	Washington	11,600
19	Indiana	37,400	Utah	43,600	Wisconsin	11,100
20	New Jersey	34,200	Mississippi	42,400	Missouri	9,400

Source: USDA, National Agricultural Statistics Service

Exhibit 1.4.6 details U.S. federally inspected plants sorted by annual number of cattle processed. The U.S. had 654 federally inspected plants that slaughtered 29 million head in 2014. Fifty-six percent of total cattle slaughter came from 13 plants that processed 1 million or more cattle per year.

Exhibit 1.4.6 – U.S. Cattle Slaughter, Number of Federally Inspected Plants and Head Slaughtered by Size Group, 2014

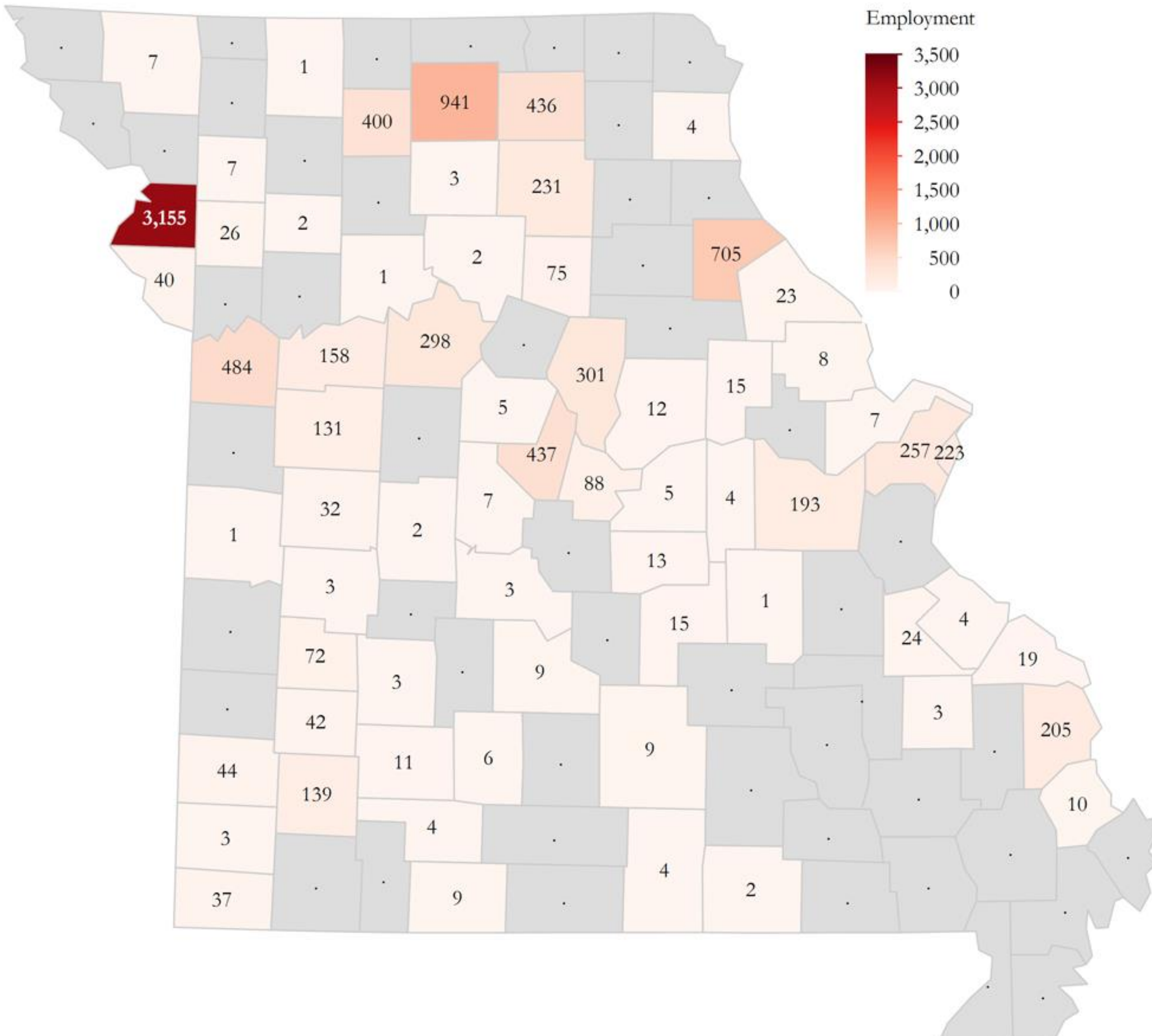
Size Group	Plants (Number)	Total Head
1 - 999	468	147,000
1,000 - 9,999	106	239,100
10,000 - 49,999	21	508,100
50,000 - 99,999	12	857,700
100,000 - 199,999	9	1,243,400
200,000 - 299,999	7	1,672,800
300,000 - 499,999	14	5,944,200
500,000 - 999,999	4	2,416,200
1,000,000 +	13	16,655,600
Total	654	29,684,100

Source: USDA, National Agricultural Statistics Service

Missouri's slaughter and further meat processing industries provide jobs and economic benefits that are valuable to the state's economy. IMPLAN Pro economic analysis software provides a framework for measuring these economic effects. IMPLAN offers county-level information for more than 500 industry sectors. Two IMPLAN industry sectors represent Missouri's livestock processing industries: animal slaughter, excluding poultry, and meat processed from carcasses. The meat processed from carcasses industry is primarily engaged in purchasing boxed meat and further cutting and packaging that meat into value-added products. Information reported in the following exhibits quantifies the direct contributions by each industry sector to Missouri counties for two metrics: employment and industry sales. Employment refers to the annual monthly jobs average; jobs may be either full-time or part-time. Also known as output, industry sales represents the value of industry production.

By Missouri county, Exhibit 1.4.7 shows direct employment attributed to the animal slaughter and meat processed from carcasses industries in 2014. The top three counties in Missouri for employment in these industries were Buchanan County, 3,155 jobs; Sullivan County, 941 jobs; and Ralls County, 705 jobs. For these two meat processing sectors, state-wide employment totaled 9,417 jobs, which could be further subdivided as 5,677 jobs in the animal, except poultry, slaughtering sector and 3,740 jobs in the meat processed from carcasses sector.

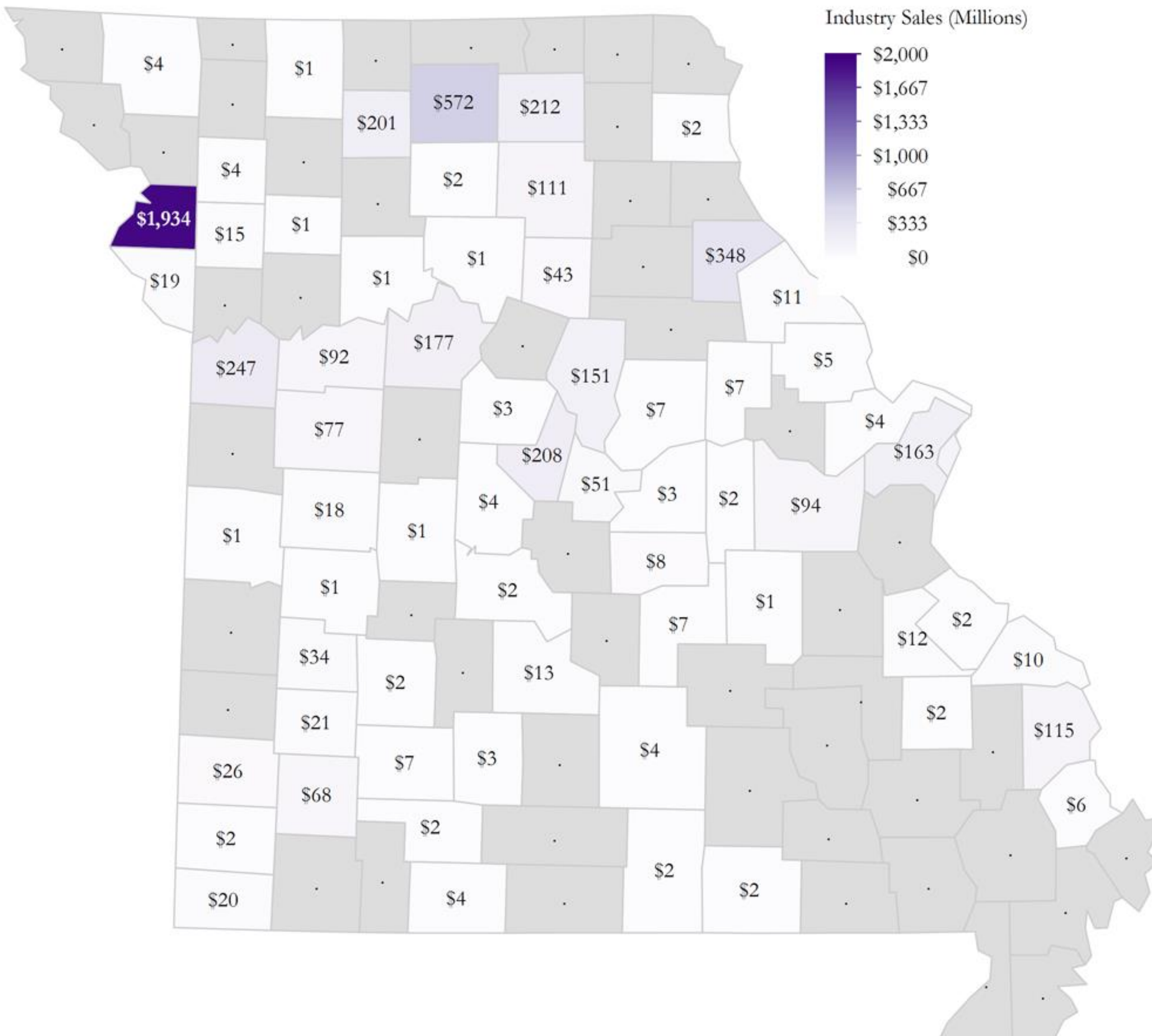
Exhibit 1.4.7 – Animal Slaughtering and Meat Processed from Carcasses Industries (Excluding Poultry), Jobs, 2014



Source: University of Missouri, using data from IMPLAN

Evaluating direct gross industry sales provides an alternative for analyzing a sector's economic importance. Exhibit 1.4.8 shows industry sales by county for the meat slaughter and processing sectors in 2014. Missouri animal slaughter accounted for $3.45 billion in industry sales. Meat processed from carcasses represented $1.83 billion in industry sales for Missouri. The top three Missouri counties for animal slaughtering and meat processed from carcasses industry sales were Buchanan County, $1,934 million; Sullivan County, $572 million; and Ralls County, $348 million.

Exhibit 1.4.8 – Animal Slaughtering and Meat Processed from Carcasses Industries (Excluding Poultry), Industry Sales, 2014



Source: University of Missouri, using data from IMPLAN

1.5 Economic Contribution of Missouri Cattle/Slaughter/Processing Industries

To gauge economic impact, this study involved preparing a multi-industry economic contribution analysis using the IMPLAN economic impact software system. The 2014 IMPLAN dataset for Missouri was used to estimate economic effects by industry. Three Missouri industries were examined from IMPLAN data for their economic importance: beef cattle and ranching, including feedlots; animal, excluding poultry, slaughtering; and meat processed from carcasses.

Three components influence total economic contribution for agricultural sectors: direct contributions, indirect contributions and induced contributions (English, Popp and Miller, 2014). Livestock production and processing create direct contributions. Indirect contributions accumulate when agribusinesses and plants purchase materials and services from other Missouri businesses. Induced contributions accrue when employees or suppliers of these businesses spend income locally.

Several terms communicate the importance of these industries. Employment refers to the annual monthly jobs average; jobs may be either full-time or part-time. The value-added impact measures labor income; indirect taxes; and other income such as corporate profits, net interest and rent. Additionally, value-added represents a measure of an industry's contribution to gross domestic product (GDP). Labor income refers to employment income, which includes proprietor income and employee compensation such as wages and benefits. Tax revenues are also included in the value-added classification. Tax impact values convey the tax revenue generated from employee compensation, proprietor income, indirect business taxes, households and corporations.

Exhibit 1.5.1 details the Missouri beef industry, livestock slaughter and further livestock processing industries' contribution to the state's economy. Direct contributions from these industries totaled 45,088 jobs and $1.028 billion in labor income paid during 2014. Indirect and induced contributions are shown separately. Total contributions – direct, indirect and induced – from these industries supported 72,566 Missouri jobs and provided $2.081 billion in labor income. Total value added to the state's economy totaled $3.812 billion in 2014. The Missouri beef cattle, livestock slaughter and further livestock processing industries also provided $304 million in state and local taxes and $459 million in federal taxes during 2014.

Exhibit 1.5.1 – Economic Contribution of Missouri Beef, Slaughter and Processing Industries, 2014

	Jobs (#)	**Labor Income** (millions)	**Value Added** (millions)	**Taxes**	
				State/local (millions)	**Federal** (millions)
Beef cattle and ranching (including feedlots)	35,670	$547	$1,199		
Animal, excluding poultry, slaughtering	5,677	$279	$533		
Meat processed from carcasses	3,740	$202	$290		
Total Direct Contributions	**45,088**	**$1,028**	**$2,022**		
Indirect contribution	16,763	$608	$997		
Induced contribution	10,716	$444	$792		
Total Contribution (Direct, Indirect & Induced)	**72,566**	**$2,081**	**$3,812**	**$304**	**$459**

Note: May not sum due to rounding
Source: University of Missouri, using data from IMPLAN

2. Covered Feeding Facilities (backgrounding and/or finishing)

2.1 Why Covered Facilities?

For several reasons, covered facilities have piqued interest of some beef industry stakeholders. Shelter can protect cattle from weather events, and it may mediate problems like heat stress, cold stress and muddy conditions. Operating a covered cattle production facility can also influence manure characteristics. Maintaining an open feedlot influences manure nutrient capture and value, and the open lot may also create some environmental challenges. In a confined operation, the environment plays a less significant role in affecting nutrient concentrations (Euken et al. 2015). With a covered feeding facility, manure runoff is avoided (Kinley 2011).

For Missouri producers who choose to feed cattle locally rather than through traditional custom feedlots in the west, several studies have attempted to evaluate the cost and benefits associated with various covered feeding facilities. In its Beef Feedlot Systems Manual, Iowa State University evaluates multiple studies that measure feed efficiency differences based on facility model. After assessing the available research, the university publication's authors concluded that feeding cattle in open lots with shelter and sheltered bunks would improve efficiency by 4 percent relative to the efficiency recorded in open lots without shelter. The publication also assumes that efficiency improves by 4 percent with comparable feed intake for confined cattle relative to animals from open lots (Euken et al. 2015). Section 2.6 further evaluates the economic costs and benefits associated with covered facilities.

Before building covered facilities, producers should make several considerations. For example, ventilation is a chief concern. If a facility lacks the necessary ventilation, then moisture condensation may present a concern, and cattle may experience health issues. To curb such problems, the facility should have openings that constantly support building circulation (Euken et al. 2015). For covered facilities to be viable, operators need access to reasonably priced feed ingredients. Covered facilities also provide environmental uniformity, which may improve animal feeding and care. However, operating a covered facility also requires daily management and care (Kinley 2011).

When producers install covered facilities, supporting industries and business in the community may feel a positive effect. To operate a bedded manure-pack facility, one Nebraska facility described needing to buy local hay grinding, trucking, distillers grains and feed supplements and services. In the long-term, the family anticipated that it would sell its beef in the community, too (Kinley 2011).

Missouri's rainfall climate is much wetter than the rainfall climate where western open lot operations are located. This wetter climate, along with current environmental regulations, tends to encourage the selection of covered facilities to minimize the amount of rainfall runoff that must be collected and stored. Open lot systems can be constructed and operated in Missouri but typically have more environmental challenges than open lot systems located in drier climate areas.

2.2 Covered Facility Configurations

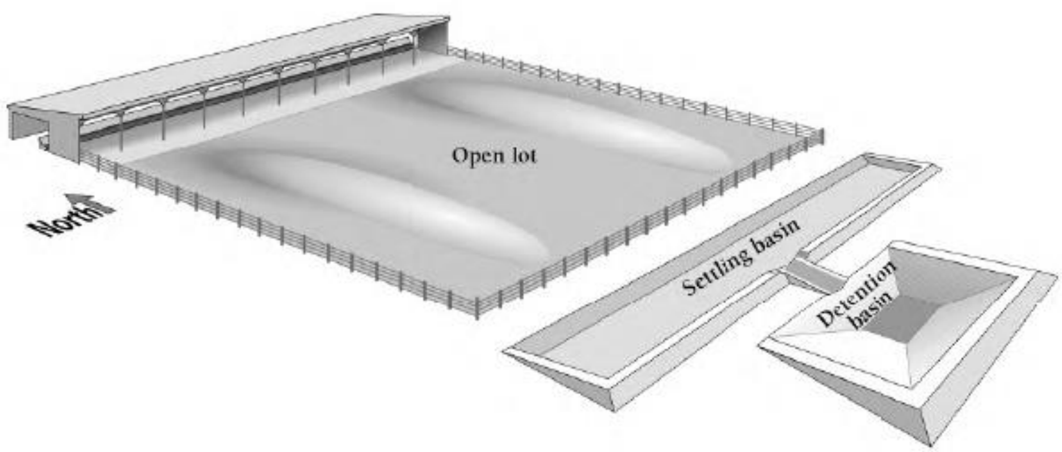
Beef producers have several possible operation designs and configurations from which to choose, and multiple options offer some sort of covered shelter for their animals. As the name suggests, an open lot without shelter doesn't have a covered component. However, open lots with shelter, bedded confinement facilities and slatted floor facilities provide cover for animals. The following sections explain more details about the covered facility options available to beef operators.

2.2.1 Open Lot with Shelter

In an open lot with shelter configuration, operators construct an earthen or concrete open lot space. Animals can access a covered shed for protection, and the feed bunks would also be covered. Iowa State University suggests that the shed may be uninsulated and use a wide post frame and guttering. If the building is curtain-backed, then operators may open the curtain to enable proper ventilation. When designing earthen open lots, producers may create mounds in the lots that will remain dry, even during wet seasons. With an earthen open lot and shed, producers generally allocate 125 square feet per animal in the lot and 25 square feet per animal within the shed area (Euken et al. 2015).

Iowa State University offers the schematic in Exhibit 2.2.1.1 to visualize an open lot feeding facility with shelter. The graphic, which is intended for an earthen lot configuration, illustrates that producers may position the shelter toward the northern side of the facility. Moving south, the open lot transitions to a settling basin and then a detention basin (Euken et al. 2015).

Exhibit 2.2.1.1 – Open Earthen Lot with Shelter Schematic

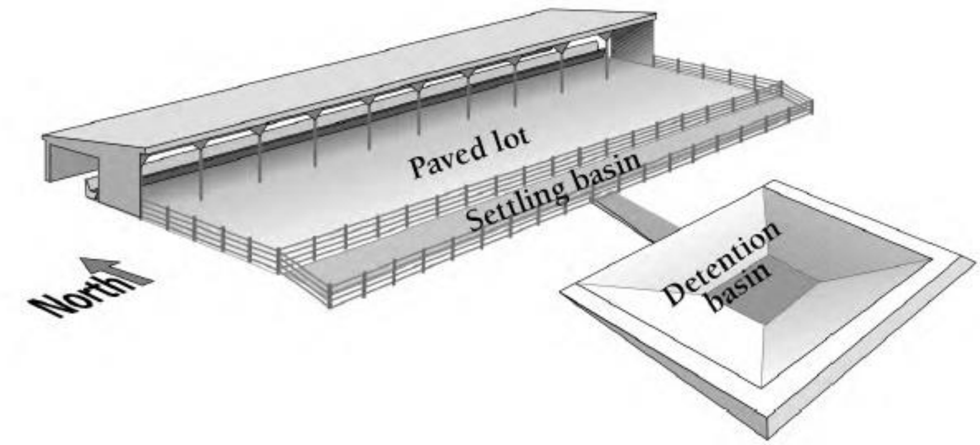


Source: Iowa Beef Center (Euken et al. 2015)

For concrete open lots with sheds, producers may allocate 50 square feet per animal in the lot itself and provide 20 square feet per animal within the covered shed area. Choosing a concrete lot surface may reduce surface maintenance and acreage needs, but relative to earthen areas, the concrete option would also require a greater initial investment. On a weekly basis, the lots would require scraping. Typically, concrete surfaces require less maintenance than earthen lots, and concrete building features, such as walls, would have greater longevity than gates or wood (Euken et al. 2015).

The schematic in Exhibit 2.2.1.2 illustrates a general plan for an open concrete lot with shelter. The settling area will help to settle runoff solids. Operators may also pump the area to control effluent and avoid discharges. The settling space can double as a cattle sorting and handling area. Depending on the operation size and configuration, beef producers may require a permit and professional engineering expertise.

Exhibit 2.2.1.2 – Open Concrete Lot with Shelter Schematic



Source: Iowa Beef Center (Euken et al. 2015)

2.2.2 Bedded Confinement

In deep-bedded confinement, a high roof completely covers the operation and creates plenty of air space. The floor may be solid concrete, or it may be an earthen lot covered in crushed limestone or other material on which bedding could be applied. Feeding bunks would have a concrete apron. At the minimum, facilities would allocate 40 square feet per animal housed. However, the specific square footage allowance may differ widely from facility to facility. For operators using deep-bedded confinement configurations, their cattle may be more likely to have digital dermatitis. The condition is otherwise known as hairy heel warts (Euken et al. 2015). Thus, producers using deep-bedded confinement facilities may need to adopt control measures that address this condition.

In a bedded-pack facility, producers must accept that the facility would have greater management needs, and these facilities require a more substantial initial investment. The facility will require management for bedding the facility, scraping it and hauling manure from it (Crawford 2011). Bedded facilities have bedding chopped and blown into the barn once or twice a week (Euken et al. 2015). Types of bedding may include corn stalks, soybean stubble, barley straw, wheat straw and oat straw (Shouse et al. 2008). Operations must have access to adequate bedding resources. On an annual basis, bedding needs per head space total nearly one ton (Crawford 2011).

Bedding material may accumulate in the middle of pens within wide barns. For narrow barns, the bedding tends to accumulate in the back of the facility. Frequency of bedding pack removal depends on the operation model adopted. Producers may choose a shallow bedding model, which would involve removing packed bedding after three weeks to four weeks. As an alternative, operators can maintain the pack until the facility's next cattle turn. At least once or twice a week, operators typically remove wet manure that accumulates near bunk aprons and pack edges using a scraper (Euken et al.

2015). Manure storage will be required if producers don't plan to immediately apply it after cleaning facilities (Shouse et al. 2008).

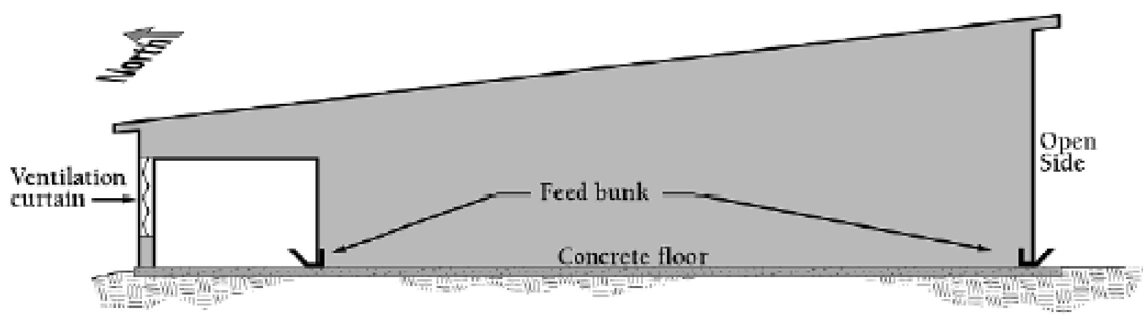
Deep-bedded confinement operations are further classified given their roof type. The following subsections explain roof variations – monoslope, gable and hoop – within the deep-bedded confinement category.

2.2.2.1 Monoslope Roof

Roof slope for monoslope deep-bedded facilities must at least provide a 1.5-foot rise per 12-foot run. Clear sidewall openings must measure at least 10 feet tall. These roof slope and sidewall guidelines ensure that the facility has the proper ventilation. Width can vary for monoslope roof facilities. Wide facilities generally have a 100-foot width compared with a 40- to 60-foot width commonly used for narrow monoslope facilities. Feed bunk position will vary slightly in wide and narrow barns. Within wide monoslope barns, feed bunks are usually situated along the facility's north wall and south edge. Narrow facilities, on the other hand, generally only have a feed bunk available in the south area of the facility. Depending on the facility's design, the roof line may cover the southern feed bunks (Euken et al. 2015).

Exhibit 2.2.2.1.1 provides a schematic drawing for a wide monoslope roof facility. As illustrated, the barn opens to the south. The northern wall has a ventilation curtain. When opened during the summer, the curtain can encourage cross ventilation. The schematic also indicates that the wide monoslope facility would have a concrete floor (Euken et al. 2015).

Exhibit 2.2.2.1.1 – Monoslope Roof Facility with Wide Layout



Source: Iowa Beef Center (Euken et al. 2015)

2.2.2.2 Gable Roof

Like monoslope facilities, gable roof facilities also generally have an east-west orientation. On average, gable roof facilities will record 90-foot to 100-foot widths. Producers may position feed bunks on the north and south sides. To ventilate gable roof facilities, producers may open the north wall's ventilation curtain. Usually, gable roof barns have a partial concrete north wall that measures 5 feet to 6 feet tall. The ventilation curtain hangs above it. A facility's south wall, constructed as a 2-foot wall and 5-foot fencing placed above the wall, would facilitate air flow (Euken et al. 2015).

As the defining feature of gable roof facilities, the gable itself would also facilitate air exchange if the facility has an open center ridge. For every 10 feet in building width, the ridge should allocate 2 inches of open area (Euken et al. 2015).

