Finishing time and weights of grass-fed beef animals NCR-SARE Project #FNC12-860 Final Report, April 2015

Acknowledgements

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Abstract

Environmental impact of grass-fed beef was greater than feedlot-finished beef in a 2010 life cycle analysis (LCA) of beef production systems. [1] The LCA assumed 1100 lbs. live weight and 22 months of age at slaughter for grass-fed beef; compared to 1400 lbs. and 17 months for feedlot beef. The grass-fed beef figures came from data sets that may have included heritage cattle breeds and/or use of poor-quality forage. This project tracked grass-fed beef steers with modern British genetics, born in 2011 and 2012 on four Minnesota farms. Calculation of an age-weight index allowed comparison between steers in this study and the model grass-fed and feedlot steers from the LCA study. One farm using dairy infrastructure and feeding high-quality forage had many steers that approached and one that exceeded the performance of feedlot steers, indicating potential for an all-forage system to produce beef efficiently while gaining the environmental benefits of perennial forage. One farm with both a modern British breed herd and a heritage breed herd under the same management showed a marked difference in age-weight index between the two herds, confirming the possibility of confounding effects of cattle breed in studies of grass-fed systems.

Introduction

This project began in response to a 2010 paper by Nathan Pelletier, et al.[1] I received a copy of that paper from an acquaintance, read it carefully and checked some of the authors' assumptions for grass-fed beef production against my own experience, and realized that I was finishing grass-fed beef cattle to similar or higher weights in less time. The life-cycle analysis presented in the paper showed a higher environmental impact from grass-fed beef than from feedlot beef. In a later conversation about the grass-fed beef assumptions with one of the authors, Rich Pirog, he suggested that inputting shorter finish times for grass-fed beef could have rendered a different outcome in the life cycle analysis, and laid down a challenge to collect the necessary data to support a shorter finish time. This project grew out of that challenge.

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[1] Nathan Pelletier, Rich Pirog, and Rebecca Rasmussen. 2010. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. Agricultural Systems. 103(6):380-389. http://www.sciencedirect.com/science/article/pii/S0308521X10000399

This project tracked the time to finish and finishing weights for beef steers on four farms in Minnesota. Steers only were used because the best heifers would likely be kept as breeders by the farms. This would have created two problems: 1) result in a lot of data collection and payments for data points that would later have to be dropped from the study when heifers were retained; and 2) skew final data toward poorer performance of non-breeding heifers. A consequence of the decision to use only steers in the study, though, is that the economic analyses are skewed toward the higher performance of steers relative to heifers.

All bull calves born in 2011 and 2012 on these farms were enrolled in the project, except for two that were selected by the farmers to keep as breeding bulls. There was some attrition of steers during the course of the project for various reasons: death of one steer, death of a cow early in the calf's life and sale of the calf, early sale of two calves that were performing poorly. These types of losses would need to be figured in to any economic or environmental-impact analysis, but in this project the herd sizes were small and the loss events were not necessarily representative of the long-term average losses for these farms. The lost animals were simply dropped from the project.