2.2.2.3 Hoop Roof

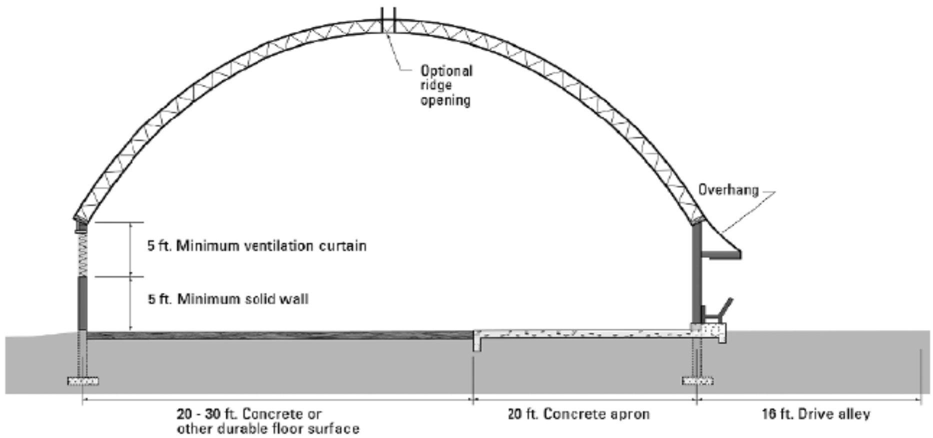
Hoop structures originated in Canada, where producers used them to house swine (Frederickson 2012). With hoop facilities, a tarp shapes to a hoop or gable-style frame to form the roof. Exhibit 2.2.2.3.1 illustrates a possible configuration for a facility that uses a hoop-shaped roof. Like other deep-bedded confinement facilities, hoop barns also tend to use an east-west orientation (Euken et al. 2015). To encourage the best airflow, avoid positioning a hoop structure near features like other buildings and trees that may hinder summer breezes from reaching the structure. As another strategy to promote ventilation, hoop barns may include sidewall curtains (Shouse et al. 2008).

Hoop structures typically range from 40 feet to 60 feet wide, and they use a 12- to 20-foot concrete apron for the bunk area. The hoop structure may also include an overhang above feed bunks, which typically are positioned on the structure's south side or east side. The back wall uses wood, concrete or other strong material to create a 5-foot wall, and then, a curtain closes the remaining open wall space. Hoop building floors may be crushed limestone or concrete (Euken et al. 2015).

To cover the hoop structure, producers may use a woven polyethylene fabric. To promote a longer life and safety, the cover may undergo treatments with a UV stabilizer and fire-resistant product. Avoid choosing a clear cover. If using a white cover, then the facility may be more well-lit. Light-colored, reflective covers are preferable (Shouse et al. 2008).

Livestock producers may choose to install a hoop structure if they'd like to move the facility at some time in the future. As an animal housing option, hoop facilities may provide shade in pasture or lots. During the cold winter season, a dry bed will enable cattle to feel comfortable in a hoop structure. Hoop structures have other uses, too. They may store hay, machinery and feed. A hoop building's tall ceilings and inexpensive, fast construction would make it well-suited for these alternatives (Shouse et al. 2008).

Exhibit 2.2.2.3.1 – Hoop Roof Facility Schematic



Source: Iowa Beef Center (Euken et al. 2015)

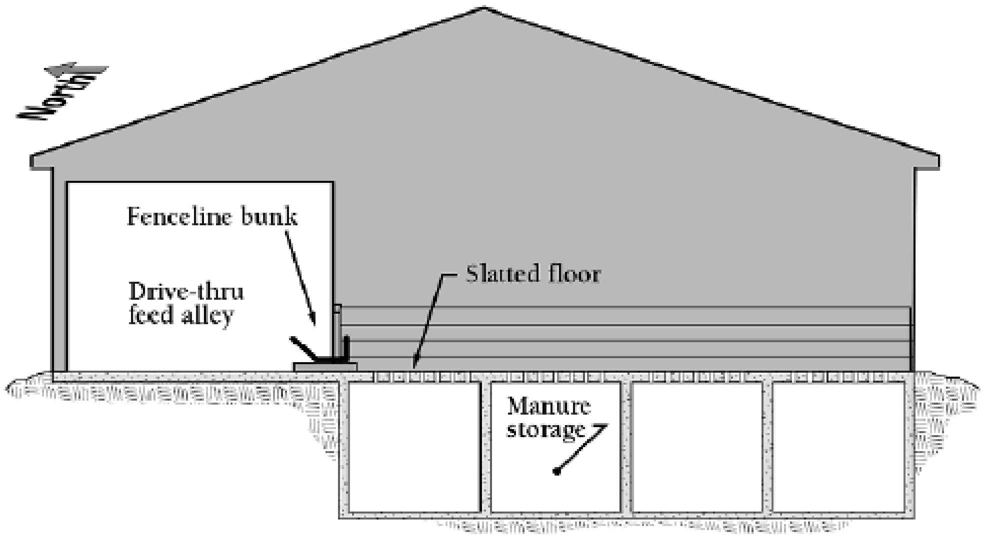
2.2.3 *Slatted Floor with Pit*

Facilities that use a slatted floor and deep pit have several defining characteristics. Exhibit 2.2.3.1 illustrates features of a typical facility that uses a slatted floor and pit. Slatted floors cause animal waste to pass through the floor and accumulate in the storage pit below the facility. Formed from concrete, the slatted floor may create some cattle feet and leg problems (Euken et al. 2015). Because of this issue, some producers choose to only house cattle in slatted floor facilities for 100 days to 125 days before harvesting animals. Sensitivity to the slatted floors may require producers to instead place some cattle being finished in dirt or bed-pack environments. Based on interactions with some producers, this may be true for 2 percent to 5 percent of cattle (Crawford 2011). To address these issues, producers may add rubber mats designed to align with the concrete slats and act as a cushion for animals. Although research hasn't conclusively suggested that installing the rubber mats would influence feed efficiency or daily gain, some research indicates performance improvements when using the mats (Euken et al. 2015). Rubber mats would add costs, however. According to 2011 estimates, rubber mat expense per head space may range from $75 to $175 (Crawford 2011).

To catch animal waste that passes through the slatted floor, these facilities have concrete pits located below them. For a pit that has an 8- to 12-foot depth, it can be pumped two times annually. Liquid waste that collects in the pits experiences less volatilization, and as it's injected or otherwise incorporated into planting areas, this process contributes to less nutrient loss. Pumping, handling and application equipment can be expensive, however, and such equipment would have its annual use limited to a few days. As a result, producers may entertain hiring custom providers for this service, assuming that custom operators are available (Euken et al. 2015).

The roof for slatted floor buildings could be a monoslope, gable or hoop roof. Generally, slatted floor facilities measure 40 feet to 60 feet wide. The north wall would have a 5-foot wall poured from concrete and ventilation curtain hung above this partial wall. Operators usually leave the south wall of slatted facilities open. In a slatted floor building, each animal will need about 22 square feet to 25 square feet (Euken et al. 2015).

Exhibit 2.2.3.1 – Slatted Floor and Deep Pit Facility Schematic



Source: Iowa Beef Center (Euken et al. 2015)

2.2.4 Covered Facility Operation and Management

For any covered facility to provide desirable animal performance and profitability, producers must adhere to good management practices. Poor management may abolish benefits that a producer intended to capture with a given facility design (Crawford 2011). Building ventilation and stocking densities must be followed for the various facility configurations to enable desirable animal performance.

All the facility options discussed in this section will require a manure handling and storage system to be designed to fit the facility design selected, individual site considerations and operational parameters. Operational parameters include but are not limited to the particular type of facility desired and accompanying bedding use requirements. Individual site considerations include but are not limited to local topography, size of operation, manure storage size, and available land for assimilating manure nutrients. A manure system will be required regardless of size of operation. Operations less than concentrated animal feeding operations (CAFO) size (typically less than 1,000 head total capacity) may have more manure system design flexibility. Specific designs and costs for surface water management, manure storage structures and/or any lot runoff collection and storage are beyond the scope of this report. Finally, a water supply with sufficient quantity and adequate quality must be established to support the operation if not already available.

2.3 Covered Facilities by Value Chain Stage

As the beef cattle industry has begun installing covered facilities, producers have evaluated multiple uses for these facilities. Throughout the beef products value chain, operations have adopted covered housing and feeding areas. The following sections briefly explain potential uses for covered facilities, including their application in cow-calf, backgrounding and feedlot operations.

2.3.1 Cow-Calf

In January 2015, Rabobank released a report that described confinement as an opportunity for the cow-calf segment. According to the report, several external conditions contribute to confinement being recognized as an opportunity. For example, as grass acreage availability shrinks and pasture access becomes more competitive, confined production offers an alternative in regions with expensive land costs. For young producers, they may lack the capital required to begin cow-calf production. As a result, they may entertain options that can make the capital investment less onerous (Close 2015). If land prices drop in the future, then using a covered facility for cow-calf operations may have less appeal and economic justification.

A 2014 story from *Wallaces Farmer* described one Iowa farm family that originally intended to build hoop facilities for cattle finishing. After more consideration, however, the family tried using hoop facilities for cow-calf production, which has worked well. With a hoop facility, the operation can divide its herd into three groups for calving and give calves their own dedicated space. By establishing three calving groups, the farm can make good use of facility space; more efficiently use its bulls; and stagger calving during low calf production periods, which may improve marketing opportunities (Harris 2014). Allowing marketing opportunities rather than weather to drive selling decisions may be a key motivator toward building facilities for some cattle producers. Operating a cow-calf covered facility may also enable the producer to feed otherwise underutilized feed ingredients such as baled stalks and other co-products (Harris 2014).

Because cows under cover experience less environmental stress, they tend to record good conception rates (Brown). Other benefits associated with cow-calf production in covered facilities include less time spent searching for animals; therefore, producers may record better daily observations and more quickly treat illnesses. Additionally, they may spend less time mending fences. For producers who want to diversify their operations but have limited land availability, they may construct a covered facility at a cost per animal that is less expensive than buying pasture acreage for that animal. This concept may appeal to lenders (Sweeter 2015). Again, this assumes that land prices remain high. If they decline, then the relationship between expense to build a facility and expense to use pasture may change.

2.3.2 Backgrounding

Relative to most other states, Missouri has a large beef herd. Historically, however, Missouri hasn't retained most calves raised by its cow-calf operations. After weaning, three-quarters of the calves raised in Missouri are shipped elsewhere (Ernst). During the backgrounding stage, producers take calves from 350 pounds to 550 pounds and maintain them until they weigh 700 pounds to 900 pounds. Commonly, backgrounding operations rely on pasture for feed. To raise backgrounded calves in confinement, the animals would require other feed sources such as corn silage, hay, grain and co-product feed ingredients (Halfman 2010).

Operations that choose to background calves require several characteristics. They need to provide enough bunk space and water access. When introduced to a new facility, some calves may be timid. If they need to compete with the more aggressive calves for tight feed and water access space, then they may not adjust well to the facility. Backgrounders should have good bedding and resting areas available. For protection, animals at least need a windbreak. In an enclosed environment, proper ventilation should be prioritized. The calves need good airflow and air exchange (Halfman 2010).

To background calves, some producers have tried using covered facilities. A Missouri farm family built a Hoop Beef System facility to respond to a local opportunity for backgrounding more cattle. The covered structure, which measures 44 feet by 320 feet, enabled the family to expand its operation without relying on a major pastureland acquisition. Plus, the facility has provided easy access to feed and water, and it addresses weather-related concerns (Brown).

In 2012, the *Dakota Farmer* described another instance where producers had used a covered facility for calf backgrounding. The North Dakota farm family built a three-sided hoop structure that measures 42 feet by 546 feet. It uses corn stalk bedding, and after removing manure from the facility, the family stores it on a containment pad. Later, the manure is applied to the family's crop acreage. The family noted that the hoop structure prevented them and their animals from needing to deal with mud. In addition to backgrounding calves, the family has also used the structure for calving and housing cull cows as they're fattened (Tonneson 2012).

The Hoop Beef System originated as a housing option for cows and calves. However, its developer later realized that the facility had possible application in the backgrounding and cattle feeding market segments. First available publicly during June 2006, the company had sold more than 130 systems by March 2010. At the time, the company offered its hoop structures as a build-your-own option. Alternatively, buyers could engage a contractor, or the company also offered turn-key solutions that would house 320 animals (Struck 2010).

2.3.3 Cattle Feeding

As mentioned earlier, for being a significant beef cattle state, Missouri doesn't typically retain many calves born in the state. Estimates suggest that 95 percent of Missouri-born cattle don't undergo feeding and processing within the state. Instead, these value chain activities occur elsewhere, despite Missouri having reasonably priced feed available (Ernst).

For a feedlot operator, several factors are important to consider when assessing facility options. Those include regulations, cattle comfort, water quality, other environmental implications, neighbor relations, site attributes, employee safety, expenses and cattle performance (Euken et al. 2015).

Several producers have adopted various covered facilities for feeding cattle. A 2011 story from *Nebraska Farmer* shared about a family that had built a bedded manure-pack barn that could handle 400 animals. The facility measures 100 feet by 200 feet. At the south side, the height peaks at 28 feet tall. After sloping down to the north side, the building measures 18 feet high. To create the pack, the family adds straw bedding in the middle of the barn, and it forms straw-manure layers (Kinley 2011).

Before constructing the covered facility, the Nebraska family didn't have space for feeding cattle, so it sold its feeder calves to a feedlot located close to the farm. Now, however, the family can retain the animals and essentially manages a farm-to-slaughter operation. In addition to raising calves and feeding them, the family also produces hay and corn. After cleaning the bedded manure-pack building, the operation can use the pack material as a fertilizer for its crop fields (Kinley 2011).

If a cow-calf producer retains calves to feed and finish, then that producer can track finishing performance and use the data to inform cow-calf management decisions (Kinley 2011). For example, the producer may pinpoint that several cows don't produce calves that gain well when they're exposed to feeding rations. In that case, the producer may cull those cows. Without the vertical integration, or unless the value chain shares information with cow-calf producers, the cow-calf producers may not have the information necessary to make such decisions. However, by owning animals for a longer time period, producers also expose themselves to financial risk regardless of whether they choose to use covered facilities or uncovered facilities. Producers must consider this risk as they evaluate the potential for their operations to background or finish calves.

2.4 Popularity of Covered Facility Options

As described earlier, beef producers have multiple covered facility options to consider. Iowa has conducted research to determine the extent of facility adoption. Although the following data are specific to Iowa, they may provide some insights into beef producer interest in various types of covered facilities and indicate how producers would use them. Iowa State University has assumed a leadership position in hoop barn use and research. These facilities first entered Iowa during the mid-1990s and had mainly been adopted to house swine. Later, in 2004/2005, the university constructed one of the first hoop barns dedicated to feed cattle (Honeyman and Harmon).

To assess Iowa confined facilities used for beef production, Iowa State University coordinated a survey among its six livestock/beef cattle specialists. The survey asked the specialists to estimate the number of Iowa beef cattle hoop barns and other bedded confined cattle feeding facilities on Jan. 1, 2011. The results estimated that the state had 680 beef cattle hoop barns. Of those, the industry used an estimated 566 hoop barns to feed beef cattle in bedded confinement. Purposes for the other hoop barns included calving, bull housing, open shelter and calf feeding (Honeyman and Harmon).

On average, the hoop barns used for cattle feeding had the capacity to handle 325 animals per barn. Assuming that the industry used these hoop barns to feed two animal groups per year, the estimated 368,000 cattle fed annually would represent 15 percent to 20 percent of the state's annual fed cattle output. With respect to other bedded confined cattle feeding facilities used, the survey respondents estimated that about 470 facilities existed in Iowa. This category would include facilities such as mono-slope structures. These other bedded facilities had capacities that averaged 600 animals. Thus, their combined one-time capacity would total 282,000 animals (Honeyman and Harmon).

More recently, Iowa State University coordinated a survey that assessed covered facility use among in-state feedlot operators during 2013. According to the survey data, half of the cattle finished by respondents were fed in open lots with shelter. Exhibit 2.4.1 presents more results from this survey question. Slightly more than one-quarter of the cattle finished were fed in open lots without shelter. Compared with bedded hoop and slatted floor confinement facilities, the bedded monoslope or gable buildings were a more popular confinement option for finishing Iowa cattle (Schulz 2014).

Exhibit 2.4.1 – Facilities Used to Finish Cattle in Iowa Feedlots by Share of Cattle Finished*

	Number Reporting	Percent Reporting
Confinement bedded monoslope or gable roof building	192	13.7%
Confinement bedded hoop building	192	4.9%
Slatted floor/deep pit building	192	4.0%
Open lot with shelter	192	50.6%
Open lot without shelter	192	26.8%
Other	192	0.0%

* Survey question read: "In 2013, approximately what percentage of cattle finished in your operation was fed in the following facility?"
Source: Iowa Beef Center 2014 Feedlot Operator Survey (Schulz 2014)

Another question from the Iowa feedlot survey measured the share of respondents who indicated adding various feeding facility capacity through expansion. More than half of the respondents noted that they didn't expand their operations during the previous five years. See Exhibit 2.4.2. Of those that had expanded, the most popular facility types were open lots with shelter, confinement bedded facilities with monoslope or gable roofs and open lots without shelter. Respondents may have provided multiple answers (Schulz 2014).

Exhibit 2.4.2 – Type of Facilities Added or Expanded in Past Five Years*

	Number Reporting	Percent Reporting
Did not expand in the last five years	98	55.7%
Confinement bedded monoslope or gable roof building	24	13.6%
Confinement bedded hoop building	13	7.4%
Slatted floor/deep pit building	9	5.1%
Open lot with shelter	26	14.8%
Open lot without shelter	20	11.4%
Other	0	0.0%

* Survey question read: "If you have expanded in the last 5 years what type of facility was added or expanded?"
Source: Iowa Beef Center 2014 Feedlot Operator Survey (Schulz 2014)

The 2014 Feedlot Operator Survey conducted by the Iowa Beef Center also asked producers about practices that they've adopted to manage and control manure. Stockpiling and solids settling basins were the most popular practices used by feedlot operators. The percent of respondents reporting these manure control practices totaled 69.7 percent and 49.2 percent, respectively. Respondents may have provided multiple answers. Using a confinement building ranked third in popularity to manage and control manure. Nearly 28 percent of respondents noted using confinement (Schulz 2014).

2.5 Comparing Covered Facility Options

To compare various feeding facilities, MidWest Plan Service developed the table shown in Exhibit 2.5.1. The table breaks down the performance of several types of facilities for several types of attributes. With respect to thermal comfort control, the two confinement facilities – confinement in steel building with liquid manure pit and confinement in hoop – perform best. They also make controlling runoff easy. Relative to the other options, however, the two confinement facilities generally require more significant initial and operating management investments (Shouse et al. 2008).

Exhibit 2.5.1 – Advantages and Disadvantages of Cattle Facility Types

	Thermal Comfort Control	Runoff Control	Initial Investment	Operating Management
Outside lots	Poor	Difficult	Low	Medium
Outside lots with steel loafing shed	Fair	Difficult	Medium	Medium
Outside lots with hoop loafing shed	Fair	Difficult	Low-medium	Medium
Confinement in steel building with liquid manure pit	Good	Easy	High	Medium-high
Confinement in hoop	Good	Easy	Medium	Medium-high

Source: Midwest Plan Service (Shouse et al. 2008)

2.6 Covered Facility Economic Considerations

Each type of covered facility has varying economic considerations. The Beef Feedlot Systems Manual from Iowa State University evaluated facility cost considerations. With respect to initial investment required, Exhibit 2.6.1 highlights the estimated initial investment for five feeding models. The table estimates facility expenses based on a survey of contractors experienced in confinement facility construction. These individuals provided turnkey bids, which reflect the cost for bunks, waters, gates and facility construction labor. The estimates don't reflect site preparation and manure storage area expenses. To find a cost per head, the analysis assumes that deep-bedded facilities would require 40 square feet per animal and that slatted floor buildings would require 23 square feet per animal. The table estimates the cost per animal for facilities that have less than 1,000 animals and those that have more than 1,000 animals (Euken et al. 2015).

For the five models assessed, the estimated lot, building, feed bunk and fence expense was greatest for the slatted floor confinement facility. It cost nearly twice as much as the earthen lot with shed. Feed storage, feed handling and cattle handling had equivalent expenses for each covered facility type. Both confinement facilities had little to no initial investment required for environmental structures and engineering. For lots, however, environmental and engineering activities can add expense. Operation size – those with fewer than 1,000 head and those with more than 1,000 head –influence the total facility cost. If constructing a facility for fewer than 1,000 cattle, then these estimates suggest that a confinement facility with slatted floors would be the most expensive option; the cost would total nearly $1,190 per animal, according to the survey results. The least expensive option would be an earthen lot with windbreak, which costs an estimated $317 per head. For facilities with more than 1,000 head, confined facilities with slatted floors would cost nearly $1,190 per head and represent the most expensive option. In this scenario, earthen lot with windbreak operations would be the most economical option per head followed by confinement facilities with solid floors (Euken et al. 2015).

Although not shown in the table, confinement facility cost will vary somewhat based on the roof used. On average, the lot, building, feed bunk and fence expense averaged $651 per head for solid floor bedded confinement facilities. With a monoslope roof or gable roof, the expense averaged $666 per animal, which was $36 more on average than the estimate for hoop or other fabric-covered facilities. For slatted floor, deep pit confinement facilities, the lot, building, feed bunk and fence expense would average $1,277 per head if using a monoslope or gable roof. If installing a hoop roof for deep pit confinement, then the average cost was an estimated $914 per head. The bids included rubber mat costs, which were roughly $175 per head space on average. Although canvas or tarp roofing may require a smaller initial investment, steel tends to last longer. On average, using steel as a roofing material should about double roof life expectancy compared with roofs made from the canvas tarp material. Some producers who have constructed facilities with steel roofs have insulated the roof with plywood or spray foam insulation to minimize condensation (Euken et al. 2015). Using insulation would influence facility investment costs, too.

Exhibit 2.6.1 – Initial Investment for Various Covered Facilities per Head

	Earthen Lot with Windbreak	Earthen Lot with Shed	Concrete Lot with Shed	Bedded Confinement, Solid Floor	Deep Pit Confinement, Slatted Floor
Lot, building, feed bunk, fence	$196	$573	$723	$651	$1,121
Feed storage, feed handling, cattle handling	$65	$65	$65	$65	$65
Environmental structures, engineering (<1,000 head)	$56	$56	$51	$0	$0
Environmental structures, engineering (>1,000 head)	$138	$138	$133	$4	$4
Total cost per head (<1,000 head)	$317	$694	$839	$716	$1,185
Total cost per head (>1,000 head)	$399	$776	$921	$720	$1,189

Source: Iowa Beef Center (Euken et al. 2015)

Exhibit 2.6.2 computes the cost of gain for various covered facilities. The estimates account for non-feed and feed-related expenses incurred when raising yearling steers and steer calves, and they assume 100 percent facility occupancy. For both yearling steers and steer calves, the cost of gain was estimated to be greatest in confinement facilities with slatted floors and confinement facilities with solid floors. Considering the cost of gain and initial investment information, the two confinement options are generally the most expensive (Euken et al. 2015).

Exhibit 2.6.2 – Cost of Gain for Various Covered Facilities Given 100% Occupancy

	Earthen Lot with Windbreak	Earthen Lot with Shed	Concrete Lot with Shed	Confinement, Solid Floor	Confinement, Slatted Floor
Yearling steers	$0.82	$0.84	$0.85	$0.86	$0.89
Steer calves	$0.79	$0.81	$0.82	$0.83	$0.86

Source: Iowa Beef Center (Euken et al. 2015)

Multiple assumptions led the cost of gain estimates in Exhibit 2.6.2. Exhibit 2.6.3 highlights the performance assumptions guiding these estimates. These data indicate that average daily gain and feed-to-gain both improve in sheltered lots and confinement facilities.

Exhibit 2.6.3 – Performance Assumptions Guiding Cost of Gain Estimates

	Yearling Steers		Steer Calves	
	Open Lots (No Shelter)	Sheltered Lots and Confinement	Open Lots (No Shelter)	Sheltered Lots and Confinement
Average daily gain, pounds	3.47	3.61	3.27	3.40
Feed/gain, dry matter	7.20	6.92	6.80	6.54
Dry matter intake, pounds	25.00	25.00	22.20	22.20
Days on feed	144	138	184	176

Source: Iowa Beef Center (Euken et al. 2015)

From a cost perspective, the analysis assumes that feed ingredients are corn, hay, modified distillers grains and a supplement. The assumed costs for these ingredients are $4.25 per bushel for corn, $125 per ton for hay, $65 per ton for modified distillers grains and $0.30 per pound for the supplement. Additionally, Exhibit 2.6.4 outlines non-feed costs per head space per year. Costs reflected in these totals are building lot ownership, feed storage handling, environmental controls, manure handling, bedding, labor and other non-feed costs (Euken et al. 2015).

Exhibit 2.6.4 – Non-Feed Costs Per Head Space

	Earthen Lot with Windbreak	Earthen Lot with Shed	Concrete Lot with Shed	Confinement, Solid Floor	Confinement, Slatted Floor
Yearling Steers					
<1,000 head	$249.53	$310.73	$326.34	$349.58	$388.14
>1,000 head	$258.62	$319.81	$335.43	$349.89	$388.45
Steer Calves					
<1,000 head	$234.59	$295.08	$310.70	$333.95	$372.47
>1,000 head	$243.67	$304.16	$319.78	$334.25	$372.78

Source: Iowa Beef Center (Euken et al. 2015)

As described earlier, confinement facilities promote manure quality because environmental factors don't influence manure characteristics. Table 2.6.5 adjusts the cost per pound of gain for yearling steers based on manure value differences in each model. After making this adjustment, earthen lots with windbreaks and bedded confinement facilities with solid floors were estimated to produce the lowest cost of gain. Concrete lots with sheds and deep pit confinement facilities with slatted floors tied for an $0.81 net cost per pound of gain (Euken et al. 2015).