Table 1. Description of the four farms in the "Finishing time and weights of grass-fed beef animals" NCR-SARE Project #FNC12-860.	
Grass Meadows Farm **Pine City, MN** Jake and Lindsay Grass have a joint operation with relatives located farther north in Iron, MN. Calves are born at the Iron location, a 210-acre farm. Beef steers are intensively rotationally grazed for their finishing on 70 acres at the Pine City location. Pastures include cool-season grass and legume species: red and white clover, alfalfa, birdsfoot trefoil, tall fescue, orchardgrass, timothy. Two paddocks are in warm-season annuals; sorghum-sudangrass or grazing corn. Winter feed is produced on about 120 acres of rented land. Winter feed protocol includes three separate streams of feed types offered to cattle. Finished beef cattle are sold to Thousand Hills Cattle Company.	**Bill McMillin** **Plainview, MN** During the course of this project Bill had a cow/calf herd of 30 and grass-fed beef finishing operation. All cattle are rotationally grazed in summer on 40 acres of cool-season grasses and legumes. Bill uses his former dairy infrastructure to produce alfalfa hay and haylage for his winter feed on about 35 acres. Cows get a combination hay and haylage ration with lower-quality hay, and steers get a similar ration with higher-quality hay. Finished beef animals are sold to Hidden Stream Farm, a regional distributor of grass-fed beef, pastured pork and chicken and organic produce.
Jane Jewett **Palisade, MN** Jane has a cow/calf herd of 12 and finishes animals on 71 acres of rotationally grazed pastures. Pastures include birdsfoot trefoil, quackgrass, timothy, red and alsike clovers, orchardgrass, tall fescue, reed canarygrass, and Canadian bluejoint. Hay is purchased from her brother, who uses about 50 acres of rented land to produce it. Cows have continual access to bales in bale rings in the winter. Nearly all of her beef is direct-marketed through the Grand Rapids Farmers' Market or by sales of quarters and halves.	**Edgar Brown** **Willow River, MN** Edgar has a cow/calf herd of 19 and finishes animals on 60 acres of rotationally grazed pastures. Pastures are cool-season grasses, alfalfa and clover. He makes hay on about 100 acres rented from neighboring farms. Cows have free access to bales without bale rings in winter, and sort for their preferred fraction of the hay. Some of Edgar's beef is direct-marketed locally, and the remaining animals are sold to Thousand Hills Cattle Company.

Comparison figures from Pelletier et al.

This report uses figures from the Pelletier et al. paper as a comparison for the performance of the farms involved in this project. The Pelletier et al. paper uses the following figures for beef cattle finishing times and weights in three different finishing systems:

Table 2. Figures used in the Pelletier et al. life cycle analysis for beef cattle finishing times and weights in three different finishing systems.ł

	Beef cattle finishing systems		
	Weaned to feedlot, hormone implants	**Weaned to backgrounding on wheat pasture, followed by feedlot; hormone implants at feedlot**	**Weaned to pasture, finished on pasture & hay; no hormone implants**
Age at weaning (months) ǂ	7	7	7
Time to finish after weaning (months)ᛃ	9.9	14.8	14.8
Finished weight (rounded)	1400 lbs.	1400 lbs.	1110 lbs.

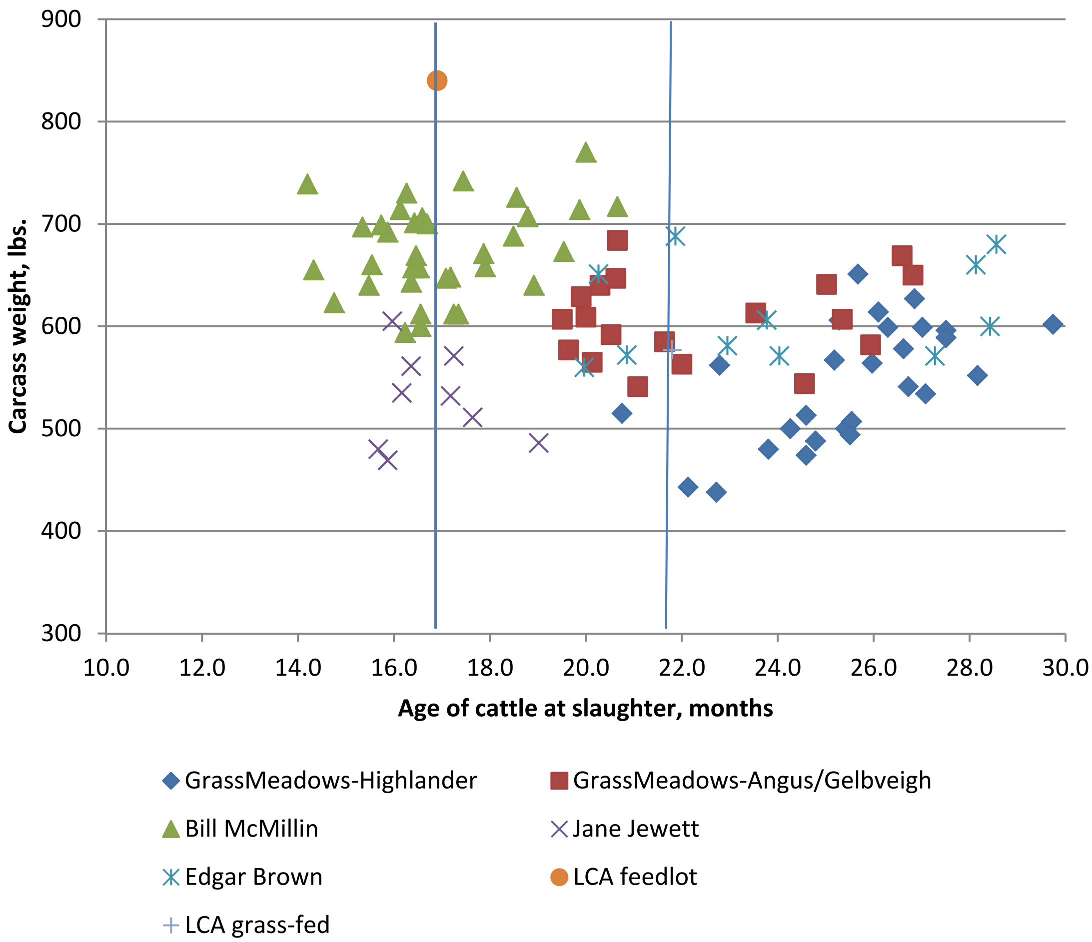
ł Nathan Pelletier, Rich Pirog, and Rebecca Rasmussen. 2010. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. Agricultural Systems. 103(6):380-389. http://www.sciencedirect.com/science/article/pii/S0308521X10000399