Exhibit 2.6.5 – Cost of Gain for Various Covered Facilities Given 100% Occupancy Plus Manure Credit for Yearling Steers

	Earthen Lot with Windbreak	Earthen Lot with Shed	Concrete Lot with Shed	Bedded Confinement, Solid Floor	Deep Pit Confinement, Slatted Floor
Cost per pound of gain	$0.82	$0.84	$0.85	$0.86	$0.89
Manure value per pound of gain	$0.04	$0.04	$0.04	$0.07	$0.08
Net cost per pound of gain	$0.78	$0.80	$0.81	$0.79	$0.81

Source: Iowa Beef Center (Euken et al. 2015)

2.7 Backgrounding and Finishing Economics

Profitability in growing and finishing beef cattle depends primarily on the cost of producing gain and the value of that gain. The value of gain per pound is the difference between an animal's purchase price and its sales value divided by the gain added during ownership.

Normally, the price per pound of cattle decreases or slides as beef animals get larger. This price slide depends on calf supply and demand and beef supply and demand. Price slides vary given different feed costs, cattle cycle stages and seasons.

Historically, Missouri cattle price slides and return per pound of gain by weight have varied during the past year and during previous time periods. Exhibit 2.7.1 shares historical price relationships by evaluating different periods of the 10-year cattle cycle. Relationships between prices of different steer weight ranges were calculated using weighted average price summaries from Missouri weekly livestock auctions for January 2005 through mid-December 2015. The data reflect medium and large frame #1 steer prices. Experienced feeders may be able to enhance returns by timing purchase and sell decisions around temporary price distortions or seasonal price cycles. In addition, many backgrounding operations increase their value of gain by buying odd lots of calves that have mixed sizes and raising value through correcting and sorting.

Exhibit 2.7.1 – Returns per Pound of Gain when Growing and Finishing Steers in Missouri Derived from Historical Price Relationships

Years	Backgrounding Gross Margin		Finishing Heavy Feeders Gross Margin		Finishing Calves Gross Margin	
	Price slide between 525 lb. steer and 775 lb. steer *($/cwt)*	Return per lb. of gain *($/cwt)*	Price slide between 775 lb. steer and 1,325 lb. steer *($/cwt)*	Return per lb. of gain *($/cwt)*	Price slide between 525 lb. steer and 1,325 lb. steer *($/cwt)*	Return per lb. of gain *($/cwt)*
2015	$51.48	$100.38	$59.46	$65.25	$110.94	$76.23
2010-2014	$25.47	$94.16	$25.24	$86.86	$50.71	$89.14
2005-2009	$16.94	$69.86	$17.03	$64.42	$33.97	$66.12
2005-2015	$23.90	$83.61	$24.63	$74.45	$48.53	$77.31

Three Missouri confinement beef feeding models were developed in this report to demonstrate the economics and financial viability of operations that could be developed within the state. These example models intend to demonstrate a whole business analysis based on cattle price relationships in the marketplace as of December 2015, and they include some sensitivity analysis around changes in prices, operating costs and interest rates. The following examples of confined beef growing and finishing enterprises in Missouri are:

1. Backgrounding: Buying calves at 525 pounds and selling at 775 pounds
2. Finishing Feeders: Buying at 775 pounds and selling at 1,325 slaughter weight
3. Finishing Calves: Buying at 525 pounds and selling at 1,325 slaughter weight

The models assume that the cattle producer owns a farm and now has decided to allocate two acres of land to build a 400-head capacity beef confinement facility that would remain full of calves at least 340 days per year. Further, it is assumed that the farm already owns the following machinery: tractor with front-end loader and blade, vertical feed mixer wagon and manure spreader. Each model assumes borrowing $280,000 of additional capital for 20 years at 5 percent interest to build a new confinement beef feeding facility that houses 400 head at capacity. The structure would include 16,000 square feet of animal pack area plus feed lane(s), manure storage and cattle working facility. Model sizes were designed to allow animal sorting and marketing on approximately a two-week schedule and employ one worker half time. Exact structure design – a hoop, monoslope or gable facility – is not specified, but $700 per animal space is assumed necessary to complete the facility, assuming no concrete floor under the bedding area. Also, a 4 percent operating loan is used to finance 100 percent of the feeder livestock inventory. All three models assume four hours of labor per day for 340 days per year to manage the operation.

Exhibit 2.7.2 presents further details for the three confinement models. The table articulates assumptions related to factors such as buying and selling prices, facility use, bedding, water needs and feed usage. With the given assumptions, all three models generate an annual cash surplus; however, slight changes in assumptions can trigger different results. For example, prices decreasing by 5 percent would cause the cash surplus for backgrounding and finishing feeders operations to drop to negative values. Similarly, a 5 percent increase in operating expenses would generate negative cash surplus values for operations that background calves or finish feeders.

Exhibit 2.7.2 – Summary of Three Confinement Beef Growing and Finishing Models

Assumption	Backgrounding	Finishing Feeders	Finishing Calves
Buy/sell weights and prices	Buy 525 lb. @ $1.70/lb. Sell 775 lb. @ $1.47 lb.	Buy 775 lb. @ $1.47/lb. Sell 1,325 lb. @ $1.22/lb.	Buy 525 lbs. @ $1.70/lb. sell 1,325 lbs. @ $1.22/lb.
Livestock plan	1,360 head per year 400 head per turn 2.50 lbs. daily gain 250 pounds of gain/hd. Inbound 15 trucks/yr. Outbound 22 trucks/yr.	906 head per year 400 head per turn 3.66 lbs. daily gain 550 pounds of gain/hd. Inbound 15 trucks/yr. Outbound 25 trucks/yr.	544 head per year 400 head per turn 3.20 lbs. daily gain 800 pounds of gain/hd. Inbound 6 trucks/yr. Outbound 15 trucks
Bedding usage	340 Tons	340 Tons	340 Tons
Potential water need	6,000 gallons/day	8,000 gallons/day	8,000 gallons/day
Feed usage	17,000 bushels corn	41,223 bushels corn	31,572 bushels corn
	630 tons hay	200 tons hay	310 tons hay
	476 tons DDG	340 tons DDG	394 tons DDG
Facility debt	$280,000	$280,000	$280,000
Average livestock line of credit	$374,976	$509,640	$466,860
Annual cash surplus	$17,493	$39,107	$41,083
Cash surplus impact of 5% decrease in prices	($56,332)	($18,910)	$12,479
Cash surplus with 5% increase in operating expenses	($53,065)	($13,713)	$16,522
Cash surplus with 3% increase in interest rate	$1,234	$24,318	$27,465

Source: University of Missouri

Exhibit 2.7.3 presents an annual income statement for the three confinement models described earlier. Given the assumptions provided, all three models would enable producers to operate profitably. Net farm income for backgrounding operations is estimated to total more than $15,000. For operations that finish feeders, net farm income is projected to reach nearly $49,000, and operators that finish calves could anticipate net farm income to exceed $52,000.

Exhibit 2.7.3 – Annual Income Statement of Three Confinement Beef Growing and Finishing Models

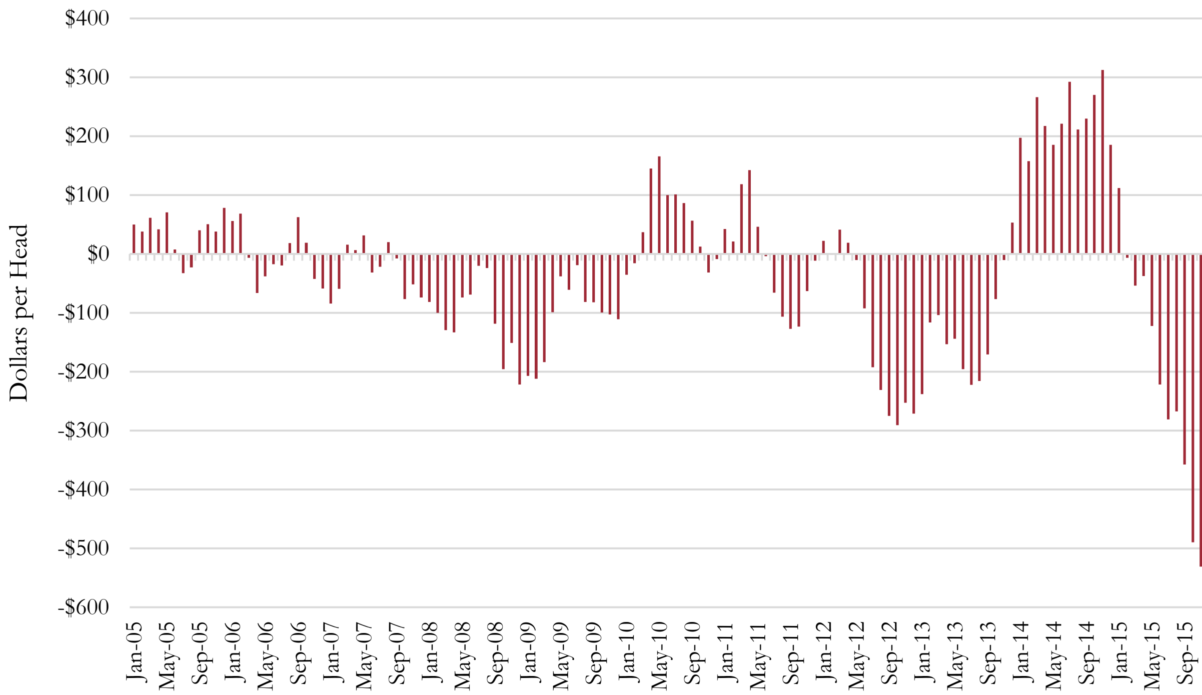
Category	Backgrounding	Finishing Feeders	Finishing Calves
Gross farm income	**$1,533,886**	**$1,449,904**	**$866,185**
Corn *($3.75/bu.)*	$63,750	$154,586	$118,393
Hay *($60.00/ton)*	$28,560	$12,231	$18,768
Feeder livestock purchase	$1,213,800	$1,032,161	$485,520
Purchased feed (DDG/Mineral)	$85,000	$71,348	$76,840
Veterinary	$10,200	$8,607	$7,072
Bedding *($35/ton)*	$10,200	$11,891	$11,900
Marketing	$34,857	$32,951	$19,785
Interest	$28,131	$33,518	$31,806
Fuel & oil	$2,400	$2,400	$2,400
Repairs	$2,800	$2,800	$2,800
Hired labor	$13,600	$13,600	$13,600
Real estate taxes	$400	$400	$400
Personal property taxes	$150	$150	$150
Farm insurance	$1,400	$1,400	$1400
Utilities	$600	$600	$600
Dues & Miscellaneous	$840	$840	$840
Total cash farm expense	**$1,496,668**	**$1,379,482**	**$792,275**
Net cash farm income	$37,198	$70,421	$73,910
Depreciation	$21,500	$21,500	$21,500
Net farm income	**$15,698**	**$48,921**	**$52,410**

Source: University of Missouri

It is important to understand that purchase prices, selling prices and feed costs are major drivers that influence profitability of backgrounding and finishing beef animals. These models were developed with purchase prices, selling prices and feed costs based on December 2015 market conditions, and efforts were made to match historical cattle weight-price relationships. Market conditions are highly volatile. Unhedged cattle feeding can be very profitable or very unprofitable.

Historically, feedlot profitability has fluctuated cyclically over time. Iowa State University has estimated cattle feeding profitability from finishing steers in Iowa, and Exhibit 2.7.4 shares the results. This model assumes purchasing a 560-pound steer and feeding the steer to 1,300 pounds during a 253-day period. Exhibit 2.7.4 represents estimated returns for cattle feeders who harvest cattle in the month listed, and it assumes no hedging gains or losses.

Exhibit 2.7.4 – Estimated Returns to Finishing Iowa Steer Calves

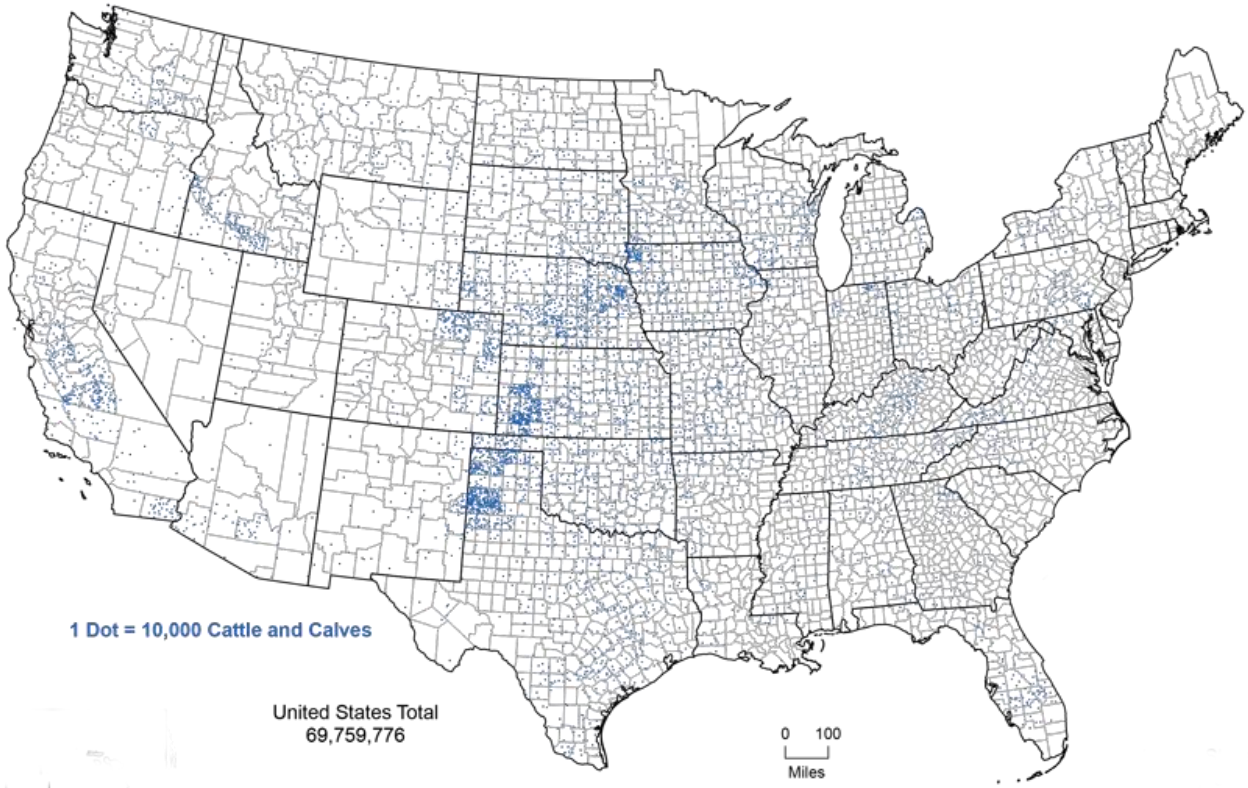


Source: Iowa State University (Schulz, 2015)

2.8 Potential Shift in Cattle Feeding Regions

A majority of U.S. cattle on feed and large slaughter plants are centered in the Great Plains region. The USDA Census of Agriculture does not map cattle finishing operations, but it does map "Cattle and Calves Sold," which can serve as a proxy for major cattle finishing sites. Exhibit 2.8.1 shows the number of cattle and calves sold during 2012 by geography. Areas with a large number of blue dots – one dot equals 10,000 cattle and calves – are those with a more concentrated beef feedlot industry.

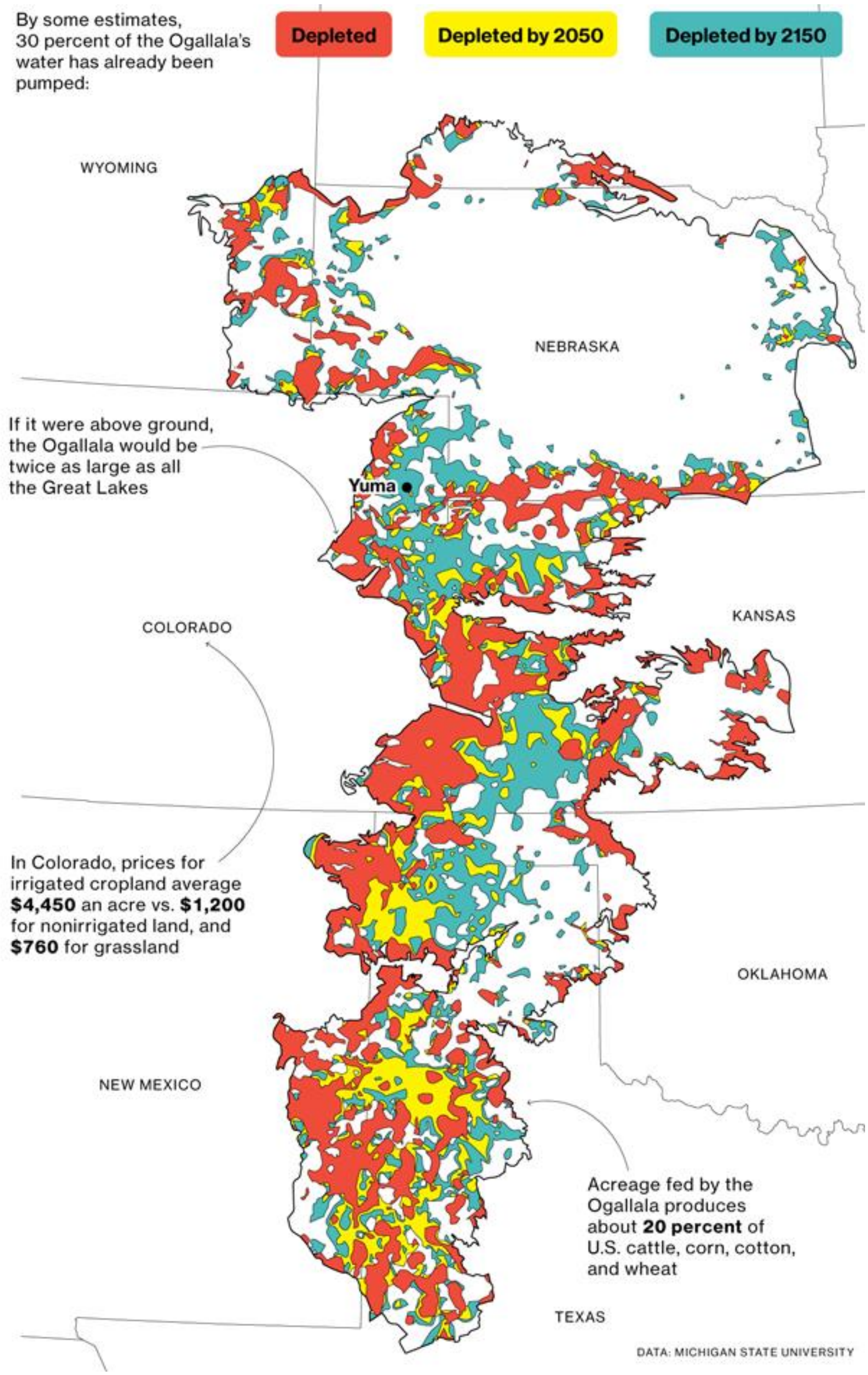
Exhibit 2.8.1 – U.S. Cattle and Calves Sold, 2012



Source: USDA, National Agricultural Statistics Service, Census of Agriculture

Given the water challenges emerging in the region where many cattle feedlots concentrate, operating in this area may not be ecologically viable in the future. BloombergBusiness (Bjera, 2015) discussed that Ogallala aquifer depletion will impact farmland in eight states located through the Great Plains. Exhibit 2.8.2 illustrates estimates about the aquifer's depletion. According to this article, 20 percent of all U.S. cattle, corn, cotton and wheat depend on this aquifer, which is currently 30 percent depleted. In 50 years, an additional 39 percent will be gone. Producing beef cattle relies significantly on water for irrigating feed and pasture acreage, fulfilling daily livestock water needs and processing animals. In the long term, it is reasonable to expect that cattle feeding will shift to areas that have adequate water resources and the infrastructure necessary to support it.

Exhibit 2.8.2 – Ogallala Aquifer Depletion Estimates



Source: BloombergBusiness (Bjerga, 2015)

For Missouri, a limited amount of groundwater is used by the livestock sector. Exhibit 2.8.3 presents 2010 groundwater use data for Missouri, Iowa, Kansas and Nebraska. Primary groundwater use in Missouri is for irrigation. In 2010, irrigation used 75 percent of total Missouri groundwater. Missouri and Iowa both had low percentages of groundwater used relative to the total state water supply. Kansas and Nebraska relied more on groundwater to accommodate their water needs.

Exhibit 2.8.3 – Groundwater Use: Missouri, Kansas, Iowa, and Nebraska, 2010

State	Total Groundwater		Livestock/Aquaculture		Irrigation	
	Fresh, no saline (mgd)	% of total state water supply	Groundwater (mgd)	% of total groundwater used	Groundwater (mgd)	% of total groundwater used
Missouri	1,810	21%	29	2%	1,350	75%
Kansas	3,200	80%	96	3%	2,880	90%
Iowa	650	21%	116	18%	42	6%
Nebraska	4,710	59%	99	2%	4,300	91%

Source: National Groundwater Association (2015)

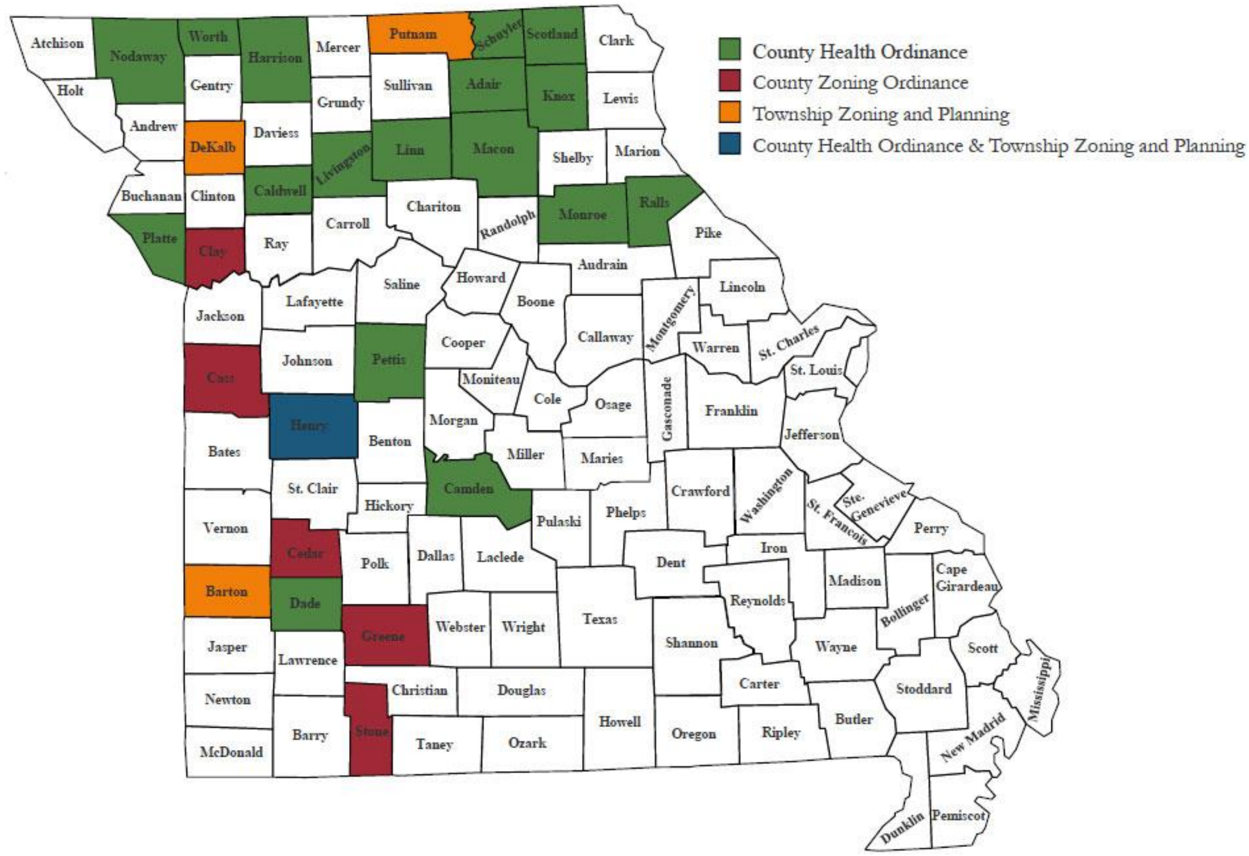
2.9 Regulatory Environment

Most of Missouri's beef industry consists of small, pasture-based operations. For larger beef operations under confinement, however, concentrated animal feeding operations (CAFO) are typically subject to regulation from the Missouri Department of Natural Resources. A CAFO is an operation that confines/feeds animals for 45 days or more in a 12-month period and one where a ground cover of vegetation is not sustained over at least 50 percent of the confinement area. In general, beef CAFOs with at least 1,000 head (1,000 animal units) must have an operating permit. Operations with fewer than 1,000 head may be required to obtain a permit to correct noncompliance with state rules. Additional requirements call for operations obtaining a land disturbance permit if one acre or more is disturbed during construction, and a construction permit is needed when constructing an earthen manure storage basin.

Missouri is unique because it enables farmers, except those with the largest operations, to choose a degree of regulation. Options include either a state permit or a National Pollutant Discharge Elimination System (NPDES) permit. Having two parallel permit options is more complex, but the complexity offers flexibility for producers. Agreeing to never discharge eliminates permit requirements for public notice and submission of records. State permits will cost $150 to $300 annually, and an NPDES permit will cost $350 to $450 per year. Operations larger than 7,000 beef animals must have a site-specific operating permit, which costs $5,000 annually. Operating permits include various requirements to protect water quality within the state and submit reports annually. Examples of requirements include those for buffer distances, manure land application setback, recordkeeping logs, mortality management, inspection and a nutrient management plan. Site-specific operating permits have special requirements such as additional monitoring, inspection and reporting.

One impediment that could limit Missouri beef confined feeding growth are local restrictions. Some local governments have imposed additional requirements and fees on animal feeding operations beyond those required by the Missouri Department of Natural Resources. County health and zoning ordinances are two strategies used by local governments to add requirements. In counties with such restrictions, any livestock industry expansion or new entrants have typically stopped. For the confined beef industry, local regulation typically will affect operations larger than 300 head. Exhibit 2.9.1 color codes counties based on their adoption of animal feeding operation restrictions. Those with no shading have no county or township restrictions imposed on animal feeding operations.

Exhibit 2.9.1 – Missouri County and Township Restrictions on Animal Feeding Operations



Source: University of Missouri

2.10 Economic Impact of Increased Backgrounding and Finishing in Missouri

If more calves were backgrounded and/or finished within Missouri, the Missouri economy would be affected. New industry sales would occur from retaining animal ownership past the cow-calf stage. Local vendors would provide goods and services to these cattle feeding operations. Missouri crop farmers would have additional markets for selling feeds (corn, hay, etc.), and local biofuel plants could provide co-products for feeding beef calves. Additionally, the beef industry would create jobs and provide labor income to spend in local economies.

To understand the economic effects associated with backgrounding and finishing calves, it is important to consider gross sales for each beef production stage. Exhibit 2.10.1 shows three stages of beef production – cow-calf, backgrounding and finishing – and it indicates selling prices at each stage. Five-year average steer and heifer prices were used to simulate possible cash receipts realized by selling at each stage. For example, if a beef farmer sold his animal at 500 pounds to 550 pounds, then that animal's selling price would be $984.95. If this farmer retained ownership beyond the cow-calf stage and backgrounded the beef animal, then the selling price would total $1,242.33. Lastly, if the farmer finished the animal, then the selling price would increase to $1,727.70.

Exhibit 2.10.1 – Gross Beef Value by Production Stage and Value Change by Stage

Cattle Category	Price/Cwt.	Gross Animal Value	Value Change from Previous Stage
Steers and Heifers, 500-550 lbs, Medium and Large Frame #1	$187.61	$984.95	N/A
Steers and Heifers, 750-800 lbs, Medium and Large Frame #1	$160.30	$1,242.33	$257.37
Fed Steers and Heifers, ~1,300 Lbs., All Grades	$132.90	$1,727.70	$485.38

Note: Prices were based on a five-year average (December 2010 to November 2015) provided by Livestock Marketing Information Center (LMIC). Feeder prices from Combined Auctions in Missouri. Fed prices from 5 Area Average (Texas-Oklahoma; Kansas; Nebraska, Colorado; Iowa-Minnesota).

Shown in Exhibit 2.10.1, the value change between stages represents additional industry sales that Missouri's economy could capture if more beef calves were backgrounded and/or finished in the state. Exhibit 2.10.2 shows potential additional industry sales given different levels of backgrounding and finishing adoption. The table quantifies additional sales for as few as one animal to as many as 100,000 head. If an additional 100,000 head of Missouri beef calves were backgrounded and finished within the state, then this activity would generate $74.3 million in new industry sales. If these calves were only backgrounded and then sold, then new industry sales would total $25.7 million.

Exhibit 2.10.2 – Additional Industry Sales in Missouri if Calves Retained Beyond Cow-Calf Stage

Number of Head	Backgrounded Sold at 775 lbs.	Finished Sold at 1,300 lbs.	Total
Per Head	$257	$485	$743
10,000 Head	$2,573,725	$4,853,750	$7,427,475
25,000 Head	$6,434,313	$12,134,375	$18,568,688
100,000 Head	$25,737,250	$48,537,500	$74,274,750

Source: University of Missouri, using data from IMPLAN

New beef industry sales would generate economic impacts within the state. Estimations were prepared to simulate economic effects associated with these new industry sales by using IMPLAN economic impact software. IMPLAN is an input-output model, and it includes economic data sets, multipliers and demographic statistics for the entire U.S. economic infrastructure. A robust tool, it assesses the effects of economic changes by sector, and economists and analysts widely use it. Estimations in this report used the 2014 IMPLAN data set for Missouri.

IMPLAN categorizes impacts into three different economic effects: direct, indirect and induced. A direct effect can be defined as a direct change in an area that results from a change in an industry. For example, additional new sales revenue from beef operations that background or feed calves would have a direct economic effect. These operations would create an indirect effect when they purchase goods or services from other industries (feed, veterinarian, transportation, etc.). Induced effects are changes in household spending that originate from income generated by direct and indirect effects. For instance, employees will spend their income to buy real estate, shop at grocery stores or spend on other goods or services in the local economy. For the following economic impact examples, all three economic effects – direct, indirect and induced – were totaled and reported.

One measure of demonstrating annual economic impact is value-added. Value-added consists of labor income including wages, benefits and proprietor income; indirect taxes; and other income such as corporate profits, net interest and rent. Additionally, value-added measures gross domestic product (GDP) generated by the industry. Exhibit 2.10.3 shows the additional value-added to Missouri's economy for backgrounding and/or finishing more calves in Missouri. If 25,000 head were retained and both backgrounded and finished in Missouri, then approximately $15 million in new value-added would be created for Missouri's economy.

Exhibit 2.10.3 – Additional Value-Added to Missouri's Economy if Calves Retained Further than Cow-Calf Stage

Number of Head	Backgrounded Sold at 775 lbs.	Finished Sold at 1,300 lbs.	Total
10,000 Head	$2,095,286	$3,951,469	$6,046,755
25,000 Head	$5,238,216	$9,878,674	$15,116,890
100,000 Head	$20,952,863	$39,514,695	$60,467,558

Source: University of Missouri, using data from IMPLAN

Another measure of annual economic impact is jobs. Jobs that would be supported by backgrounding and finishing through direct, indirect and induced effects are displayed in Exhibit 2.10.4. Employment refers to jobs, either full-time or part-time, as an annual average. If Missouri backgrounded 25,000 head that were previously exported to other states, then retaining these animals in Missouri would result in supporting 130.4 jobs. If 100,000 beef calves were both backgrounded and finished in Missouri, then these activities would support 1,505 jobs.

Exhibit 2.10.4 – Additional Jobs Supported in Missouri's Economy if Calves Retained Further than Cow-Calf Stage

Number of Head	Backgrounded Sold at 775 lbs.	Finished Sold at 1,300 lbs.	Total
10,000 Head	52.1	98.3	150.4
25,000 Head	130.4	245.9	376.3
100,000 Head	521.5	983.5	1,505.0

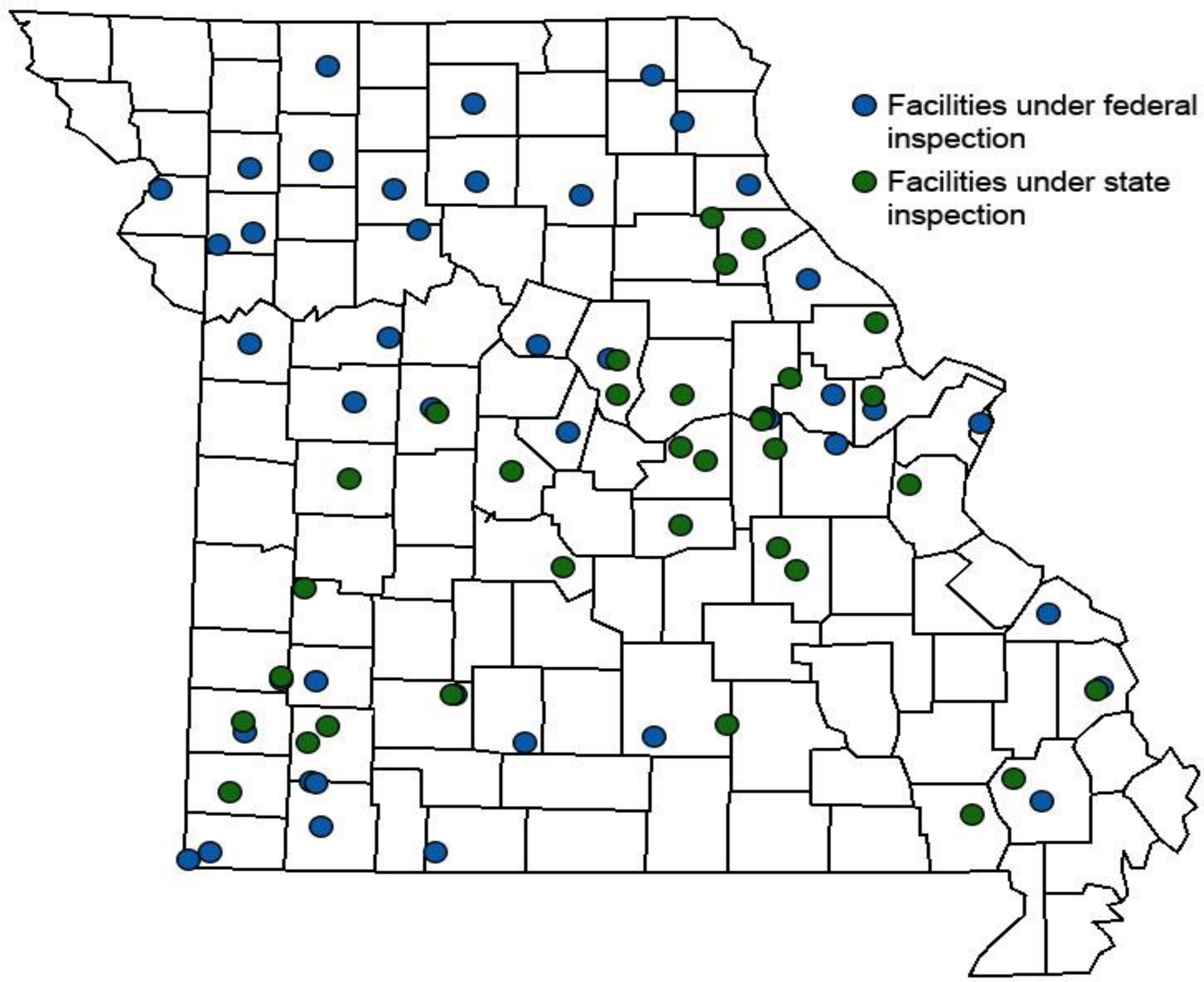
Source: University of Missouri, using data from IMPLAN

3. Small Beef Processor Modernization and Training

3.1 Meat and Beef Processing Industry

The USDA National Agricultural Statistics Service (NASS) reports that 38 federally inspected meat slaughtering facilities operate in Missouri today. State or federal representatives periodically inspect such slaughtering facilities and meat processors to ensure that facilities follow safe practices. According to the USDA Food Safety and Inspection Service (FSIS), Missouri is one of 27 states that currently offer a state inspection program. Products that originate from state-inspected facilities must not enter interstate commerce, including online sales and mail orders. Only federally inspected facilities may ship and sell product over state lines. Exhibit 3.1.1 charts locations of Missouri slaughter plants under inspection in January 2016.

Exhibit 3.1.1 – Slaughter Facilities in Missouri, January 2016



Source: Missouri Department of Agriculture and USDA, Food Safety and Inspection Service

Exhibit 3.1.2 lists federally inspected plants shown by the USDA FSIS. This information source provides a similar number of meat slaughter plants as USDA NASS, but given the different data sources, they are not identical.

Exhibit 3.1.2 – Missouri Federally Inspected Slaughter Plants, January 2016

Company	City
Alewel's Country Meats	Warrensburg
Butterball, LLC	Carthage
Cabool Kountry Meats, LLC	Cabool
Campo Lindo Farms	Lathrop
Cargill Meat Solutions Corpora	California
Chillicothe Meat Locker, LLC	Chillicothe
College of the Ozarks	Point Lookout
Dan's Country Meats	New Melle
Frickenschmidt Foods, LLC	Lockwood
Fruitland American Meat	Jackson
George's Processing, Inc.	Cassville
Gibson Packing Co.	Seymour
Golden City Meats, LLC	Golden City
Hale Meat Locker, LLC	Hale
Horrmann Meat Company	Fair Grove
International Dehydrated Foods	Monett
Jennings Premium Meats	New Franklin
Kleoppel Meats, LLC DBA Alma's F	Alma
Lumley Locker	La Belle
M & M Packing	Perryville
Paradise Locker Meats	Trimble
Rains Natural Meats	Gallatin
Ridgeway Freezer Inc.	Ridgeway
Rutledge Meat Processing	Rutledge
Simmons Prepared Foods, Inc.	Southwest City
Smithfield Farmland Corp.	Milan
Special D Meats	Macon
Sprague Slaughter House	Brookfield
Star Packing Co., Inc.	St. Louis
Swiss Processing Plant, Inc.	Hermann
Town and Country Butcher Shop	Palmyra
Triumph Foods	St. Joseph
Tyson Foods, Inc.	Dexter
Tyson Foods, Inc.	Sedalia
Tyson Foods, Inc.	Noel
Tyson Foods, Inc.	Monett
University of Missouri Abattoir	Columbia
Warner Locker, Inc.	Maysville
Williams Brothers Meat Co.	Washington
Winter Meat, Incorporated	Blue Springs
Woods Smoked Meats, Inc.	Bowling Green
Wright City Meat Company, Inc.	Wright City

Source: USDA, Food Safety and Inspection Service

Currently, an additional 33 meat slaughter plants fall under state inspection, which is carried out by the Missouri Department of Agriculture. Exhibit 3.1.3 lists these plants.

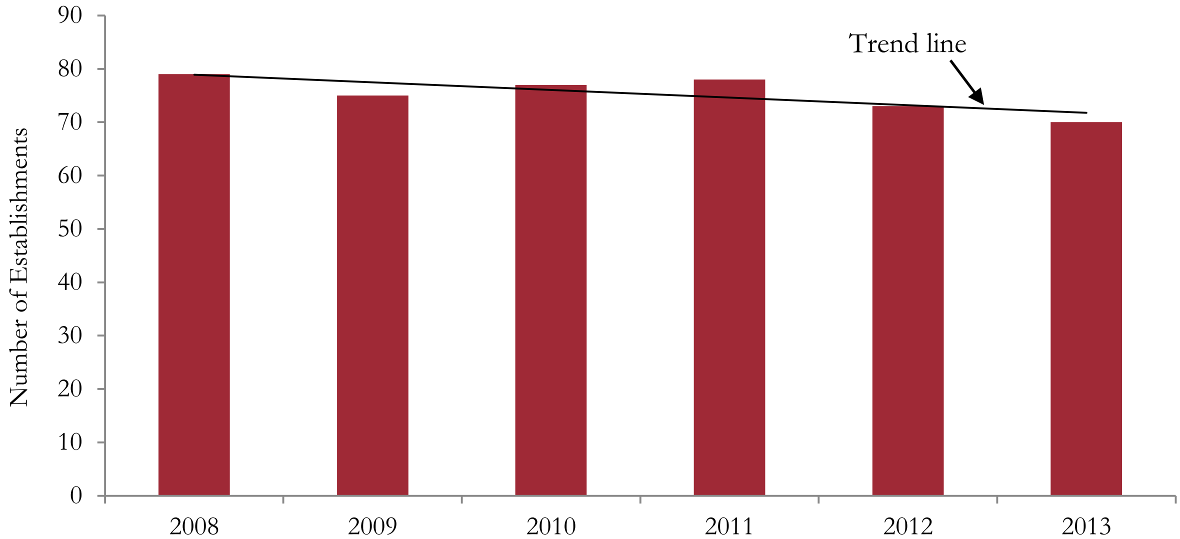
Exhibit 3.1.3 – Missouri State-Inspected Plants, January 2016

Company	City
American Halal Meats	Stony Hill
Brown's Smokehouse Meats	Elsberry
Center Locker Service	Center
Central Missouri Meat & Sausage	Fulton
Cloud's Meats, Inc.	Carthage
Crane's Meat Processing	Ashland
Davis Meat Processing, LLC	Jonesburg
Dittmer Meat Packing Company	Dittmer
Four Quarters Processing	Perry
Golden City Meats	Golden City
Hatfield's Smoked Meats	Neosho
Heintz Processing	Cuba
Hermann Wurst Haus	Hermann
Hetherington Meat Processing	Clinton
Holloway Distributing	Puxico
Horrman Meat Company	Fair Grove
J&H Backes Poultry, LLC	Loose Creek
Josephville Meat Processing	Wentzville
Kempf's Custom Butchering	Sedalia
Mary's Valley Meat Processing	Steelville
Miller FFA Cardinal Pride Meats	Miller
Reis Meat Processing	Jackson
RS & C Processing	El Dorado Springs
Scherf Meat Processing, LLC	Linn
Shady Maples Farm	Versailles
Show Me Farms Gourmet Foods, LLC	Columbia
Swiss Meat & Sausage Co.	Hermann
The Butcher Shop, LLC	Vienna
The Deep Freeze	Poplar Bluff
Tom's Slaughtering and Meat Processing	Montreal
Troyer's Meat Processing	Stotts City
White Barn Processing	Monroe City
Zimmerman Meat Processing	Summersville

Source: Missouri Department of Agriculture

During the past few years, the number of Missouri animal, except poultry, slaughtering establishments has declined. Exhibit 3.1.4 tracks operational animal slaughtering establishments, except poultry processors, by year from 2008 to 2013. It also includes a trend line that indicates the decline in establishments. In 2008, 79 animal, except poultry, slaughter establishments operated in Missouri. By 2013, the number of establishments had dropped to 70 (U.S. Census Bureau 2013).

Exhibit 3.1.4 – Number of Missouri Animal (Except Poultry) Slaughter Establishments



Source: U.S. Census Bureau (2013)

Of the Missouri animal, except poultry, slaughter establishments that operated during 2013, most had small staffs, which would indicate that these facilities are relatively small operations. Relative to the U.S. average, the Missouri animal, except poultry, slaughter establishments tend to operate on a smaller scale. Exhibit 3.1.5 reports the share of all 2013 establishments that had varying staff sizes. In 2013, the U.S. Census Bureau reported that 83 percent of Missouri animal, except poultry, slaughter establishments had between one employee and nine employees. On a national scale, 64 percent of such establishments had between one employee and nine employees. Thirteen percent and 26 percent of Missouri and U.S. animal, except poultry, slaughter facilities, respectively, maintained staffs that ranged from 10 people to 99 people. Ten percent of U.S. establishments employed at least 100 people; that share totaled 4 percent for Missouri (U.S. Census Bureau 2013).

Exhibit 3.1.5 – Share of Animal (Except Poultry) Slaughter Establishments by Employment Size Category, 2013

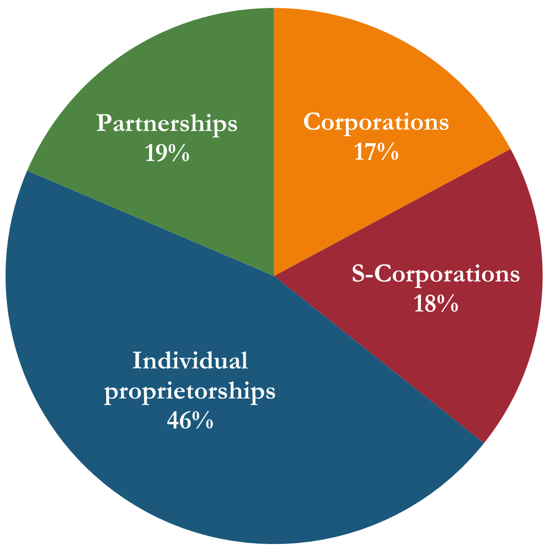
Number of Employees	Missouri	U.S.
1 to 9	83%	64%
10 to 99	13%	26%
100 or more	4%	10%

Source: U.S. Census Bureau (2013)

According to USDA National Agricultural Statistics Service data, U.S. federally inspected cattle slaughter plants that have a throughput less than 10,000 animals represented 87.8 percent of all plants operating during 2014. Those 574 plants, however, only processed 1.3 percent of total cattle slaughtered. In the U.S., the 80 facilities with throughput of at least 10,000 head processed 98.7 percent of the animals slaughtered during 2014 (USDA National Agricultural Statistics 2015). In 2013, the U.S. had 12 percent fewer federally inspected cattle slaughter facilities that annually processed fewer than 10,000 head than it did in 2001 (Swanson 2015).

The U.S. Census Bureau also reports the legal structure used by animal, except poultry, slaughter establishments. For Missouri, the most predominant legal structure used by such establishments in 2013 was the individual proprietorship. See Exhibit 3.1.6. Assuming that small-scale processors would likely organize as individual proprietorships, this again suggests the significant role that small-scale animal, except poultry, slaughter establishments have in Missouri. In 2013, the share of animal, except poultry, slaughter establishments organized as partnerships, S-corporations and corporations were similar: 19 percent, 18 percent and 17 percent, respectively (U.S. Census Bureau 2013).

Exhibit 3.1.6 – Legal Structure Used by Missouri Animal (Except Poultry) Slaughter Establishments, 2013



Source: U.S. Census Bureau (2013)

3.2 Small Beef Processor Challenges

As the previous section described, the Missouri meat processing industry has become increasingly smaller, which creates challenges for livestock producers who need local processors to slaughter and further process animals that they raise. Local processing reduces transportation costs for livestock producers and provides marketing channels for them to develop niche markets. Value chain stakeholders often name processing infrastructure as a bottleneck (Stillman et al. 2013). In some cases, insufficient slaughtering availability has prompted livestock producers to enter the meat processing business to provide enough capacity for their slaughtering and processing needs, limit transportation involved in shipping animals to USDA-inspected facilities and provide the quality demanded by their buyers (Swanson 2015).

To operate and serve livestock producers, the processors themselves experience multiple challenges that they must address to make their businesses function well. The following subsections describe some of these challenges and present ideas for responding to them.

3.2.1 Regulatory

In 2014, the Agricultural Utilization Research Institute surveyed 280 small meat and poultry processors that operated in Minnesota. The survey found that regulatory compliance costs can be burdensome to small-scale operators. Respondents indicated that the paperwork took time, too few inspectors were available and restrictions influenced profitability potential. Despite regulatory matters creating some challenges for small-scale processors, survey respondents noted that documentation, product tracking and safety improved due to regulations (Morrison 2014).

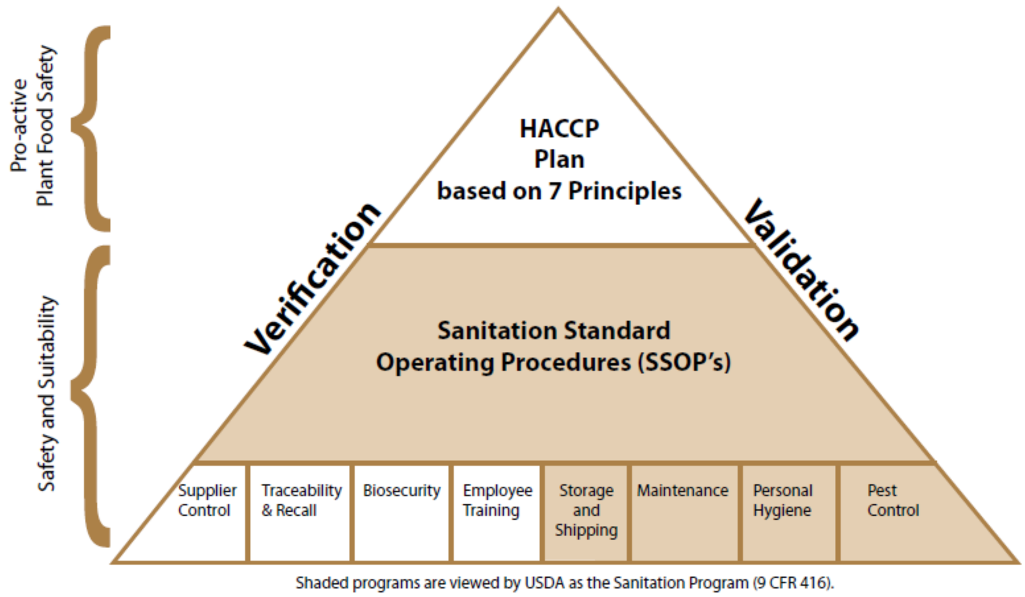
3.2.2 HACCP

HACCP refers to Hazard Analysis Critical Control Point as a food safety program. With a HACCP plan, meat processors take a proactive role to identify and assess possible hazards and address strategies that may thwart, diminish or eradicate hazards. The need to address hazards stems from USDA Food Safety and Inspection Service regulations that emphasize a meat and poultry plant's role in identifying, controlling, limiting or removing three types of hazards: chemical, physical and biological. To summarize the HACCP process, Purdue University developed Exhibit 3.2.2.1. As illustrated, several prerequisites exist for such programs. For example, employees need food safety training, and through Sanitation Standard Operating Procedures, a facility must commit to written methods for cleaning and sanitizing. It must also validate protocols and keep sanitation records. The Code of Federal Regulations offers further descriptions in Title 9, Part 416 (Keener 2007).

Before assembling a HACCP plan, a facility first needs to name a HACCP team, which must include at least one individual who has completed HACCP training. Other components include sharing about products being processed and distributed to identify potential hazards for these products; explaining a product's intended use and targeted customers; outlining a flowchart that illustrates the production process; and verifying the flowchart for correctness and exhaustiveness (Keener 2007).

The HACCP plan itself would have several components: analyze possible hazards, identify critical control points, quantify critical limits, create a critical control points monitoring plan, determine corrective actions to enforce if procedures are violated, commit to recordkeeping and documentation standards and outline verification processes. Complete HACCP regulations are available within the Code of Federal Regulations, Title 9, Part 417 (Keener 2007).