ǂ The Pelletier et al. study did not specify months of age at weaning, but all three systems assumed spring-born calves weaned in November. Seven months of age is a typical weaning age for calves in the Upper Midwest.

ᛃ The Pelletier et al. study reported the time to finish as days. Days were converted to months with this formula: days/30.5 = months.

Finished carcass weights and times to finish

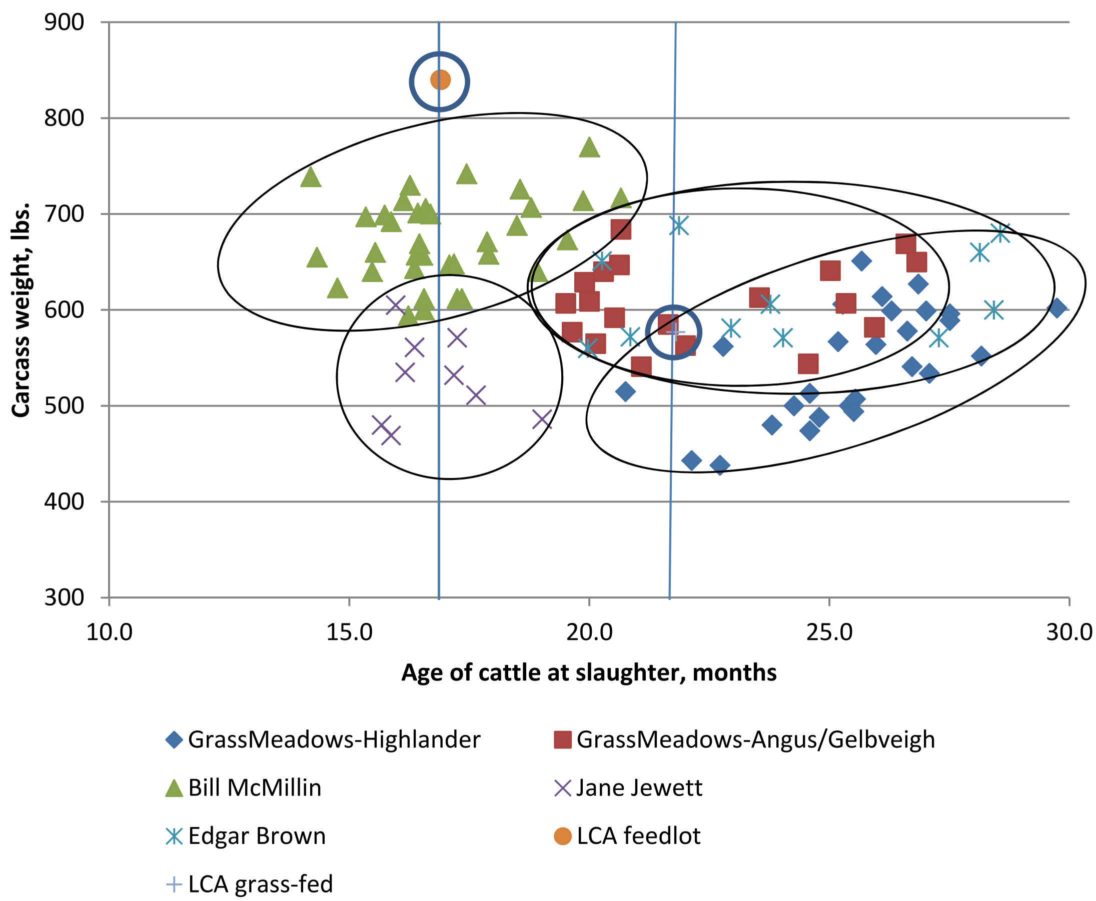
Figure 1. Age of animal vs. carcass weight, for four MN farms with comparison to Pelletier, et al. (2010) life cycle analysis (LCA) figures for feedlot-finished beef and grass-fed beef.



The chart above shows performance of all of the grass-fed beef steers on the four farms included in this project. It also shows data points for the figures used in the Pelletier, N. et al. life cycle analysis (LCA) for beef weaned directly to a feedlot and for grass-fed beef.

There are five clusters of points on the chart (Figure 2), representing the McMillin, Jewett, and Brown farms; and within the Grass Meadows farm, the Angus/Gelbveih stock and the Scottish Highlander stock. Vertical lines for age of animals in the life cycle analysis show that many of the grass-fed beef animals on the four farms were finishing earlier than the LCA figure of 21.8 months for grass-fed beef. Some of the grass-fed animals were finishing earlier than the LCA figure of 16.9 months for feedlot beef.

Figure 2. Age of animal vs. carcass weight, for four MN farms with comparison to Pelletier, et al. (2010) life cycle analysis (LCA) figures for feedlot-finished beef and grass-fed beef: five clusters of animals



Age-Weight Index for Beef Cattle Performance

An Age-Weight index is another way to look at the data and make comparisons of performance of the farms with each other and with a standard, in terms of how fast and how heavy a beef steer could be produced for slaughter. This index figure incorporates both the age of the animal and the weight of the carcass, and allows plotting of that number against some other factor. Table 4 shows per-farm average steer age and steer weight figures used to calculate the age-weight index, as well as the carcass weights and carcass yield percentages from each farm. The age-weight index was not used in the Pelletier et al. paper, so Table 3 shows the calculation of it from the carcass weight figures used in that paper and from estimates of carcass yield for feedlot and grass-fed beef.

Table 3. Averages for age at time of slaughter, live weight, carcass weight, and carcass yield percentage for the four farms.

Farm	Age (months)	Live weight (lbs.)	Carcass weight (lbs.)	Carcass yield %
Grass Meadows – Highlander	25.5	1080	546	51
Grass meadows – Angus/Gelbveih	22.3	1198	608	51
McMillin	17.0	1204	675	56
Jewett	16.8	1038	528	51
Brown	24.1	1135	617	54

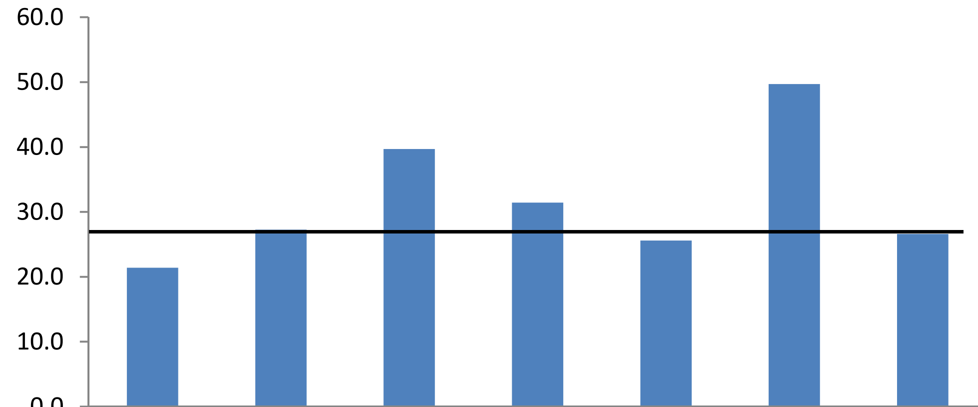
Table 4. Estimate of Age-Weight index of the feedlot beef and grass-fed beef in the Pelletier, et al. study.