Exhibit 3.2.2.1 – Food Safety Pyramid



Source: Purdue University (Keener 2007)

Given that some small-scale processors process many different animals and products, these processors may need to develop multiple HACCP plans. For each plan, the processor would need to validate it using scientific studies and tests. Plus, it must have established a recordkeeping system. Per pound of meat processed, the cost to develop and vet these plans can make such measures substantially more expensive for small-scale facilities as fixed costs associated with HAACP plans are spread across a smaller amount of meat processed (Central Appalachian Network 2012).

The USDA Food Safety and Inspection Service lists state-level HACCP contacts who offer outreach to plant operators. In Missouri, the USDA Food Safety and Inspection Service recognizes individuals at the Missouri Department of Agriculture and University of Missouri as resources available. Technical assistance and other resources may be available from these contacts. The Food Safety Inspection Service also has catalogued some HACCP models for processors. Specific guides and models are available by topic area (USDA Food Safety and Inspection Service).

3.2.3 Food Safety

According to a 2015 report from the USDA Economic Research Service, food safety compliance represents a barrier that frequently influences small-scale meat processors. As a share of revenue, the food safety compliance costs represent a significant investment (Low et al. 2015).

To market meat through interstate commerce, facilities processing such meat require USDA inspection. Cooperative state inspection programs are an alternative (Low et al. 2015). During all operational hours, these plants must have government meat inspectors on the premise based on the Federal Meat Inspection Act of 1906 (Swanson 2015). The current law has exceptions for custom-exempt facilities, which still must adhere to basic sanitation principles. Custom-exempt facilities don't require daily inspections. They may only process animals marketed live, and their processed meat must bear a "not for sale" label. Custom-exempt processing would be permissible if a buyer purchased a live finished steer and chooses to slaughter it for personal consumption (Low et al. 2015). For red meat plants, custom-exempt, retail-exempt, state-inspected and federally inspected work may occur simultaneously. Poultry plants don't have the same flexibility. Retail-exempt refers to a processor using its retail storefront to sell meat but forgoing HACCP plan development and daily USDA inspection, though it would have periodic inspections. Retail-exempt processing requires using state- or USDA-inspected livestock, and retail-exempt products have some potential to be marketed to wholesale customers (eXtension 2015).

Recent legislative activity has offered some suggested changes to the current law. In July 2015, the Processing Revival and Intrastate Meat Exemption Act, otherwise known as PRIME, was introduced. If approved, then this act would permit farmers to engage custom meat processing facilities that lack daily USDA inspector oversight and sell meat processed through these facilities within state borders. Proponents suggest that the caveat provided by this proposed bill would make small-scale processing more viable. Opponents insist that processing all meat with inspectors present controls disease risk and promotes food safety (Swanson 2015).

Through the Cooperative Interstate Shipment program, state-inspected facilities in 27 states with standards that are "at least equal to" those imposed by the USDA Food Safety and Inspection Service may market products interstate and internationally. Missouri is one of the 27 states that could participate in the Cooperative Interstate Shipment program, but currently, only Indiana, North Dakota, Ohio and Wisconsin participate. For products that qualify, they will have a federal inspection seal (USDA Food Safety and Inspection Service).

3.2.4 Succession Planning

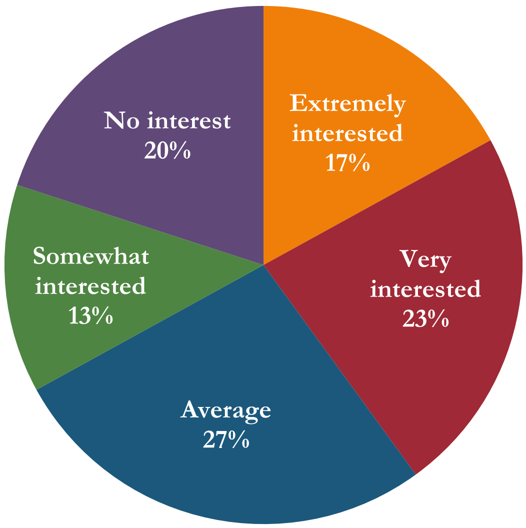
The survey of Minnesota small-scale meat processors found that succession planning will soon affect a majority of the state's small-scale meat processors. Within the next 10 years, survey results indicated that about 75 percent of the respondents would need to consider succession. When they took the survey, two-thirds of owners responding said that they hadn't developed a succession plan, but two-thirds of owners noted that they were at or near retirement age (Morrison 2014).

3.2.5 Offal

Offal refers to animal bones, fat, organs and blood yielded from animal processing. As a general rule, such coproducts contribute 40 percent of animal live weight. Companies that source offal may choose suppliers that offer large volumes. Independent small-scale processors tend to not produce offal in quantities that would attract buyers. However, if such processors were to market their offal production collectively, then market opportunities may materialize (Ag Innovation News 2004).

In 2003, Iowa, Nebraska, Missouri and Wisconsin meat processors received invitations to complete a survey conducted by the Food Processing Center at the University of Nebraska-Lincoln. The survey sought to understand processor interest in types of facility inspection; receiving certification for organic, Hallal and kosher production; directly interacting with producers; collaborating with other processors; and other topics. The survey also addressed small-scale meat processing market opportunities and obstacles. One question specifically asked respondents to indicate their experience and interest in collaboratively developing collective markets for offal. Based on the survey results, nearly three-quarters of the respondents shared that they had no experience with developing offal collective markets. Exhibit 3.2.5.1 presents the degree of meat processor interest in developing offal collective markets. Forty percent of the survey respondents noted being extremely interested or very interested in developing collective markets for offal (Food Processing Center 2004).

Exhibit 3.2.5.1 – Meat Processor Interest in Developing Collective Markets for Offal



Source: University of Nebraska-Lincoln (Food Processing Center 2004)

Several years ago, Iowa, Wisconsin and Minnesota groups studied offal supplies generated by meat processors in each respective state, and these efforts also assessed opportunities for processors to pool their supplies and offer larger volumes that interest big buyers. The pet food industry and renderers represent two potential markets (Ag Innovation News 2004). Within the pet food segment, organ meats offer protein and other nutrients to cats and dogs. They also have nutrient-dense attributes, and they're recognized as a digestible nutrient source. To use organ meat, it can undergo rendering and find use as a protein meal. Alternatively, many wet pet food products use organ meat and viscera as ingredients. Treats represent another possible application (Aldrich 2012).

Beef processors in Missouri may be well-positioned to consider pet food manufacturers as an opportunity to sell offal collected from multiple processing facilities. Within the animal health corridor that spans from Columbia, Mo., to Manhattan, Kan., four large pet food manufacturers operate production facilities. Those companies are Hill's, Nestle Purina, Mars Petcare and J.M. Smucker's Big Heart Pet Brands. In addition to these large-scale companies, the region also has contract manufacturers that produce pet food. Pet food manufacturers have located within this area because of the meat and grains available. Logistics also create an advantage (Hooper 2015).

3.2.6 Operations Management

From an operations perspective, small-scale meat processors can experience supply and demand seasonality. Facilities tend to have peak demand during fall and early winter months (Morrison 2014). Late spring and early summer tend to be downtimes (Central Appalachian Network 2012). Such variable business patterns can create challenges related to managing cash flow and the labor force (Morrison 2014). Inconsistent revenue streams may challenge the ability for small-scale processors to retain qualified employees and pay for year-round expenses such as those for equipment and utilities (Stillman et al. 2013).

From 2011 to 2012, researchers from the USDA Economic Research Service and universities coordinated site visits and phone interviews with seven federally inspected local meat and poultry processors, which were located throughout the country. After collecting information during these interactions, the researchers concluded that successful processing businesses are typified by committed business relationships and a long-term look at processor-farmer interdependence. Processors may seek commitments by identifying "anchor" customers, who offer the processor reliable business in steady volumes. Processors may also choose to work with partners that can aggregate animals. When engaging farmers or partners in the processing business, the entities participating must make good communication a priority (Stillman et al. 2013).

The USDA Economic Research Service- and university-developed case studies revealed other management-related practices adopted by successful processors. Processors may use active scheduling systems, offer variable pricing and impose no-show penalties. These strategies enable processors to maintain a reliable stream of business. By offering marketing and distribution expertise and resources to producers, processors may attract more business from farmers. To ensure their viability, processors may engage farmers in several ways. For example, farmers may provide loan funding, purchase stock, finance equipment purchases or contribute expertise to benefit the processing business (Stillman et al. 2015).

In many cases, discussions about small-scale processor challenges often emphasize regulatory compliance, human resources and by-product disposal expenses as concerns. Based on the USDA Economic Research Service and university research, however, the processing facilities studied for their case studies recognized these frequently mentioned challenges as issues and costs that they would expect to encounter as they do business. No strong opinions about these topics were recorded from the participating local processors (Stillman et al. 2013).

3.3 Small Beef Processor Opportunities

To strengthen the small-scale meat processing sector, several opportunities are available. The following sections further describe these ideas for processors themselves and supporting entities.

3.3.1 Marketing Opportunities

Demand for local foods has been well-documented. Small-scale meat processors may have an opportunity to develop products meant to serve local audiences (Morrison 2014). Local products may also carry a premium. USDA retail data indicate that a bone-in ribeye sourced locally may command $1 more than a conventional steak alternative on average (Swanson 2015).

Consumer trends have also created interest in convenience products. Pre-cooked and pre-assembled main dishes have offered opportunities. In Minnesota, many small-scale meat processors have already started pursuing product development in this area. For example, the 2014 survey conducted by the Agricultural Utilization Research Institute found that more than half of the Minnesota small-scale meat processors responding to the survey produced marinated meats that consumers can cook in the oven or on the grill. Other market trends that may create opportunities for small-scale meat processors include rising interest in nutritious snacks and ethnic foods (Morrison 2014).

For small-scale meat processors, they may develop a comparative advantage for offering customized product lines that are difficult to replicate by larger processors. Unlike standardized products typically available from large-scale processors, the niche products carried by small-scale processors could include special meat cuts, sausages, cured meats and custom packaging or labeling (Low et al. 2015). Research from Minnesota indicates a possible need for opportunities to connect small-scale meat processors with upstream stakeholders like producers and downstream stakeholders like consumers (Morrison 2014).

3.3.2 Training Programs

3.3.2.1 Wisconsin Master Meat Crafter Program

Wisconsin has a model training program named the Master Meat Crafter Program. During the roughly two-year program, enrollees participate in several types of learning activities. Those include six multi-day workshops focused on topics such as fresh meats, food safety, meat curing and sausage (Sindelar and Potratz 2015). Led by expert instructors, the workshops may use presentations, demonstrations and product manufacturing to teach participants (Sindelar and Weyker). Other program elements include a mentoring program, which requires participants to mentor a colleague about meat science and processing, and an in-plant research project, which dictates that participants select a topic, research it, design a hands-on study about the topic and present research findings in written and oral form. Throughout the program, participants will also have at least six homework assignments to further participant exploration in certain areas. Additionally, if participants haven't previously completed the HACCP training for meat and poultry processors, then they must have that training (Sindelar and Potratz 2015).

Per class, the Master Meat Crafter Program accepts 30 participants (Sindelar and Potratz 2015). During 2012, the program had 17 graduates (Sindelar and Weyker). The 2014 class had 21 graduates. To be eligible, candidates must submit an application. Those who have owned, operated or worked in meat processing for at least five years may receive admittance preference. Participation cost varies depending on establishment location. For the 2016 to 2018 program, in-state plants would pay $5,000, and the cost increases to $6,000 for out-of-state plants. The fee covers the six workshop registrations, materials and handouts, business meals, awards and certificates (Sindelar and Potratz 2015). Participants may choose to pay with quarterly installments (University of Wisconsin).

After completing the program, a graduate may designate himself or herself as a "Master Meat Crafter" (Sindelar and Potratz 2015). Additionally, graduates may brand their products with a Master Meat Crafter logo to indicate that their products originate from an operator who has completed the program's training (University of Wisconsin).

3.3.2.2 Wisconsin-Minnesota Meat Processing School

To serve a wider audience than the Master Meat Crafter candidates alone, the Wisconsin-Minnesota Meat Processing School is another training option for Upper Midwest meat processors. The program focuses on teaching meat processing principles. The training is well-suited for commercial processors who have limited experience with curing meat and making sausage. At the 2015 event, workshop topics included pathogens and effective pathogen control; sausage casings; fresh, emulsified, cooked, dried and semi-dry sausages; meat microbiology; smoking meat; processing ham and bacon; and artisanal meat processing (University of Wisconsin River Falls).

In 2015, Wisconsin-Minnesota Meat Processing School registrants paid $275 per person in registration fees. After completing the training, participants received a certificate to verify their participation. The sponsors cap enrollment to 40 participants. Several stakeholders sponsored the 2015 event: University of Wisconsin Extension, University of Wisconsin-Madison, University of Wisconsin-River Falls, Minnesota Association of Meat Processors and Wisconsin Association of Meat Processors (University of Wisconsin River Falls).

3.3.2.3 North Carolina State University

North Carolina State University created a Food Safety Manager Certification program to serve non-degree enrollees and the university's undergraduate and graduate students. Offered through distance education, the program features three courses: Basics of Food Safety and Quality, Introduction to Hazard Analysis and Critical Control Points and Quality Control in Food and Bioprocessing. Students enrolled in the program learn about food safety, quality control and operations management (North Carolina State University a).

The university also offers an Online HACCP Certification course that introduces students to executing and managing a HACCP program. During the 16-week course, enrollees learn by using videos, reading an online textbook, taking quizzes, participating in activities and discussion forums and analyzing case studies. Instructors structured the course to address 12 steps involved in creating and executing HACCP plans. After they finish the course, students will receive HACCP certification, and completing the course would fulfill one requirement of the Food Safety Manager Certification Program. For enrollees who aren't seeking a degree, they would pay $654 for the online HACCP course if they're North Carolina residents. Non-residents would pay $1,266. The course also accepts international enrollees (North Carolina State University b).

3.3.3 Business Development Programs

3.3.3.1 Wisconsin Specialty Meat Development Center

Through the Specialty Meat Development Center, Wisconsin offers various services to sausage and cured meat processors. Structured as a nonprofit organization, the center and meat enterprise assistance team provide business development, product development, labeling and packaging, market development and food safety and quality services. With respect to business development, the center can assist clients in analyzing costs and other financial indicators and projecting business results. The product development component involves University of Wisconsin Extension and the meat science departments at three University of Wisconsin campuses. Labeling and packaging consulting seeks to help clients create packaging that attracts customers and differentiates products. With respect to market development, the center can study marketing channels and consider options to grow the customer base. Through the food safety and quality component, clients can learn about sanitation, storage considerations and best safety practices (Swenson).

3.3.4 Other Efforts to Support Small-Scale Meat Processors

3.3.4.1 Iowa

In Iowa, the Small Meat Processors Working Group formed in 2006. Directly, the group intended to offer support to small Iowa meat processors interested in expanding, upgrading or building new facilities. Secondarily, supporting small meat processors in the state would also provide livestock producers with ready access to local markets, and at the buyer level, small-scale processing facilities expand the purchasing options available. During 2010, the group ended its formal commitment to small meat processors work. However, while the group was active, it produced several resources focused on improving small-scale processors' viability. Those resources include guides about accessing resources for Iowa meat processors, buying whole animals and planning facilities. The Iowa Meat Processors Resource Guidebook offers step by step information that small-scale producers can use to build, expand or update their facilities (Leopold Center for Sustainable Agriculture).

3.3.4.2 Minnesota

For meat processors interested in making facility improvements, the Minnesota Department of Agriculture funds the Minnesota Value Added Grant Program. All proposals submitted to the grant program must illustrate that the project expands opportunities to use and process Minnesota agricultural products. Farmers, businesses, agricultural cooperatives and local government entities may apply for funding to purchase equipment or make physical improvements. Specifically, the funds may help livestock processors to start, expand or update their businesses. Alternatively, value-added business applicants can request funding to start, upgrade or modernize their businesses. Several conditions would provide priority to a project. A meat processing-related project is one that would receive priority points (Minnesota Department of Agriculture 2015).

During fiscal year 2016, the Minnesota Value Added Program planned to solicit applications during two different application periods. For each round, as much as $1 million in awards may be provided. Applications for projects focused on purchasing equipment or making physical improvements could request as much as one-quarter of the project's total cost. At the maximum, the grant program would supply $150,000 in funding, and $1,000 would be the minimum grant award (Minnesota Department of Agriculture 2015).

3.3.4.3 Niche Meat Processor Assistance Network

The Niche Meat Processor Assistance Network exists to ensure that the niche meat sector has the right processing infrastructure – this may include capacity, equipment, inspection status, human resources and financial capital – to continue operating viably. As a collaboration among various individuals and organizations, the network coordinates, creates and disseminates content and resources for multiple niche meat processing stakeholders, including processors, producers, buyers and regulators. State affiliates throughout the U.S. offer support. The network also has a relationship with eXtension to share and disseminate information (Niche Meat Processor Assistance Network).

Within several categories, the Niche Meat Processor Assistance Network curates content that the small-scale meat processing community can use. Such topics include building a new facility or expanding a facility, adhering to regulations and food safety parameters, using mobile slaughter and processing units, operating a plant and learning from webinars and case studies. The group also posts research findings on its website (Niche Meat Processor Assistance Network).

3.3.4.4 North Carolina

In North Carolina, the NC Choices initiative started in 2011. The Center for Environmental Farming Systems at North Carolina State University supported the initiative, which existed to reach small-scale processors with technical assistance. Later, in 2012, the Small-Scale Meat Processors Business and Technical Assistance Project formed. For this project, North Carolina small-scale meat processors could apply if they were interested in receiving technical assistance focused on optimizing plant efficiency, growing their capacity and expanding their businesses to include new enterprises. In June 2014, NC Choices project efforts formally concluded (Gwin et al. 2014).

Eight processors participated in the project, and five finished the program. Participants benefitted from workshops, one-on-one consultation, peer interactions and other experts. Those who completed the program received $5,000 to use as matching funds. They could use the funds for executing plans for adding business systems, improving business operations and/or upgrading equipment (Gwin et al. 2014).

In October 2014, the organizations contributing to these small-scale meat processor efforts published a report that summarized activities used throughout the project period. The document shares ideas for processors to evaluate and improve their businesses, and it also describes some technical assistance activities used to reach small-scale meat processors. For example, NC Choices has experience with coordinating processor roundtables and facilitating tours to emphasize peer learning. Roundtables have been structured like panel discussions to share information and develop camaraderie. Held during the Carolina Meat Conference, past roundtables emphasized topics such as managing human resources, working in aging facilities and correcting supply chain bottlenecks. Arranging facilitated tours gives processors a first-hand look at other facilities. Tours can enable processors to delve into minute details about facility operations (Gwin et al. 2014).

NC Choices also supported the Carolina Meat Institute as a venue for hosting interactive training sessions and conferences. Topics addressed at the Carolina Meat Institute included local products and niche or pasture-based business opportunities (Gwin et al. 2014).

3.3.4.5 Hack//Meat Silicon Valley and Hacking Meat

During 2013, the Institute of Design at Stanford hosted Hack//Meat Silicon Valley. Two key groups attended: 1) technology experts from companies such as Facebook and Google and 2) advocates from the agriculture community. The event briefed the tech community about meat sector challenges. Together, the two groups created 24 concepts and business models that used technology to address meat sector obstacles. The hackathon complemented a "Hacking Meat" online series that asked food and technology industry experts to consider technology's role in the meat sector's future. Food+Tech Connect, GRACE Communications Foundation and Applegate offered support to these meat hack efforts (Gould 2013).

3.3.5 Technology Adoption

Small-scale producers may choose to differentiate their businesses by adopting innovative technologies. The following technologies may offer small-scale processors unique opportunities to promote food safety and appeal to growing market segments. High-pressure processing is an example. The process involves sealing food in a package and applying pressure to surround the package. Without preservatives or other additives, high-pressure processing can lengthen product shelf life. Contamination doesn't represent a significant risk because products undergo the high-pressure processing after they're packaged. High-pressure processing has current application for ready-to-eat meats, but its use may later expand into raw products (Nath 2014).

For sanitation needs, ozone technology has historically been used to clean food contact surfaces at processing plants. Highly reactive ozone particles, however, may have application on meat products themselves. Ozone technology works by creating O3 molecules and mixing them with water. Because O3 molecules quickly convert into oxygen, this approach to sanitation is an environmentally friendly alternative. Another technology targeted for food safety purposes are bacteriophages. These live viruses can invade targeted bacterial cells and control them. In a meat processing context, bacteriophages may have application as E. coli and Listeria controls (Nath 2014).

3.3.6 Mobile Processing Facilities

For small-scale processors, using a mobile slaughter facility represents an opportunity. With a mobile unit, the slaughter facility can move to farms that have animals ready for slaughter, and depending on the unit's configuration, this processing can occur under inspection (Low et al. 2015). In communities where small-scale meat processing facilities have closed, mobile meat processing units may represent a solution to satisfying local processing needs (Koepke 2011).

Mobile units can resolve transportation challenges for beef producers, who may need to move livestock long distances to reach a traditional brick-and-mortar slaughter facility. Reducing transportation would also decrease animal stress. Such units could serve producers who raise beef cattle, buffalo, sheep, goats and swine. Slaughtering animals on farms would also keep slaughter waste on farms, which could compost the waste. Small-scale slaughter facilities could also consider adding a mobile cutting service and marketing local products. In one mobile processing unit example, the facility slaughters animals under USDA inspection. After slaughter, a refrigerated truck moves the carcasses to another facility, which further processes the carcasses and packages meat. By transporting carcasses instead of animals, hauling weights drop by 35 percent (Koepke 2011).

In Washington state, a farmer group committed to mobile processing when neighbors inhibited plans for a brick-and-mortar facility. Per day, the group's mobile unit can only process five to nine steers, so it's a small endeavor. One individual can operate the unit, which includes areas dedicated for processing, refrigeration and storage. Like the previously discussed model, the Washington mobile unit sends carcasses to a different facility to portion them (Krause 2006).

USDA-approved mobile units are available to producers in Washington, Arkansas, California, Nebraska, Colorado, New Mexico, New York and Texas (Swanson 2015). At http://www.mobilemeatprocessing.com/, the Mobile Meat Processing Group has more information available about using mobile units for livestock slaughtering.

3.4 Beef Processing Economics

Meat processing in general and beef processing in particular are dominated by relatively few participants with high volumes and thin margins. Although USDA identified more than 900,000 farms with cattle and calves in the 2012 Census of Agriculture, only 80 facilities accounted for 98.7 percent of cattle slaughtered during 2014. Given the economies of scale that exist with large facilities, as well as the proximity of most to the larger cattle feedlots of Iowa, Nebraska, Kansas and Texas, competing with these facilities based on processing cost is virtually impossible.

Exhibit 3.4.1 compares beef supply chain costs for a hypothetical local beef processor working with a small number of cattle versus a commodity beef processor. As illustrated, average price per pound totaled $8 for the local entity relative to $4.65 for the commodity processor.

Exhibit 3.4.1 – Beef Supply Chain Costs, Local versus Commodity

	Pounds	Cost/lb.	Cost	Share of Final
Local (1)				
Beef	13,200	$2.10	$27,720	42%
Livestock trucking			$350	1%
Processing	13,200	$0.65	$8,580	13%
Subtotal			**$36,650**	
20% margin for marketing, distribution			$9,163	14%
30% margin for retailer			$19,634	30%
Total			**$65,446**	
Average price/lb.			**$8.00**	
Commodity (2)				
Beef	13,200	$1.85	$24,420	64%
Livestock trucking	13,200	$0.02	$264	1%
Distribution	13,200	$0.15	$1,980	5%
Subtotal			**$26,664**	
30% margin for retailer			$11,427	30%
Total			**$38,091**	
Average price/lb.			**$4.65**	

(1) Assumptions: 20 grass-fed cattle, USDA Select, 660-lb carcasses, 62% carcass-to-meat yield; livestock trucking 100 miles at $3.50/loaded mile; conventional grocery retail margin (natural foods retailers often charge 35-50%).
(2) Assumptions: beef price based on 2010-11 average meat yield price for 600- to 900-lb Select carcasses, 62% carcass-to-meat yield; livestock trucking and meat distribution with company-owned or contracted whole truckloads. No cost for processing, as discussed above.
Source: USDA Economic Research Service, "Local Meat and Poultry Processing" (Gwin, Thiboumery, Stillman, 2013)

The study containing the above table suggests that processing costs for local and commodity beef processing plants are not even able to be compared given that these facilities utilize very different business models. Exhibit 3.4.1 shows that commodity beef processors typically earn enough from by-product revenue to completely offset the cost of processing live animals into cuts of meat (that is why there is no processing cost shown in the table for commodity beef). Local processors, however, normally earn nothing from by-products, or in fact, they may pay to dispose of by-products and must bear the full processing cost shown in the table above.

Exhibit 3.4.2 summarizes costs involved in operating three local processing establishments, which vary by size. The table suggests that labor represents the most significant expense for local meat processors regardless of their scale. Raw materials, ingredients and packaging and processing-related overhead followed as the second and third most significant costs, respectively. The table also reports the estimated annual beef cattle throughput, or revenue equivalent that considers other livestock, necessary for each facility to break even and cash flow. To operate viably, even very small facilities require processing many cattle (Stillman et al. 2013).