	Feedlot beef	Grass-fed beef
Age at slaughter (months)	16.9	21.8
Carcass weight (estimate)ł	840 lbs.	577 lbs.
Age-weight index	49.7	26.5

Ł Assuming a carcass yield of 60% for feedlot beef and 52% for grass-fed beef. Carcass yield estimate for grass-fed beef was taken from the low end of the range of yield percentages seen in this study. Carcass yield estimate for feedlot beef was obtained from: Dressing Percentage of Slaughter Cattle. 2006. Agriculture, Food and Rural Development, Government of Alberta, Canada. http://www.thebeefsite.com/articles/759/dressing-percentage-of-slaughter-cattle/

Figure 3, below, puts the data from Tables 3 and 4 together and shows average age-weight index figures for each farm, and for the two different breed groups on the Grass Meadows farm, in comparison to the LCA feedlot and grass-fed beef figures.

Figure 3. Average Age-Weight Index for four farms, compared to standard figures for feedlot and grass-fed beef.ƚ



	Grass Meadows - Highlander	Grass Meadows - Angus/Gelbveih	McMillin	Jewett	Brown	LCA-Feedlot	LCA-Grass-fed
Age-Weight Index	21.4	27.3	39.7	31.4	25.6	49.7	26.6

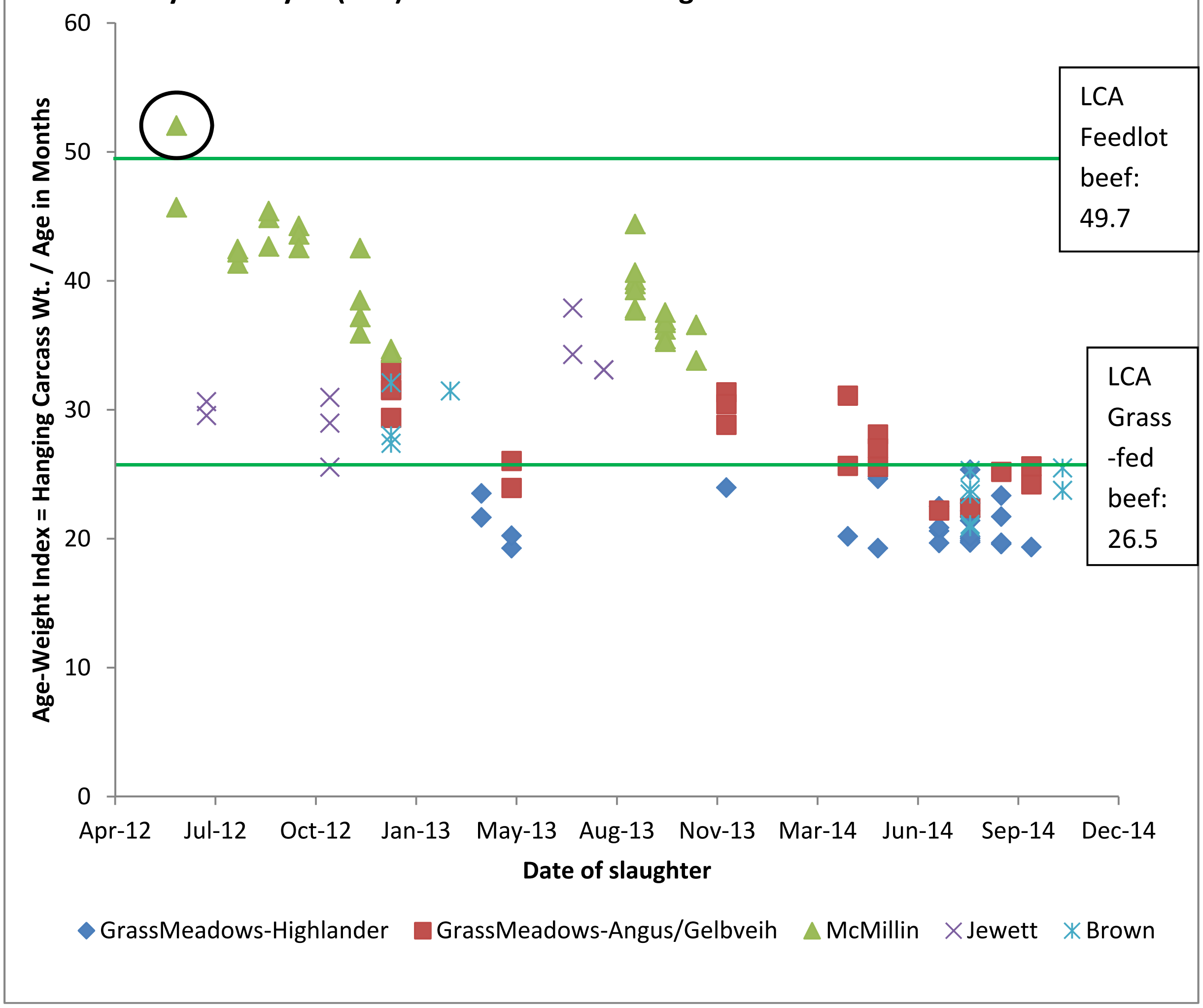
ƚ LCA-Feedlot and LCA-Grass-fed figures come from Pelletier et al., 2010.

The Grass Meadows Angus-Gelbveih group, the McMillin farm, and the Jewett farm all exceeded the LCA grass-fed beef age-weight index. The Brown farm's age-weight index was slightly below the LCA figure, due to older average age of animals at slaughter from the Brown farm.

The difference between Scottish Highlander cattle and other cattle in this study highlights the issue of confounding of grass-fed beef production systems with beef breed. The Scottish Highlander group of cattle had an average age-weight index well below that of the LCA. This is to be expected of the Scottish-Highlander breed, which typically takes 30 months to finish on grass and hay and returns a lighter carcass than mainline British breeds. Calculations of the potential for grass-fed beef productivity that are based on results from Scottish Highlander, "old" Angus, lowline Angus, and other heritage or small-stature breeds are not representative of the potential from modern Angus, Hereford, and other British breeds that have undergone selection for faster growth.

The average age-weight index per farm doesn't tell the whole story. There was a considerable variation from steer to steer within farms. The chart below (Figure 4) shows that one of Bill McMillin's grass-fed animals exceeded the performance of the feedlot beef when viewed as an age-weight index. That particular animal produced a 739-lb. carcass at 14.3 months of age.

Figure 4. Age-Weight Index of grass-fed steers from four Minnesota farms, compared to figures calculated from Pelletier, et al. (2010) life cycle analysis (LCA) for feedlot beef and grass-fed beef.



All of Bill McMillin's steers, most of Jane Jewett's, about half of Edgar Brown's, and about half (10 of 19) of Grass Meadows's Angus-Gelbveih steers exceeded the assumed standard for grass-fed beef when viewed as an age-weight index (Figure 4). None of Grass Meadows Farm's Scottish-Highlander cattle exceeded the assumed standard for grass-fed beef.

The results show that all four of the farms in this project had beef animals that exceeded the performance standard for grass-fed beef used in the Pelletier et al. paper. The poor showing of grass-fed beef in terms of environmental impact in that life-cycle analysis may be too pessimistic of the potential for grass-fed beef. Based on the spread of animal performance seen within and among these four farms, there is clearly potential here for grass-fed beef production efficiency to improve. The results of this project suggest that the right combination of genetics, feed quality, and management system can generate grass-fed beef carcass weights and finishing times that are at least more competitive with feedlot beef than is usually acknowledged. More systems work is needed to help grass-fed beef producers optimize their systems.

Average Daily Gains

It is common practice in grass-fed livestock production to weigh animals on a regular basis to track average daily gain (ADG). See, for example, Thousand Hills Cattle Company's 100% Grass-Fed Beef Program Recommendations:
www.thousandhillscattleco.com/files/100GrassFedBeefProgram.pdf.