These models make several assumptions. For example, very small plants operate as custom-exempt facilities with 2,000 square feet and four full-time equivalent workers. They would offer few services for making sausage and smoking and curing meat, but they would process multiple species, such as beef, pork, sheep and goats. For raw meat, these facilities would use butcher paper packaging but may vacuum package cooked sausage. The small facility is assumed to have USDA or state inspection, despite also possibly dabbling in custom-exempt work, and employ 10 full-time equivalent workers. A small operation would use a facility with 4,000 square feet. Like very small facilities, small facilities would also slaughter beef, pork, sheep and goats, but they'd offer more sausage-making, smoking and curing services. They'd also use butcher paper for packaging raw meat and vacuum packaging for cooked sausage and boneless cured meats. The regional facility, assumed to measure 15,000 square feet, would have USDA inspection for all products, undergo regular third-party audits and maintain a quality assurance department. These regional facilities could make sausage and cure and smoke meat with exact weights, and they would use vacuum packaging for both raw and cooked meat. They would also use four-color pre-printed labels. Operating a regional facility would require an assumed 60 full-time equivalent employees, who receive health insurance and retirement matching benefits (Stillman et al. 2013).

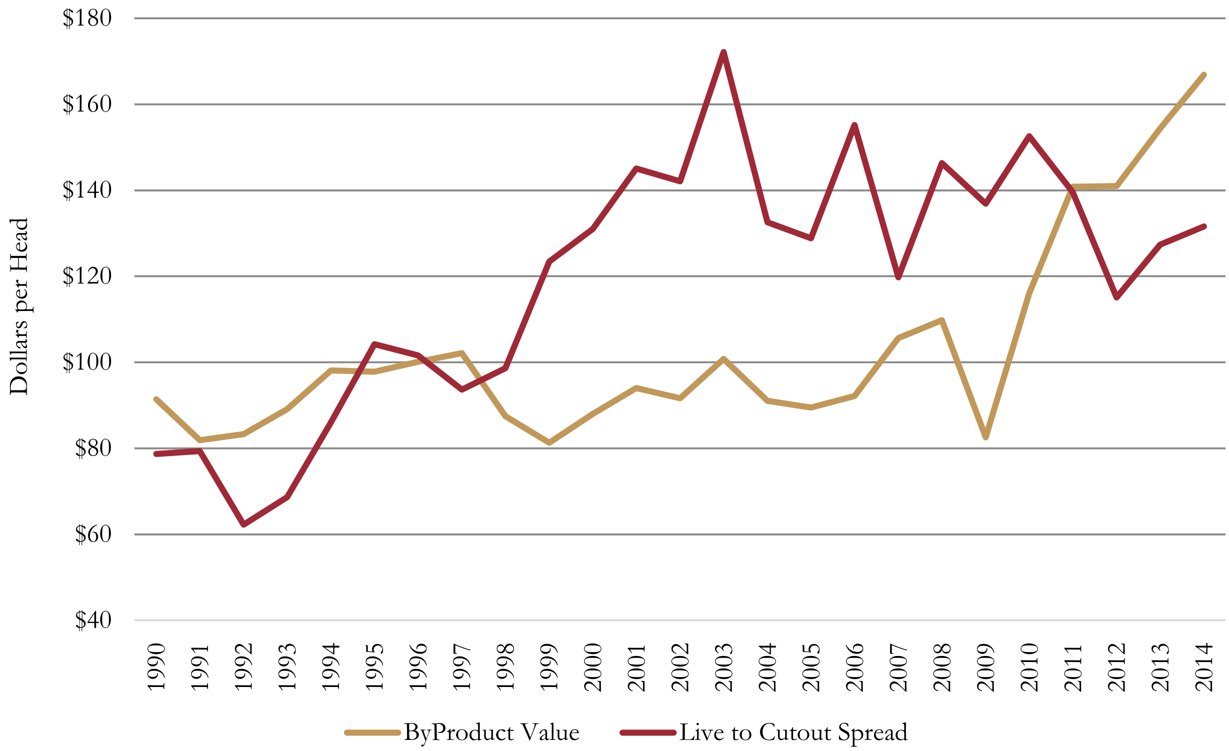
Exhibit 3.4.2 – Local Meat Processing Expenses for Very Small, Small, Regional Facilities

	Very Small	Small	Regional
Raw materials/ingredients/packaging	$50,000	$120,000	$700,000
All-inclusive labor	$110,00	$300,000	$2,800,000
Office supplies and equipment, advertising, phone/postage	$1,000	$4,000	$25,000
Processing utilities, small tools, supplies, repairs/maintenance, vehicle, laundry	$30,000	$61,000	$450,000
Overhead insurance, license, property taxes, legal/accounting, donations, dues, travel, misc.	$20,000	$32,000	$150,000
Local interest	$10,000	$25,000	$165,000
Depreciation	$10,000	$23,000	$152,000
Total expenses	**$231,000**	**$565,000**	**$4,442,000**
Annual beef revenue equivalent to break even	462	1,130	8,884
Annual beef revenue equivalent to cash flow	442	1,084	8,580

Source: USDA Economic Research Service Amber Waves (Stillman et al. 2013)

One of the main profitability constraints for smaller beef processors involves fully realizing the potential value of animal by-products. As noted above in section 3.2.5 on offal, independent small-scale processors tend to not produce offal in quantities that would attract buyers. However, given the relatively tight margins of the meat processing business, by-product value is quite often the difference between a profit and a loss. Exhibit 3.4.3 shows the relationship between the annual by-product value of a 1,000-pound steer and the live-to-cutout spread as reported by the Livestock Marketing Information Center from 1990 to 2014. Note that the live-to-cutout spread does not account for any processing costs. It purely takes into account the boxed beef value of a Choice carcass less the cost of a fed steer adjusted for the by-product value realized from the animal.

Exhibit 3.4.3 – By-Product Value vs. Live-to-Cutout Spread, 1990 to 2014



Source: Livestock Marketing Information Center

In many years, the value of by-products accounted for more than the total margin prior to accounting for processing costs. This underscores the importance of taking advantage of the full value of these available products. Unfortunately for many small-scale meat processors, not only is the full by-product value rarely realized, but arranging for by-product disposal when a buyer cannot be found, also becomes a significant cost.

When Oregon had two in-state rendering plants close in 2006, many meat packers and processors in the state reported that disposal costs increased by 33 percent to 50 percent. Exhibit 3.4.4 shows the disposal costs from using rendering or landfill for Oregon meat processors based on the Animal Byproduct Technology Assessment and Market Analysis conducted for the state in 2007.

Exhibit 3.4.4 – Indicated Disposal Costs, by Source and Location

Type of Disposal and Location	Disposal Using Rendering	Disposal Using Landfill
Dairy mortality, Tillamook County	$52 per animal*	$73 per animal
Beef or dairy mortality, Redmond/Central Oregon area	$117 per animal ($40 pickup+$77disposal)	$54 per animal** ($40 pickup+$14disposal)
Beef or dairy mortality, Grants Pass/Medford area	No service available	$175 per animal ($90 pickup+$85disposal)
Meat processing by-product, South-Willamette Valley/Oregon Coast	$210 to $215 per pick up (up to approx. 1,800 lbs.)	NA
Meat processing by-product, Klamath Falls	$85 to $115 per pick up (up to approx. 1,800 lbs.)	NA
Meat processing by-product, Portland Metro Area	$85 to $115 per pick up (up to approx. 1,800 lbs.)	NA
Meat processing by-product, Redmond/Central Oregon Area	$210 to $225 per pick up (up to approx. 1,800 lbs.)	NA

Note: Animal mortality calculated based upon a 1,200 lb. weight.
* This rate is based on current, historically high prices for meal and bone meal and tallow; normally the landfill cost option is lower than long distance hauling for rendering.
** Crook County Landfill will not accept mortality or by-products after October 2007.
Source: Animal Byproduct Technology Assessment and Market Analysis: Options for Oregon (Cascade Economics LLC 2007)

3.5 Missouri Beef Processing Strengths and Challenges

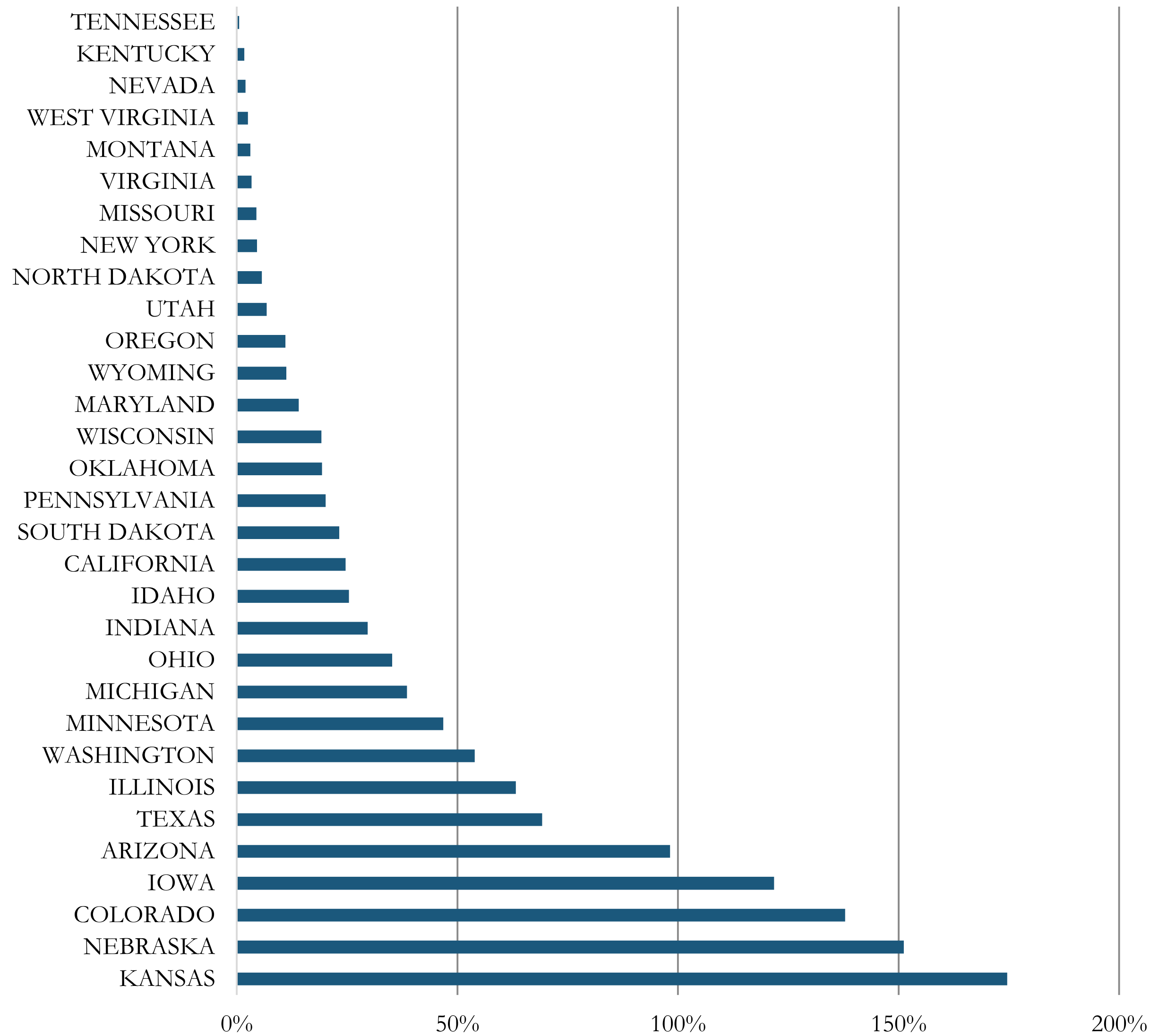
Missouri's long-standing tradition as a state where beef is important is a plus for any endeavor related to the beef industry. The state has ranked second, third or fourth in the nation in terms of calves born every year since 1965. A recent study conducted by the Pelegrin Research Group and funded by beef industry councils in Missouri, Iowa, Kansas and Nebraska shows that consumers in Missouri were more likely to name beef as a top choice for dinner than the national average – 75 percent vs. 70 percent – and they're more likely to eat beef three or more times per week – 45 percent vs. 38 percent. Missouri demographics also point to a strong beef demand base. The percentage of Missouri's population located in non-metropolitan areas has registered nearly 26 percent every year since 1988. Conversely, the portion of the U.S. population in non-metropolitan areas declined from almost 17 percent in 1988 to less than 15 percent in 2013. This is important given that a USDA Economic Research Service study in 2005 showed that per-capita beef consumption in rural areas outpaced that in urban areas by nearly 14 percent and was 20 percent greater than that in suburban areas.

Given that this information places Missouri as a relatively strong beef-demand state, the results found in section 3.3.1 regarding marketing opportunities are likely to be realized at least to the extent listed there if not to a greater extent. However, as noted earlier, securing premium pricing for part of the carcass is only one piece of the profitability equation. The economics shown in Exhibit 3.4.1, which estimate the cost of production per pound at more than $3 per pound higher for local processors vs. commodity processors, represent a need for strong demand for all carcass components in order to be financially viable. This will be a severe challenge for any new Missouri processing plant. A stable customer base for animal by-products and lower-valued parts of the carcass would need to exist. Exploration into whether Missouri, which cited $30.8 million in food purchases for corrections facilities and $269.4 million for school food services in FY 2013, could provide a steady demand base for some carcass cuts might be warranted (State of Missouri Office of Administration, Department of Corrections and Department of Elementary and Secondary Education).

Missouri's cattle industry tends to provide some of the highest quality beef in the nation. Missouri plays a significant role in producing calves that grade Choice and higher under today's USDA grading system. Currently, Certified Angus Beef® (CAB®) estimates that Missouri-sourced calves represent at least 10 percent of total CAB® supplies, and they perhaps represent a higher share of CAB® Prime. That equates to more than 300,000 cattle yielding nearly 40,000 tons of boxed-product for the CAB® brand (Angus Journal, 2010). Local producers and processors working in tandem could produce a quality beef product that easily demands premiums in the marketplace. Additional incentives provided to local processors could provide a much needed jump start that could result in a Missouri premium product that could command a higher price and ultimately drive more dollars back to the Missouri cattle industry.

One of the largest challenges Missouri processors would face in competing, from a processing cost standpoint, with large beef processors involves proximity to large fed cattle supplies. Although cow-calf operations exist in most areas of the U.S. and are particularly prevalent in Missouri, which had the third largest calf crop from 2012 to 2014 compared with other states, more than 85 percent of commercial cattle slaughter occurred in Nebraska, Kansas, Texas, Colorado, California, Wisconsin and Washington based on 2014 data available. Exhibit 3.5.1 shows the relationship between cattle on feed and calf crop from 2012 to 2014 for states in which data are available.

Exhibit 3.5.1 – Cattle on Feed as Percent of Calf Crop, 2012 to 2014



Source: Computed from USDA, National Agricultural Statistics Service

Despite the challenges of competing with large beef processors located near large fed cattle supplies, success stories for small-scale meat processors do exist. The 2013 USDA Economic Research Service report about local meat and poultry processing documented cases of successful meat processing operations. However, given available expense estimates and the capital-intensive nature of starting, maintaining and expanding processing businesses, even a small processing plant that provides basic services must annually process at least 450 head of cattle to be profitable as indicated by the USDA Economic Research Service report. The study also highlighted the need for strong coordination and communication between processors and their customers and suppliers to succeed.

Successful processors in the studies either had one or more anchor customers that provided some, or all, of the throughput to help ensure steady business for the plant. They also were able to overcome relatively high regulation and food safety control costs by garnering enough of a premium for all of their product output to absorb the higher unit processing costs. For a plant in Missouri to be financially viable, it would need to take advantage of the types of premium marketing opportunities identified in section 3.3.1 in large enough volumes to justify the higher processing costs.

3.6 Economic Impact of Increased Meat Industry Sales in Missouri

If more animals were slaughtered and processed within Missouri, then Missouri's economy would experience economic effects. New industry sales would be generated from existing or new animal slaughter and further processing businesses. Local vendors would supply goods and services to these businesses. Missouri livestock producers would be able to process more of their animals locally. Additionally, jobs would be created in these industries, and they would provide income that the labor force and proprietors could spend in the local economy.

Estimations were prepared to simulate economic effects from these new industry sales by using IMPLAN economic impact software. IMPLAN is an input-output model that includes economic data sets, multipliers and demographic statistics for the entire U.S. economic infrastructure. A robust tool, it assesses the effects of changes in the economy by sector, and economists and analysts widely use it. Estimations in this report used the 2014 IMPLAN data set for Missouri.

IMPLAN-generated impacts can be separated into three economic effects: direct, indirect and induced. A direct effect is a direct change to an industry. For example, new sales from meat industry businesses would be a direct economic effect. Businesses purchasing goods (inputs) or services from other industries would create an indirect effect. Induced effects are the changes in household spending from income generated by direct and indirect effects. For instance, employees will spend their income on other goods or services in the local economy. For the following economic impact examples, all three economic effects – direct, indirect, induced – were totaled and reported.

One measure of demonstrating annual economic impact is value-added. Value-added impact consists of labor income including wages, benefits and proprietor income; indirect taxes; and other income such as corporate profits, net interest and rent. Additionally, value-added is also a measure of gross domestic product (GDP) generated by the industry. Exhibit 3.6.1 shows additional value added to Missouri's economy, both in the animal slaughter and further processing industries, at various levels of new industry sales. For example, if $1 million in new sales were generated in the animal slaughter industry, then the value added to Missouri's economy would total $656,213. If an additional $1 million in sales were to occur in the further meat processing (carcasses) industry, then an additional $568,177 in value would be added to the state's economy. The economic impact from $1 million in new industry sales to each industry would sum $1,224,390.

Exhibit 3.6.1 – Value Added to Missouri's Economy with New Industry Sales in Animal Slaughter and/or Meat Processing Industries (Excluding Poultry)

New Industry Sales	Animal Slaughter Industry	Meat Processed from Carcasses Industry	Total
$100,000	$65,621	$56,818	$122,439
$1 million	$656,213	$568,177	$1,224,390
$10 million	$6,562,134	$5,681,770	$12,243,904

Source: University of Missouri, using data from IMPLAN

Jobs are another economic impact measure. Exhibit 3.6.2 presents total Missouri jobs that would be supported by animal slaughter and meat processing industries at various industry sales levels. Employment refers to jobs, either full-time or part-time, as an annual average. If $1 million in new industry sales occurred in both animal slaughter and meat processing industries, then the sales would support 21.7 jobs. For $10 million in sales in both industries, the impact would grow to 217.5 jobs.

Exhibit 3.6.2 – Additional Jobs Supported in Missouri's Economy with New Industry Sales in Animal Slaughter and/or Meat Processing Industries (Excluding Poultry)

New Industry Sales	Animal Slaughter Industry	Meat Processed from Carcasses Industry	Total
$100,000	1.2	1.0	2.2
$1 million	12.1	9.6	21.7
$10 million	121.0	96.5	217.5

Source: University of Missouri, using data from IMPLAN

4. Feed Tracking and Monitoring Technology

4.1 Tracking and Monitoring

The beef industry has several tools available that leverage technology for tracking and monitoring animal behavior and performance. Using these systems and the data that they collect can indicate whether an animal eats efficiently, grows well, becomes sick and fits in a given marketing group. The following sections describe some of these systems and their characteristics. GrowSafe is the predominant system described for its applicability in research and production environments. However, some other technologies are available as alternatives.

4.1.1 GrowSafe

4.1.1.1 History

When GrowSafe first entered into the feed monitoring business, it focused on a system meant to track ostrich chick feed intake (Halladay 2013). The ostrich business appeared to have potential during the 1980s (Swan 2012). However, GrowSafe technology soon had development focused on serving the cattle industry. In 2000, the company introduced its first automated feed monitoring system developed for cattle. By 2007, early adopters who weren't connected to research endeavors and who intended to use the system for practical purposes had started purchasing GrowSafe systems (Halladay 2013). The company has also recently focused efforts on determining GrowSafe's potential in monitoring dairy and sheep (Swan 2012). Other users have trialed GrowSafe system application in raising goats (Welsh 2012).

GrowSafe has received several accolades for its technology. For example, in Canada, the company received recognition from the Regional Awards for New Technology for Western Canada, and it earned the ASTech award for Innovation in Agricultural Sciences. Both awards were received in November 2012. A month earlier, the company presented at the World's Best Technology Innovation Marketplace event held in California (Halladay 2013). In 2013, GrowSafe earned recognition from the Information Technology Association of Canada by receiving the 2013 Ingenious Award, which is provided to small or mid-sized private businesses for their technological innovations (So 2013).

4.1.1.2 Technology Systems

The GrowSafe system uses RFID ear tag technology. When an animal receives an ear tag, the tag is assigned a unique number. For the GrowSafe system that monitors feed intake, feeding bunks are also technology-enabled. Each trough has an RFID antenna built into its rim and is suspended on load cells. When an animal steps up the feed bunk, the antenna reads the RFID tag. GrowSafe systems enable continuous data acquisition. To compute feed disappearance, the system measures data at a 10-gram resolution, and the system measures feed disappearance as many as eight times per second while an animal is eating. Data captured from the RFID scans undergo analysis and auditing in GrowSafe software (GrowSafe Systems). The GrowSafe system designed to monitor feeding activity is called the Feed Intake and Behavior Monitoring system (Halladay 2013).

In addition to the GrowSafe system that measures feeding activity, another system called GrowSafe Beef has been developed to monitor water consumption and estimate animal weight. A single GrowSafe Beef system can accommodate as many as 250 animals through its six drinking and weighing stations (Halladay 2013). With GrowSafe Beef, the system gauges animal weight on a daily basis by taking four to six measurements during animal watering. These measurements don't convey full body weight. Instead, they compute a partial body weight, which is then converted into a full weight value (Stalcup 2008). When monitoring water consumption, the GrowSafe Beef system can also quantify the time that an animal spends drinking water (Maday 2013).

GrowSafe systems can also control data collection mishaps. For example, system software can account for error attributed to weather events, such as rain, snow and wind, and lost transponders (GrowSafe Systems). GrowSafe monitoring technology can recognize when bunk technology doesn't work as it should. Operators can then correct the issue (Gordon 2010).

In the future, GrowSafe would like to add capabilities to its systems. For example, it would like to develop systems to treat animals while they're still in the pen. Currently, the system can mark potentially sick animals with spray paint, but the producer must manage treatment (So 2013). Although the system could eventually automate some animal health treatments, operators would still play a role in ensuring animal health. For example, an operator may be better able to identify whether an animal has experienced an injury than the computer. Although the GrowSafe system could possibly detect a pain response eventually, human interaction with the animals would speed response time (Swan 2012). The company would also like to refine its system to predict hot carcass weight by animal. Such predictions would help producers schedule when they would remove growth-promoting additives from animal rations (Smith and Lovorn 2015).

Because of the system's robust RFID technology, GrowSafe can differentiate among multiple tags in tight areas, but the system doesn't require animal confinement. This presents an advantage because it enables data collection in more natural environments (GrowSafe Systems). With a non-invasive system like GrowSafe, the system itself doesn't lead to causing animal stress (Halladay 2013).

Based on data collected from GrowSafe systems, producers can identify animals that eat efficiently, animals that tend to occupy space at the bunks but fail to eat, animals that fit into herd social hierarchies and animals that change their eating habits (Halladay 2013). GrowSafe Beef systems designed to have an overhead spray gun can help with sorting. Using different spray paint colors, the sprayer can apply paint onto cattle to divide animals into different marketing groups given weight and performance data collected during water trough visits. Operators can use the color code to sort and segregate cattle (Maday 2013).

If the GrowSafe data indicate that animals have changed their intake habits, then those changes may be attributed to the animals beginning to feel ill. When the system recognizes that an animal may be getting sick, producers can address the problem early. Generally, GrowSafe enables producers to identify illness before other visual cues would indicate that the animal is sick (Halladay 2013). On average, GrowSafe systems seem to recognize animal illness as many as four days sooner than animals would appear symptomatic (Swan 2012). GrowSafe systems can make determinations about animal health by assessing the frequency that animals make a trip to the water trough or feed bunk, or restless movement may serve as another signal for animal health issues (So 2013). If the GrowSafe Beef system suspects that an animal has gotten sick, then a sprayer marks the animal with paint when it visits the watering station (Stalcup 2008). With the spray paint applied, operators and workers can more easily spot cattle thought to be feeling sick (Maday 2013).

4.1.1.3 GrowSafe Use

GrowSafe unit adoption has grown gradually since the company first started serving the cattle industry. Based on a December 2010 estimate, 30 GrowSafe units had been adopted by entities in the U.S. (Gordon 2010). In January 2013, worldwide GrowSafe system use totaled 85 units. About half of these were in the U.S., and they predominantly existed at universities and agricultural research centers. However, some were owned and operated privately (Halladay 2013).

By July 2015, GrowSafe system use had expanded. The company had units operating at more than 120 locations. Twenty-three different states had GrowSafe systems. Six in 10 systems had been installed on privately owned farms and ranches. The remaining systems were used at commercial performance-testing stations (Smith and Lovorn 2015). Internationally, GrowSafe systems have had application in areas such as the European Union, Brazil and Australia (Swan 2012).

Operations using the GrowSafe systems have been diverse. In 2013, the company shared that it had attracted many large-scale producers but also served smaller operations. At the time, the smallest customer maintained roughly a 200-head herd (So 2013).

The GrowSafe co-CEO has noted that comfort with technology influences GrowSafe adoption. According to a 2013 story, the company characterized most of its commercial customers at the time as early adopters. Many agriculture stakeholders have resistance toward technology (So 2013).

Missouri has served as a key location for experimenting with GrowSafe technology. The University of Missouri was the first higher education institution to have a GrowSafe system installed (Welsh 2012). Based in Nevada, Mo., Green Springs Bull Test started using GrowSafe in 2005. It was the first bull test to adopt the technology (Gugelmeyer 2011). GrowSafe lists several Missouri testing centers that have GrowSafe systems available: Circle A Angus Ranch, Green Springs Bulltest Station, Seedstock Plus - RJM Feeders, University of Missouri Animal Sciences and University of Missouri Southwest Center (GrowSafe Systems).

Midland Bull Test has elected to use GrowSafe for its bull testing. Bar T Bar Ranch in Arizona also tests residual feed intake (RFI) using GrowSafe for its bulls; it conducts the testing at Synder Livestock Company in Nevada. For more information about using RFI as an alternative tool to assess feed efficiency, see section 4.2. The ranch started using the test to respond to increasing input expenses (Halladay 2013). A South Dakota ranch started using the GrowSafe system during 2009. The South Dakota operator sought to test RFI performance in the ranch's bulls. The data collected indicated some stark differences between feed intake in efficient and inefficient bulls. Specifically, in one dataset, the rancher noted that the least efficient bull required 12 pounds of feed intake to generate one pound of beef. Conversely, the most efficient bull gained one pound of beef after consuming just 4.4 pounds of feed (Gordon 2010).

The GrowSafe systems would have wider potential application than bulls alone, however. For example, by directly testing replacement heifers, producers would have access to inform that enables them to make good heifer selection decisions. Some operations using GrowSafe systems have followed this approach (Halladay 2013).

In 2012, The Samuel Roberts Noble Foundation and GrowSafe Systems announced a partnership that would enable feed efficiency testing in pasture settings using the GrowSafe Beef system that monitors water consumption and animal weight. Through the collaborative agreement, The Samuel Roberts Noble Foundation would use the GrowSafe system and provide the necessary data interpretation functions (The Samuel Roberts Noble Foundation 2012). Work conducted with the Noble Foundation and other veterinarians enabled GrowSafe to create an algorithm that applies data collected in GrowSafe systems and makes determinations about whether animals appear to be developing an illness (Maday 2013).

To begin working with GrowSafe technology, Alison Sunstrum, GrowSafe co-CEO, recommends that producers send breeding stock to a GrowSafe testing center. During 2015, more than 60 North American testing centers were available for producers to use (American Cattlemen 2015).

4.1.1.4 Cost

With respect to GrowSafe system cost, a 2015 estimate suggested that producers could expect to pay about $25 per animal as a 10-year purchase and support cost for measuring feed intake (American Cattlemen 2015). In 2008, the GrowSafe Beef system, which measures frequency of visits to watering stations and estimates animal body weight, cost an estimated $5 per animal (Stalcup 2008).

As an alternative to quoting the cost as price per animal, a December 2010 story suggested that the cost for an individual bunk would total $10,000, and the bunks are available in sets of eight. Purchasing larger units would decrease the cost per bunk. Thus, the expense per bunk would be lower for a 16-bunk system than the expense per bunk for an eight-bunk system (Gordon 2010).

Monty Kerley at the University of Missouri estimates that GrowSafe systems that monitor feed intake from 16 bunks will cost $160,000. Purchasing in 16-bunk sets enables buyers to capture quantity discounts. In addition to paying the one-time purchase cost for feed-tracking systems, GrowSafe users may also pay roughly $4,000 per year through a service contract, which includes daily data monitoring and other support provided by GrowSafe staff. Rather than sell water monitoring units, GrowSafe offers them for lease. Assuming that a feedlot has 200 head and occupancy 80 percent of the year, feedlots could anticipate paying $8 per head per year. That lease fee would include support services and hardware updates from GrowSafe.

4.1.2 Track-A-Cow

Typically used by dairies, Track-A-Cow offers producers technology that can track animal movement and feeding activity on an individual basis. University of Calgary researchers have also found that the Track-A-Cow system could have application in beef cattle feedlots. In the University of Calgary research, steers had tracking systems, otherwise known as fedometers, attached to their front legs. Testing indicates that these fedometers tend to stay well-attached to the animals, and they didn't cause any skin lesions. However, they can be expensive. If a large commercial feedlot were to invest in this technology, then the cost may average $14,500 for 100 animals (Kneeskern 2015).

To measure feeding time duration and frequency, the steers feed from bunks that have an antenna capable of producing an electromagnetic field every eight seconds. Bunks can collect data when the fedometers are within 12 inches of the front of the bunk. To measure fedometer accuracy, the research team compared the tracking system's data with visual observations. For time spent at the bunk, the fedometer provided 98 percent accuracy (Kneeskern 2015).

From an activity perspective, the fedometers measure time that the animals spend lying, walking and standing. Research indicates that the system could accurately measure lying time, but it underestimated lying frequency. The system also slightly overestimated number of steps taken (Kneeskern 2015).

4.1.3 American Calan

American Calan, based in Northwood, N.H., developed the Calan Broadbent Feeding System. To use the Calan Broadbent Feeding System, producers must equip each animal with an electronic sensor key, which hangs from the animal's neck. Using the key, animals can activate a feed door, which the animal must open before it can eat (Stalcup 2008).

American Calan describes four key components of its Calan Broadbent Feeding System. First, the system features a solid-state circuit board placed on the door. This circuit board determines when the door unlocks. Second, a sensor key worn from an animal's neck can open doors only when the door and key have been programmed to have the same frequency. By positioning the key to hang from an animal's neck, the system avoids having the door open before an animal is ready to feed. This prevents another animal from entering the door. Third, the door itself is made from molded fiberglass. Its shape fits well with animal needs, and it closes and locks quickly to prevent another animal from entering the incorrect feeding area. Within the feeding area, animals feel like they're in a natural setting. Last, the system has a feed barrier design that minimizes the wrong animal from feeding in a certain area (American Calan).

With the Calan gates, cattle are free to socialize with other animals in the feedlot (Reuter et al. 2013). The Calan gate concept has had some limitations, however. Each animal must have training to ensure that it can access feed in a system like this. Not all animals adapt to the gate system, and others may learn slowly (Schwartzkopf-Genswein and McAllister 1998). To use this system, researchers pre-weigh feed that they add to the bunk, and they remove uneaten feed when the day ends. Because the system can't control for environmental influences, entities that use Calan gates may need to build a barn or covered facility to protect the feeding area from snow and rain that could influence data collection. Some researchers continue using Calan gates (Reuter et al. 2013).

4.1.4 Micro Beef Technologies

Micro Beef Technologies has marketed the Accu-Trac electronic cattle management system as an option for individual animal management. Producers first had Accu-Trac available to them during 1994. In 2008, Farm Industry News reported that the system cost an estimated $9 per animal (Stalcup 2008). Accu-Trac would capture data twice in the production cycle. First, animals would have baseline data collected when they arrive at a new location. Second, when they've finished half of their feeding program, data collection would occur again (Reiman 2008).

The Accu-Trac system was developed to measure several indicators. The system could monitor animal weight. It used ultrasound technology to assess internal tissue attributes; back fat thickness is an example (Stalcup 2008). Other factors measured with an ultrasound would be ribeye area and marbling score (Reiman 2008). Accu-Trac also incorporated video imaging as a tool to assess an animal's external dimensions (Stalcup 2008). The video data enable the system to assign a frame score and determine an animal's target weight (Reiman 2008). Combined with science-based projections, the video imaging would enable producers to sort their animals and create uniform groups (Stalcup 2008). After the second data collection period, producers could use the information provided by Accu-Trac to form new market groups (Reiman 2008).

In 2011, Micro Beef Technologies ownership changed. MWI Veterinary Supply agreed to purchase assets from Micro Beef Technologies in that year (MWI Veterinary Supply 2011).

4.1.5 Cost

To help gauge the cost associated with animal identification technologies, BEEF magazine and Beef Stocker USA have coordinated surveys targeted to animal identification suppliers. The most recent survey available is the 2013 Survey of the Animal Identification Industry. Through the survey, companies offering animal identification technologies had the option to estimate the cost associated with using their technologies. Some companies provided a cost estimate in the latest survey, and others declined to mention a specific estimate. To see the survey results, go to http://www.beefstockerusa.org/rfid/grid.html (BEEF and BeefStocker USA 2012).

4.2 Residual Feed Intake (RFI)

Animal monitoring and tracking systems can enable producers to collect data on an individual basis and benefit from making decisions based on residual feed intake. The RFI concept first was discussed during the early 1960s (Stalcup 2008). The indicator offers an alternative to the feed-to-gain ratio commonly used to measure beef animal performance. Generally, feed-to-gain ratios are communicated by pen. The feed-to-gain ratio communicates pounds of feed needed to yield a pound of gain, and it's related to average daily gain. However, the ratio has little value for efficiency-related breeding decisions because it bases selection indirectly on gain. Consequently, this leads to choosing animals that are larger at maturity (Hale 2014).

RFI measures the difference between actual intake and expected intake (Hale 2014). Computing expected intake first involves measuring feed consumption on an individual basis. Then, using a regression equation that reflects data points for feed consumption, average body weight and average daily gain, an animal's expected intake can be estimated (Gugelmeyer 2011). Funded by a USDA National Institute of Food and Agriculture grant, The National Program for Genetic Improvement of Feed Efficiency in Beef Cattle has an RFI calculator available at http://www.beefefficiency.org/ (National Program for Genetic Improvement of Feed Efficiency in Beef Cattle 2013).

Animals that look similar and record similar average daily gains can have different RFI values and levels of efficiency. From an interview with Dr. Gordon Carstens at Texas A&M University, BEEF magazine shared the example in Exhibit 4.2.1. Two steers had similar body weights and no clear visual differences. Their average daily gain and expected intake also differed little. With respect to actual intake, however, the two were different. Because of this variance, the example illustrates that RFI can differ in steers otherwise assumed to be similar. Steer A had a -1.5 RFI score relative to the 2.3 RFI score for Steer B. Based on these differences, Steer A, which consumed less than expected, would be more efficient than Steer B, which consumed more than expected (Hale 2014).

Exhibit 4.2.1 – Residual Feed Intake Example in Comparable Steers

	Steer A	Steer B
Body weight	Similar	
Average daily gain	3.38	3.3
Expected intake	22.3	22.0
Actual intake	20.8	24.3
RFI	(1.5)	2.3

Source: BEEF (Hale 2014)

Good one-by-one animal RFI projections haven't always been efficiently available. When the industry first started assessing RFI, methods used to make those calculations required industry stakeholders to house animals individually or record pen-wide observations. When housed individually, animal behavior can change relative to the behavior recorded in a more natural herd-like setting (Halladay 2013). Much early research relied on metabolism crates, which segregated animals. When housed in a metabolism crate, researchers would need to feed the animal by hand, typically at least two times per day (Reuter et al. 2013). If research involves collecting data on a pen-level basis, then making conclusions about individual animals can be challenging. A third option to measure RFI that had been available involved using cumbersome equipment. Such equipment didn't fit well with commercial beef production (Halladay 2013). With individualized animal tracking and monitoring systems, like those described earlier, specific animal evaluations can be possible.

Evaluating RFI on an individual basis has merit because animals with similar gains can have RFI trait values that vary. As a general rule, expect RFI to vary by 40 percent between highly efficient and highly inefficient calves in the same group. That variance would also produce a 40 percent difference in feed costs. When assessing a herd's forage consumption, assume a 20 percent difference in forage consumption between the herd's least efficient third and its most efficient third (Agriculture.com 2015). On a pound basis, daily feed consumption may vary by as much as 8 pounds among highly efficient calves and highly inefficient calves with similar growth rates (Alkire 2009).

4.2.1 RFI and Other Production Attributes

Research evaluating RFI in cattle has indicated differences other than those specific to feed efficiency in animals with varying RFI values. A summary of those findings follows; however, note that some studies have produced varying conclusions. More research would be necessary to make definitive conclusions about whether selecting for RFI could influence other production attributes. A literature review from Utah State University articulated several benefits noted in beef cattle with low RFI trait values. One study cited indicated that steers with the low RFI attribute produce carcasses with more lean meat and less fat (Crozier and ZoBell 2010). The study compared steers based on parental RFI, and its abstract shared that body composition changes were small. Body composition differences in steer progeny were thought to explain less than 5 percent of sire RFI variation (Richardson et al. 2001). After reviewing several studies, The Samuel Roberts Noble Foundation described in a feed efficiency fact sheet that carcass fat, mature animal size and average daily gain change little if RFI improves (Reuter et al. 2013).

Another study summarized by Utah State University measured that heat production increases in steers with high RFI values. When animals generate heat, they essentially waste energy. To manage heat-related losses, producers may choose animals with low RFI values (Crozier and ZoBell 2010). In high-RFI animals, they eat more, and some of this additional feed intake may be used to generate additional heat rather than gain.

Methane emissions and manure output also vary between animals with low RFI values and those with high RFI values. Among animals with low RFI values, methane emissions and manure output tend to be lower (Crozier and ZoBell 2010). Cattle producing less methane addresses greenhouse gas issues commonly linked to livestock production (Welsh 2012). Again, the methane gas and manure production declines may be attributed to low-RFI cattle consuming less feed per unit of gain.

From a reproduction perspective, data also indicate some discrepancies in the effect that RFI values could have for cattle. More research would need to explore whether adding highly efficient animals to a herd would influence reproductive performance. Some of the differences found in various studies may be linked to the variables used to calculate RFI (Lancaster 2014).

One trade publication reports that low-RFI cows may not breed back as quickly, according to limited data (Agriculture.com 2015). One factor that may affect whether RFI influences reproductive performance is body fat. If low-RFI animals have less body fat and body fat levels influence reproduction, then the low-RFI trait could affect reproductive performance (Lancaster 2014). Montana State University research, however, has suggested that dry matter intake wouldn't influence reproductive efficiency, based on information shared in the Progressive Cattleman publication. In two-year-old heifers, Montana State University researchers compared reproductive-related measures for animals with high dry matter intake and animals with low dry matter intake. Between the two groups, the research didn't note differences with respect to calving scores, percent cycling at bull turnout or pregnancy rate. Research from the university, again summarized in Progressive Cattleman, indicated no differences in cow bodyweight at calving, calf birthweight, pre-weaning ADG or adjusted 205-day weight between high-RFI cows and low-RFI cows (Gordon 2010).

Not only would the feed efficiency improvement allow producers to more conservatively use feed ingredients, but the improved efficiency would also address the issue of increasingly limited resources (Halladay 2013). To help convey the feed efficiency concept, BEEF magazine facilitated a BEEF Efficiency & Profit Contest in 2014. The contest involved publishing photos, videos and background information for 12 different Brangus steers from central Texas. Six were high-RFI steers, and six were low-RFI steers. Born in January and February 2013, the steers were weaned during August 2013, and they were chosen for the contest from a group of 84 steers. After weaning, the steers spent 98 days in a trial that used GrowSafe feed bunks and were provided a diet meant to facilitate 3.2 pounds of gain per day. When the 98-day trial concluded, the steers moved to a commercial feedyard. There, they spent 152 days in a single pen before slaughter (BEEF 2014).

Data for the contest measured the extent to which net revenue and other factors varied by animal. Revenue assumptions computed carcass income based on hot carcass weight and grid-based carcass value. Then, the computation accounted for multiple expenses: the feeder calf, yardage, processing, transportation, feed and interest. Exhibit 4.2.1.1 presents a subset of data points collected for the efficiency and profit contest. As illustrated, the high RFI steer group had a higher average daily gain than the low RFI steer group, but notice that average RFI values had a 5.45-pound difference between the high RFI and low RFI groups. Carcass weight was 35.5 pounds higher on average for the high RFI group relative to that for the low RFI group, and the average USDA quality grade was slightly lower for the low RFI group. When considering return and cost factors, cost of gain and net return were both superior in the low RFI group on average. Average net return for the low RFI steers was nearly twice as high as average net return for the high RFI steers. Cost of gain for the high RFI steers averaged $1.28 relative to $1.03 on average for the low RFI steers. From a net return perspective, the high RFI group averaged $179.56, and the low RFI group averaged $351.55 (Hale and Carstens 2014). These data indicate the potential value derived from selecting low-RFI cattle.

Exhibit 4.2.1.1 – Differences in High RFI, Low RFI Steers

	RFI (pounds)	ADG (pounds)	Carcass Weight (pounds)	USDA Quality Grade	Cost of Gain	Net Return
High RFI						
1	2.28	3.09	890	Low Choice	$1.26	$234.63
2	4.16	2.96	834	Low Prime	$1.48	$102.33
3	3.77	3.14	876	Top Choice	$1.28	$148.10
4	2.43	3.20	910	Top Choice	$1.17	$350.43
5	3.44	3.21	941	Top Choice	$1.29	$62.10
6	3.18	3.63	950	Top Choice	$1.18	$179.73
Average	*3.21*	*3.21*	*900.17*	*Top Choice*	*$1.28*	*$179.56*
Low RFI						
1	(1.64)	2.61	805	Top Choice	$1.14	$215.31
2	(4.79)	3.03	874	Top Choice	$0.94	$402.19
3	(1.51)	3.18	906	High Select	$1.08	$312.08
4	(2.93)	2.83	806	Low Choice	$1.02	$326.76
5	(1.65)	3.06	886	Low Choice	$1.07	$376.45
6	(0.91)	3.59	911	Low Choice	$0.94	$476.53
Average	*(2.24)*	*3.05*	*864.67*	*Low Choice*	*$1.03*	*$351.55*

Source: BEEF (Hale and Carstens 2014)

4.2.3 RFI Effect on Selection Decisions

Using animal RFI values could help to inform animal selection decisions. Culling animals that fall into a herd's bottom third for RFI could make improvements in feed efficiency (Halladay 2013). As producers refine their herd genetics based on RFI values, the stacked selections over generations could drive enhanced efficiency benefits. For example, producers may realize production efficiency benefits that exceed 20 percent if they can stack RFI-selected genetics over generations (American Cattlemen 2015). Other research attributed an 11 percent reduction in feed consumption among steers and heifers when research that spanned two generations focused on choosing animals with lower RFI values. Despite consuming less feed, the more efficient animals had weight and performance variables that were comparable to their peers in randomly mated groups (Reuter et al. 2013). In a pasture scenario, cattle with different efficiency values would respond differently in pasture conditions with limited forage. In environments with limited forage quantity, efficient cows would require less maintenance energy. As such, they would perform better than inefficient cows in this environment. When comparing the most efficient third of cows to the least efficient third, University of Missouri research found that the most efficient group when nonlactating consumed 20 percent less forage and when milking consumed 12 percent less (American Cattlemen 2015).

To enable producers to make selection decisions based on RFI trait values, some efforts have begun to form expected progeny differences for the RFI trait (Alkire 2009). Expected progeny differences make quantitative predictions about traits that can be inherited. RFI can also be considered a simple performance measure. Previous research has found that RFI has a heritability factor that ranges from 0.16 to 0.43. Thus, it is moderately heritable (McDonald et al. 2010).

Data provided by systems that measure RFI and the management decisions based on those data can generate real economic value. Considering that a livestock operation may incur 75 percent of its total costs for feed, technology that emphasizes feed use efficiency can significantly affect livestock producers (American Cattlemen 2015). Said another way, assume that a 15 percent feed efficiency improvement would enable producers to save $60 per year per cow (Halladay 2013). In another example, assume that daily feed costs total $3.50. If an operation feeds for 150 days, then feed costs would average $525. By capturing just a 10 percent feed efficiency, producers could reduce feed costs by nearly $53. If the U.S. feedlot industry were to decrease average daily feed intake by 2 pounds, then in a year, it could realize more than $1 billion in savings (American Cattlemen 2015).

Currently, technology that measures RFI trait values on an individual basis is expensive. Because of the expense, commercial feedlots may not initially drive demand for the individual RFI testing. Instead, bull centers and purebred breeders represent initial target audiences (Agriculture.com 2015).

5. Tall Fescue Toxicosis and Emerging Mitigation Technologies

5.1 Tall Fescue Use

Tall fescue is a cool-season grass that adapts well to multiple growing environments found in Missouri (Henning et al. 1993). The grass was identified growing in Kentucky during 1931, it but had originally been introduced from Europe in the late 1800s. Later, in 1943, the Kentucky 31 fescue variety was released. Quick commercialization and adoption followed during the 1940s and 1950s (Roberts 2000). The grass's hardy characteristics enabled it to reclaim land damaged by the 1930s Dust Bowl (Herrold 2012). Fescue can resist drought, tolerate close grazing and develop into a heavy sod (Henning et al. 1993). Tall fescue can withstand insect and nematode pressures (Roberts 2000) and can handle waterlogged areas (Herrold 2012).

Tall fescue also has a long growing season, which enables more days of forage production than is typical of other grasses (Roberts 2000). By July 1, fescue may produce 60 percent to 70 percent of its annual output. Fescue then gets another growth surge as temperatures begin to cool in late summer and early fall and may accumulate another one-third of its production in August to October. Beef producers may stockpile fescue to have it available for fall and winter grazing (Henning et al. 1993). Combined, persistence and production attributes have contributed to tall fescue being a predominant forage crop in Missouri. Estimates suggest that U.S. tall fescue acreage exceeds 40 million acres in pasture and forage land. Of that total, an estimated 17 million acres are in Missouri (Roberts 2000).

However, a fungal endophyte that aides in plant persistence grows between tall fescue plant cells (Roberts 2000). Through a symbiotic relationship, the fungus benefits from plant-provided nutrients, and it synthesizes alkaloids that protect the plant and improve its persistence (Arnold and Gaskill 2014). For example, endophyte presence enables fescue to better absorb phosphorus, promotes plant growth and seed development and improves plant competitiveness (Ladd 2009).

5.2 Tall Fescue Challenges

The same endophyte can create health problems in cattle, however, because the endophyte can produce toxic alkaloids (Roberts 2000). Ergovaline is the notable alkaloid produced (Ladd 2009). It represents roughly 80 percent to 97 percent of total alkaloid production (Arnold and Gaskill 2014).

Of all fescue plant components, the seed has the most dramatic toxicity potential (Roberts 2000). On average, seed toxicity is about five times greater than toxicity levels in other plant components (Herrold 2012). The endophyte lives in fescue seed if the seed hasn't been stored for more than one year. After germination, the endophyte will migrate into the plant tissue and stem. Ultimately, the endophyte will reach the seed, and after that seed germinates, the cycle will repeat itself. To confirm the endophyte's presence, lab testing would be necessary (Roberts 2000).

Cattle that consume toxic endophyte-infected fescue may exhibit symptoms such as lower milk production, higher temperatures and respiration rates, rough hair coats, excessive salivating, diminished weight gain and reduced conception rates. With respect to gain, producers may anticipate that gains could drop by more than 50 percent, according to southern U.S. research in steers grazing pasture (Roberts 2000). Industry typically assumes drops in daily steer gain of 0.1 pound for every 10 percent increase in toxic endophyte infection (USDA Natural Resources Conservation Service 2011). Among cows, if 90 percent is an average conception rate, then exposure to endophyte-infected fescue may cause conception rates to drop to 60 percent to 70 percent (Faulkner 2005).

Infected fescue consumption influences temperature regulation because the toxic endophyte causes blood vessels to constrict. The constriction influences cooling processes and heat stress risk, and it increases the risk for body tissue at the extremities to decay. Cattle may also seek out water bodies to cool themselves, and as a result, they spend less time grazing and eating (Ladd 2009).

Two other conditions – fescue foot and bovine fat necrosis – have been linked to toxic fescue consumption. Fescue foot at least partially stems from the inhibited circulation caused by toxic fescue consumption (Herrold 2012). Producers may begin detecting fescue foot when temperatures drop below 15 degrees F, or snowy and icy conditions may also trigger noticeable symptoms, which may include an arched back, rough hair coat, gait stiffness and rear limb swelling. The problem appears especially noticeable within five days to 15 days after cattle move into a new pasture, but cattle may also develop symptoms if they haven't moved pastures (Henning et al. 1993).

Bovine fat necrosis refers to hard masses developing around cattle intestines. The condition presents an especially strong risk when infected fescue has had high nitrogen applications, which can cause toxic alkaloid levels to rise. Bovine fat necrosis can contribute to digestive problems and calving difficulties (Roberts 2000).

Considering that most Missouri fescue pastures have at least some levels of endophyte-infection, this can affect beef operations in the state. One estimate suggests that 80 percent or higher infection rates are common in many pastures (Ladd 2009). Additionally, the toxic fescue discussion often focuses on cattle, but horses and sheep could also be affected (Roberts 2000).

The endophyte can trigger significant losses for the beef industry. In Missouri alone, one estimate suggests that toxic fescue annually reduces industry value by $240 million (Harker 2015). The losses widen when considering that fescue toxicity influences producers throughout the "fescue belt" shown in Exhibit 5.2.1. This area has soil and climate conditions suitable for raising fescue. From a U.S. perspective, toxic fescue's annual economic impact totals approximately $1 billion (Aiken 2013).

Exhibit 5.2.1 – U.S. Fescue Belt Region

Source: The Progressive Cattleman (Aiken 2013)

5.3 Toxic Fescue Mitigation Technologies

Producers have several technologies and practices available that can reduce fescue toxicosis incidence and its effects. The following discussion highlights strategies such as planting novel-endophyte fescue varieties, diluting pasture with other forages, clipping fescue seed heads, treating fescue plants with herbicide, adopting a grazing strategy, ammoniating hay, supplementing diets and conducting toxic fescue tolerance genetic tests.

The recommended mitigation strategy may vary by the extent of endophyte infection. For infestation levels up to 10 percent, the infected fescue may not greatly affect cattle performance, but producers could consider clipping pastures. Acreage that records 20 percent to 40 percent infestation may benefit from management strategies such as closely grazing pastures, clipping pastures, rotating cattle and offering feed or hay supplements. At 50 percent to 100 percent infestation, renovation may be justified (Faulkner 2005). Keep in mind that some mitigation practices, such as clipping pastures and rotational grazing, may help to manage fescue toxicosis, but adopting such strategies wouldn't completely eradicate the fescue toxicosis concern. By adopting mitigation strategies, operations could make negative effects less pronounced, however.

5.3.1 Pasture Renovation and Novel-Endophyte Fescue

Novel-endophyte fescue varieties are ones where the toxic endophyte has been removed and replaced with a novel, beneficial endophyte that improves plant persistence. Unlike toxic endophytes, however, novel endophytes provide the persistence benefit without the negative health effects of traditional toxic endophyte-infected fescue (Roberts 2000). Kentucky research indicates that novel-endophyte fescue stands have survived more than 10 years if managed properly. Management practices must ensure that the pasture can regrow. With toxic alkaloids removed, cattle could graze the novel-endophyte fescue "into the ground" and hurt the stand if management practices don't involve monitoring the grazing area (Arnold and Gaskill 2014).

At one time, endophyte-free varietal adoption was considered a possibility. Because such varieties lack the endophyte, endophyte-free fescue wouldn't hinder animal performance. Without an endophyte, however, the endophyte-free fescue proved to be more susceptible to drought, overgrazing and insect and disease pressure (Roberts 2000). A University of Georgia guide describes that persistence was an issue for endophyte-free fescue, especially for stands being grazed, in many cases (Hancock and Andrae 2012). The University of Kentucky projects that endophyte-free fescue stands would persist similarly to orchardgrass (Arnold and Gaskill 2014).

Renovating pastures to remove infected fescue involves multiple steps. First, infected pasture needs a herbicide spray to kill the existing stand. Planting a smother crop provides a shade barrier to prevent escaped tillers and viable seed from re-establishing. Once the smother crop is removed, another round of herbicide is applied to kill any remaining toxic fescue plants. The process concludes by planting the desired forage (Dailey 2015).

The Alliance for Grassland Renewal exists to promote novel-endophyte fescue adoption. The alliance has engaged multiple stakeholders, including those from universities; government entities; nonprofit organizations; and industry sectors such as producers, seed companies and testing labs. Specific partners include Agrinostics, Pennington, Dow AgroSciences, University of Missouri Extension, The Samuel Roberts Noble Foundation and the USDA Natural Resources Conservation Service. Formed in 2012, the alliance uses several tools to support novel-endophyte fescue adoption. For example, it hosts one-day workshops for producers that address topics such as field testing, renovation practices, nontoxic fescue management, seed quality and potential cost-share options. From a quality control perspective, alliance stakeholders self-regulate varietal quality. Specifically, standards exist for seed purity, animal safety and plant persistence. For incentives, the alliance currently promotes that limited USDA Natural Resources Conservation Service cost-share support is available. The alliance will consider other possible funding that could incentivize producers to commit to nontoxic varieties (Alliance for Grassland Renewal 2014).

To estimate the costs and returns of novel-endophyte fescue use, the Samuel Roberts Noble Foundation and University of Arkansas conducted a study that evaluated three fescue varieties. The Texoma MaxQII and MaxQ varieties had novel endophyte characteristics. Kentucky 31 represented the traditional toxic fescue. On a random basis, the research team planted two-acre pastures in 18 different paddocks at a University of Arkansas research station. Within each paddock, half of the pasture had white clover interseeded, and the other half received 34-0-0 applications of 60 pounds during the fall and February. The researchers documented grazing data for the 2007 to 2011 grazing years. Exhibit 5.3.1.1 shares trial data for the portion of pastures that received the nitrogen applications; the clover interseeding data are explained in a later section (Biermacher et al. 2013).

For each fescue variety, the table outlines cost and return assumptions. On average, total cost per acre was highest for the two novel-endophyte fescue varieties, but these two conditions also produced better gain per acre. To grow novel-endophyte fescue, most costs are the same as those for endophyte-infected tall fescue. The differences involved varying seed and establishment expenses. Based on the net return estimates, Texoma MaxQII and MaxQ generated the best returns; however, the Texoma MaxQII variety had a statistically significant net return improvement compared with the MaxQ variety. In this study, making the novel-endophyte fescue investment generated net return that was $185 per acre to $232 per acre superior to the traditional Kentucky 31 variety's net return, which averaged a negative net return in this study. Based on these results, the research team concluded that stocker operations planning to use tall fescue for grazing could justify the additional expenses involved with novel-endophyte fescue establishment because the novel-endophyte fescue model yields better net returns (Biermacher et al. 2013).

As mentioned earlier, nitrogen applications may exacerbate toxic fescue's negative effects, so Kentucky 31 that receives nitrogen applications may have more drastic negative performance than Kentucky 31 that doesn't have nitrogen applications. Additionally, this study includes establishment costs for the Kentucky 31 fescue. For producers considering novel-endophyte fescue adoption, they may already have a Kentucky 31 stand established. Thus, they'd be interested in comparing novel-endophyte fescue renovation relative to their existing stand, whereas this study embeds the Kentucky 31 establishment as a cost. On an annualized basis, this study assumes $28 in establishment costs for the Kentucky 31 fescue. Excluding establishment costs from the analysis would decrease Kentucky 31 total costs to $328, but the net return would still total a negative value (-$35), assuming that an existing Kentucky 31 stand would lead to the performance variables provided here. As a result, this economic model indicates that novel-endophyte fescue varieties can lead to improved economic performance on a net return basis.

Exhibit 5.3.1.1 – Estimated Costs and Returns for Novel-Endophyte Relative to Toxic Fescue Models with Nitrogen Applications Per Acre*

	Texoma MaxQII	Kentucky 31	MaxQ
Grazing days	151a	151a	146ab
Total gain (lbs/acre)	538a	279d	499b
Establishment cost			
Seedbed preparation	$38	$38	$38
Fertilizer	$187	$187	$187
Pesticide application	$10	$10	$10
Seed and seed establishment	$90	$50	$90
Fescue establishment	$324	$284	$324
Fescue costs amortized @ 7.5%	$47	$28	$47
Total annual establishment costs	$47	$28	$47
Annual production costs			
Fertilizer	$118	$118	$118
Mineral	$32	$32	$31
Cattle receiving	$139	$139	$140
Interest on operating capital	$40	$40	$39
Total annual production costs	$328	$328	$328
Total cost	**$376a**	**$356b**	**$375a**
Gross revenue**	**$545a**	**$293d**	**$497b**
Net return	**$169a**	**($63)d**	**$122b**

* Different letters indicate statistical significance at the 95 percent confidence level.
** Computed using $1.21 value of gain per pound for fall grazing and $0.88 value of gain per pound for spring grazing
Source: The Samuel Roberts Noble Foundation (Biermacher et al. 2013)

5.3.2 Pasture Dilution

To dilute toxic fescue pastures, producers can consider interseeding such pastures with legumes. Possible legumes to interseed in Missouri pastures include red clover, white clover, annual lespedeza, alfalfa and birdsfoot trefoil (Roberts 2000). Pastures diluted with legumes will enable grazing cattle to choose to exclude the toxic fescue and consume the other forages (Arnold and Gaskill 2014). Incorporating grasses like Kentucky bluegrass, orchardgrass and bermudagrass can also help with toxic fescue dilution (Oregon Tall Fescue Commission).

Clover is a popular legume for interseeding pastures. Of total forage available, plan for clover to represent 20 percent to 45 percent. Cattle consuming grass and clover may experience bloat, so producers may need to consider adding products to prevent bloat in their animals (Aiken 2013).

As mentioned previously, The Samuel Roberts Noble Foundation and the University of Arkansas collaborated on a study that evaluated novel-endophyte fescue varieties and traditional Kentucky 31 fescue. Within 18 two-acre paddocks at a University of Arkansas research station, the researchers randomly planted Texoma MaxQII novel-endophyte fescue, Kentucky 31 fescue or MaxQ novel-endophyte fescue. The research team split each paddock. Half received a nitrogen application, and the other half was interseeded with white clover. Nitrogen applications were 60 pounds of 34-0-0 during the fall and February. Exhibit 5.3.2.1 adds the clover data points to the data table reported in the previous section. The data were collected from 2007 to 2011 (Biermacher et al. 2013).

Of the three treatments that used clover, the Texoma MaxQII treatment produced the greatest net return per acre. This treatment also had the superior net return of all six treatments evaluated in the study. For each variety, the research indicates that net return will increase with interseeded white clover. This may be attributed to the clover establishment costs being relatively small and the clover increasing animal weight gain in most cases. This study assumes that clover establishment costs per acre will total just $18. In Kentucky 31 pastures, these data suggest that clover interseeding will improve net return. The research suggests that Kentucky 31 pastures with nitrogen applied would generate -$63 per acre in net returns. By interseeding white clover into the Kentucky 31 pasture, net return increases to $22 per acre, which is an $85 improvement per acre (Biermacher et al. 2013). Interestingly, the study reports 258 pounds per acre in total gain for the Kentucky 31 with interseeded clover but 279 pounds per acre in total gain for the Kentucky 31 with nitrogen applications. At 95 percent confidence, total gain is not statistically different. Because clover can dilute toxic fescue, this relationship may be unexpected. Note, however, that grazing days differ for these two conditions: 137 days for the Kentucky 31 interseeded with clover and 151 days for the Kentucky 31 with nitrogen applications. In pounds per acre, total gain per grazing day totaled 1.88 for Kentucky 31 with interseeded clover relative to 1.85 per day for Kentucky 31 with nitrogen applications. When converted to total gain per day, these relationships may be more expected.

Exhibit 5.3.2.1 – Estimated Costs and Returns for Novel-Endophyte with Clover Relative to Toxic Fescue with Clover Models Per Acre*

	Texoma MaxQII		**Kentucky 31**		**MaxQ**	
	Nitrogen	**Clover**	**Nitrogen**	**Clover**	**Nitrogen**	**Clover**
Grazing days	151a	139bc	151a	137c	146ab	139bc
Total gain (lbs/acre)	538a	457c	279d	258d	499b	438c
Establishment cost						
Seedbed preparation	$38	$38	$38	$38	$38	$38
Fertilizer	$187	$187	$187	$187	$187	$187
Pesticide application	$10	$10	$10	$10	$10	$10
Seed and seed establishment	$90	$90	$50	$50	$90	$90
Fescue establishment	$324	$324	$284	$284	$324	$324
Fescue costs amortized @ 7.5%	$47	$47	$28	$28	$47	$47
Clover establishment costs	--	$18	--	$18	--	$18
Clover cost amortized @ 7.5%	--	$5	--	$5	--	$5
Total annual establishment costs	$47	$53	$28	$33	$47	$53
Annual production costs						
Fertilizer	$118	$35	$118	$35	$118	$35
Mineral	$32	$26	$32	$26	$31	$26
Cattle receiving	$139	$121	$139	$121	$140	$121
Interest on operating capital	$40	$31	$40	$31	$39	$31
Total annual production costs	$328	$214	$328	$214	$328	$214
Total cost	$376a	$267c	$356b	$247d	$375a	$267c
Gross revenue**	$545a	$462c	$293d	$269d	$497b	$443c
Net return	$169a	$195a	($63)d	$22c	$122b	$176a

* Different letters indicate statistical significance at the 95 percent confidence level.
** Computed using $1.21 value of gain per pound for fall grazing and $0.88 value of gain per pound for spring grazing
Source: The Samuel Roberts Noble Foundation (Biermacher et al. 2013)

5.3.3 Clipping Seed Heads

As mentioned earlier, toxic compounds linked to endophyte-infected fescue have the highest concentration in the seed heads (Roberts 2000). Thus, clipping seed heads before being consumed by livestock represents a management strategy to avoid seedhead development. The University of Illinois recommends cutting fescue one or two times annually. The second cutting would address plants with late seedheads. Producers should time the clipping to occur in the plant's boot stage just before the seeds begin to emerge (Faulkner 2005).

Auburn University published data from a 1999 trial that evaluated the effect that clipping pastures would have on animal gain. The study, which ran from March 11 to June 3, maintained six two-acre pastures, and endophyte infection levels exceeded 80 percent in these pastures. Within a pasture, an electric fence was built to create two equal sections, and by rotating cattle between the two sections, this model would result in more seedhead production relative to scenarios that would have had continuous or season-long grazing. Researchers mowed half of the pastures to keep seedhead presence low. Specifically, the study involved clipping the pastures to 8 inches before the animals would graze.

At a stocking rate with 1.5 animals per acre, beef steers grazed the pastures for the trial. Among steers that grazed clipped pastures, they recorded 2.53 pounds in average daily gain. On the other hand, steers from the unclipped pastures had average daily gains that recorded 2.31 pounds. During the whole trial, steers from the clipped pastures gained 212.52 pounds, whereas steers from the unclipped pastures gained 194.04 pounds. As a result, clipping produced a gain advantage per animal that totaled 18.48 pounds and per acre that totaled 27.72 pounds, given the stocking rate of 1.5 animals per acre. At the time, the research summary assumed a $0.70 market price per pound. Thus, the total clipping cost would need to total less than $19.40 per acre for the clipping to create a net return for producers. Note that realizing these gain benefits would require producers to mow their pastures at least twice (Bransby et al. 1999).

5.3.4 Herbicide Treatment

Some research data link herbicide treatments applied to fescue pastures with inhibiting the grass from forming seedheads. Because toxic alkaloids are highest in the seedheads, preventing their development can offer fescue toxicosis management benefits for beef producers. As an example, University of Kentucky and USDA Agricultural Research Service researchers have studied applying Chaparral herbicide to fescue. Available from Dow AgroSciences, Chaparral combines aminopyralid and metsulfuron active ingredients. When combined, these ingredients can stifle most fescue plants from developing seed heads. By limiting seed head development, fescue plants continue producing vegetation with better quality (Bussard 2014).

The researchers recommend applying the herbicide treatment as temperatures begin to rise and fescue appears that it will begin reproducing soon. This time will occur before fescue has entered the boot phase. For at least a couple of weeks, the herbicide-treated grass may turn yellow. Because the sprayed pasture will likely have reduced biomass and greater forage utilization, producers may need to adjust stocking rates (Bussard 2014).

Clethodim is another herbicide with fescue toxicosis management benefits. As a post-emergent herbicide, clethodim stunts grasses from maturing, and by limiting seedhead development, it can reduce ergovaline levels. A dissertation paper from the University of Missouri sought to measure the extent to which herbicide treatment could control toxicity. To measure clethodim's effect on toxic fescue, researchers applied 189 mil ha^{-1} of the "Select" herbicide brand, and they combined the herbicide with 2.5 L of crop oil ha^{-1}. Applications were made during November preceding the two test years. The research involved applying the clethodim treatment to half of 20 plots developed for the study, which was conducted near Mt. Vernon, Mo. The stands had 90 percent endophyte infection levels. After harvesting the grass by hand, the samples were processed and evaluated for their ergovaline and ergot alkaloid levels. The study illustrated that ergovaline levels decreased because of the clethodim application. See Exhibit 5.3.4.1. Weather caused some year-to-year differences in ergovaline levels. Total ergot alkaloid levels also varied in treated and untreated plots. The differences totaled 132 ug kg^{-1} DM in 2005 and 207 ug kg^{-1} DM in 2006. In both cases, the untreated areas had higher levels (Rogers 2010).

Exhibit 5.3.4.1 – Average Daily Gain in Clethodim Herbicide Treatment Experiment

	Ergovaline Concentration (ug kg^{-1} DM)
2005	
Non-treated	492
Treated	300
2006	
Non-treated	941
Treated	257

Source: Rogers (2010)

5.3.5 Grazing Strategy

By rotating cattle according to season, beef producers may better manage the effects toxic fescue can have on their herds. For example, they may choose to exclude toxic fescue pastures as grazing areas during the summer when cattle can exhibit the "summer slump" associated with toxic fescue consumption (Roberts 2000). For good performance, exclude infected fescue pastures from grazing by May. At that time, fescue toxicity begins to be a problem (Herrold 2012). Cattle may move to pastures with warm-season grasses (Arnold and Gaskill 2014).

Rather than only temporarily removing cattle from the infected tall fescue, the animals might be restricted from such pastures all summer. Toxic fescue pastures present a problem during the summer for a couple of reasons: 1) fescue doesn't grow as well given summer conditions and 2) infected fescue can seemingly become more toxic when temperatures rise (Roberts 2000). When summer weather subsides, infected fescue pastures have potential for fall grazing (Herrold 2012).

Close grazing could also control fescue toxicity issues. By closely grazing pastures, producers may minimize seed development and, thus, thwart fescue toxicity problems (Roberts 2000). Intensive grazing also presents benefits other than those specific to avoiding seed production. By intensively grazing toxic fescue, the plant dedicates more carbohydrate resources to plant growth, meaning that the plant has fewer carbohydrates to produce toxic alkaloids (Arnold and Gaskill 2014).

5.3.6 Diet Supplementation

Supplementing cattle diets with other feedstocks essentially makes the toxic fescue a less significant share of total feed intake (Herrold 2012). The additional feed will both increase dry matter consumption and enhance diet quality (Aiken 2013). The supplement shouldn't inhibit forage fiber digestion, however. Producers can consider corn as a possible diet supplement (Roberts 2000). Soybean hulls and corn gluten are also possible supplements (Herrold 2012). Dried or wet distillers grains are other options. Because animals would need to consume 0.75 percent to 1 percent of their bodyweight in supplements, co-product feeds may be more cost-effective (Aiken 2013).

Cattle grazing toxic fescue pastures may consume less total forage. As a result, producers must ensure that their animals are consuming enough minerals and trace elements. Offering a complete mineral mix may ensure that cattle diets have the proper nutrition (Arnold and Gaskill 2014).

5.3.7 Ammoniate Hay

Ammoniating hay involves applying an ammonia treatment to hay. After the ammonia treatment, toxic endophytes may have a diminished effect (Roberts 2000). To treat the hay, the process involves applying 60 pounds of anhydrous ammonia at most per ton to low-quality fescue hay, and it requires a three-week time window. Relative to pasture, the ammoniated forage has an estimated five times less toxicity. On average, producers could expect the ammoniation treatment to add $12 in expense per round bale of hay. Note that high-quality hay shouldn't undergo ammoniation treatment. Exposing high-quality hay to the ammonia can make the hay toxic. Cows consuming it could develop crazy cow syndrome (Roberts and Kallenbach 2009).

In addition to managing fescue toxicity, ammoniation yields other benefits. For example, to ammoniate hay, the hay needs a covering, which creates a better storage environment for hay. The ammoniation itself can improve digestibility as it facilitates cell wall breakdown (Roberts 2000).

5.3.8 Genetic Testing of Cattle

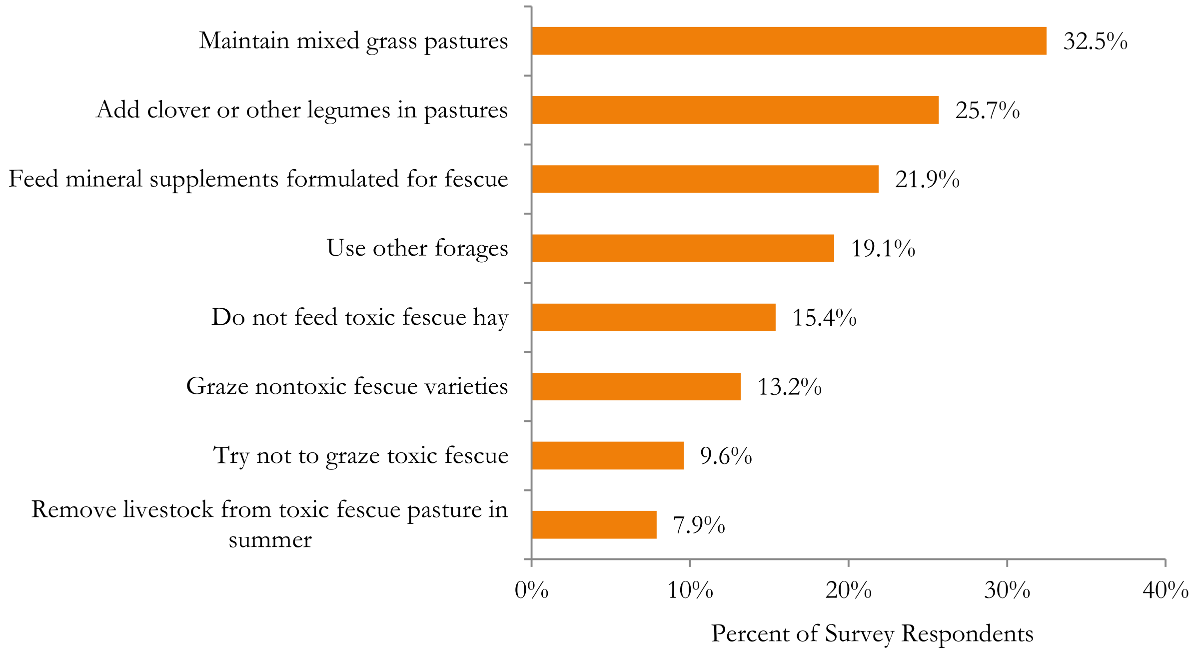
New genetic testing enables producers to gauge the predisposition of cattle to tolerate toxic fescue. AgBotanica developed the T-Snip™ test, which categorizes cattle based on their susceptibility or tolerance to toxic fescue. To conduct the test, producers submit a hair sample taken from the tail switch for each animal being tested. Hair follicles, or roots, attached to a sampling card provide DNA for the lab to analyze. At least 25 hairs per animal are necessary for a sample. AgBotanica charges $30 per test, which includes the sample card. After receiving the sample card and submission form, the lab runs the DNA analysis, and producers generally receive results within four weeks (AgBotanica 2015).

Cattle categorized as tolerant to fescue toxicosis won't completely resist the condition, but they do perform better on average than susceptible cattle. According to data from two experiments, intake and gain were 8 percent and 41 percent higher, respectively, for tolerant yearling heifers. Research that evaluated 205-day adjusted weaning weights for steers and heifers found that calves from tolerant cows were 55 pounds heavier than calves from susceptible cows (496 pounds at weaning vs. 441 pounds at weaning) (AgBotanica 2015).

5.4 Mitigation Strategy Adoption

Despite several fescue toxicosis management strategies being available to producers, producers have had limited experience with some of those options. During spring 2011, the University of Arkansas surveyed livestock producers. The researchers recruited respondents by using mail surveys, online surveys and survey responses collected at producer meetings. The survey reached 456 producers. Exhibit 5.4.1 summarizes results to one question that asked the respondents to indicate all actions that they had tried to address fescue toxicity. Nearly one-third of the survey respondents said that they had tried mixed grass pastures on their farms. The other two most popular actions taken were adding clover or other legumes to pastures and feeding specific mineral formulations to address the fescue toxicity. Note that respondents could check as many actions as they had tried. In the order of their extent of adoption, other strategies tried by the respondents included using other forages, avoiding feeding toxic fescue hay, grazing nontoxic fescue, attempting to avoid toxic fescue grazing and removing livestock from toxin-infected fescue during the summer (Jennings et al. 2011).

Exhibit 5.4.1 – Actions Tried to Reduce Fescue Toxicity



Source: University of Arkansas (Jennings et al. 2012)

5.5 Toxic Fescue Economics

The above sections show that producers have many options available to reduce or eliminate fescue toxicosis in their operations. Despite the long-proven economic losses that result from toxic fescue consumption, cattle producers generally have been slow to adopt many of the newer management strategies. Cattle producers can establish new pastures or interseed current toxic fescue pastures to reduce the effects. In addition, new strategies provide even more information for producers to make decisions about using toxic fescue in the diet. As an example, producers may try using genetic tests for individual animals to measure their sensitivity to toxic fescue. For any toxic fescue management strategy, cattle producers must evaluate the cost to use the mitigation strategy relative to the expected benefit.

No specific rules exist about toxic fescue effects, but it is generally accepted that for each 10 percent increase in endophyte infection, calving rates decline by 5 percent. Stocker cattle gains drop by 0.1 pounds per day for each 10 percent increase in endophyte infection (Roberts and Andrae 2010).

5.5.1 Novel-Endophyte Fescue Pasture Establishment Budget

Any pasture renovation or establishment strategies to remove or reduce toxic fescue has a payoff over several years. The payoff takes form as increased reproductive rates and rates of gain that must be economically evaluated relative to the renovation or establishment cost.

Seed costs can be much higher for novel-endophyte fescue varieties than for E+ fescue varieties. In some cases, seed for novel-endophyte varieties can cost more than twice, and as much as four times, seed for E+ varieties. However, cattle producers must look at total establishment costs when choosing a fescue management plan. Using a novel-endophyte seed variety will increase total establishment costs by about $50 per acre, assuming 20 pounds of seed per acre. This will increase total establishment costs by about 25 percent given that other establishment costs do not vary based on seed selection. On a percentage basis, the increase in total establishment costs is much less than the more than twice the cost of seed (Burdine 2007).

The question is whether the additional revenue makes this an economically relevant decision for cattle producers. A 10 percent increase in conception rates on a herd that weans 500-pound calves results in 50 pounds in additional weaned calves per cow with no increase in weaning weights. If calf prices are $1.75 a pound, then the 50 pounds generate an additional $87.50 per cow per year. If we assume two acres per cow, then the conception rate improvement adds nearly $44 per acre in revenue. Many producers may decide a $50 investment per acre that lasts more than 10 years is a good investment in return for receiving an additional $44 per acre each year. All the assumptions made in this example are critical. If an operation allocates four acres of pasture per cow, for example, then revenue realized per acre would be halved. If today's higher cattle prices retreat to levels seen several years ago, then the revenue improvement would also decline substantially.

5.5.2 Other Fescue Toxicosis Management Strategies

The other fescue mitigation strategies discussed in this chapter must be evaluated in a similar fashion to the pasture establishment scenario in section 5.5.1. Each mitigation strategy requires that cattle producers spend additional money to reduce fescue toxicosis in their herds. They must determine the current level of toxic fescue exposure in their own operations before deciding whether they could realize a positive return for investing in a toxic fescue mitigation strategy.

The cost of the genetic fescue test can be easily applied to the case of purchasing or raising replacement heifers. If a producer can use the $30 test to purchase or raise heifers more tolerant to fescue the return would be similar to the $87.50 per cow return shown from the novel-endophyte pasture renovation strategy above. The economic benefit of more pounds weaned per cow in the herd will need to be weighed relative to the number of heifers tested relative to cull decisions heifer decision made based upon the test.

No single answer exists for dealing with toxic fescue. An individual operation faces unique circumstances, which can often dictate the best management strategy for addressing toxic fescue.

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