Average daily gain figures from this project are not directly comparable to the Thousand Hills protocol because weights were taken less frequently. For the 2011 calf crop, weights were collected prior to turning weaned calves out on pasture and at slaughter. For the 2012 calf crop, weights were collected at weaning, prior to turning weaned calves out on pasture, and at slaughter. Birth weights were not part of the study, so birth weights were estimated in order to calculate ADG for the birth-to-weaning timeframe.

One thing to note on Table 5 is the length of the birth-to-weaning period. The average length of time that calves spent with their mothers, across the four farms, was 8.3 months. Calves were weaned at 8.9 months on the McMillin farm, 6.7 months for Grass Meadows Angus-Gelbveih, 8.5 months for Grass Meadows Highlander, and 9.1 months on the Jewett farm (Brown farm data not available). Most of these are longer than the typical 7 months to weaning in the beef industry. Keeping calves with cows for longer than 7 months is common in grass-fed beef production.

Table 5. Average Daily Gain (ADG) and average days for birth-to-weaning, weaning-to-pasture turnout, and pasture turnout-to-slaughter time periods for steers on four farms, and two breed types on the Grass Meadows farm.

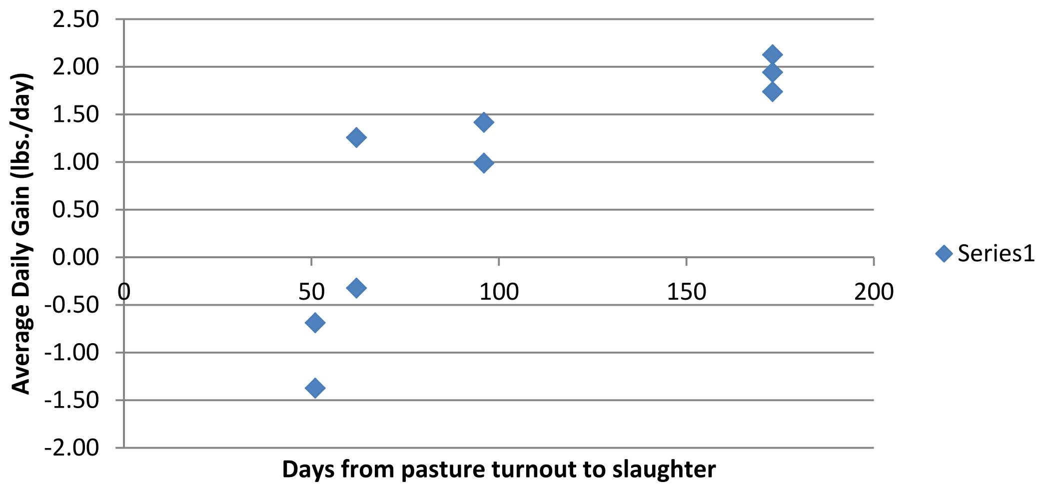
	Birth to WeaningŁ		Weaning to Pasture Turnout		Pasture Turnout to Slaughter§	
Farm & Calf Year	**Days**	**ADG**	**Days**	**ADG**	**Days**	**ADG**
Brown						
2011	na	na	na	na	245	1.83
2012	na	na	na	na	na	na
McMillin						
2011	na	na	na	na	158	1.59
2012	272	2.74	91	1.48	153	1.37
Grass – Angus/Gelbveigh						
2011	na	na	na	na	291	1.75
2012	203	1.92	137	1.62	370	1.39
Grass – Highland						
2011	na	na	na	na	338	1.42
2012	260	1.50	68	0.76	446	1.28
Jewett						
2011	na	na	na	na	129	1.35
2012	278	2.56	147	1.73	74	0.09

Ł Birth weights were not available. Estimates were used to calculate ADG for birth to weaning in 2012: 80 lbs. for the McMillin and Jewett farms, 75 lbs. for Angus/Gelbveigh on the Grass farm, and 65 lbs. for Scottish Highlander cattle on the Grass farm.

§ This time-frame is from pasture turn-out in the first spring post-weaning. Some animals also spent a second summer on pasture, post-weaning.

Average daily gains for all but the Grass Meadows Highlander cattle were generally within range of the Thousand Hills Cattle Company protocol, except for the Jewett farm's pasture turnout-to-slaughter figure in 2012. A closer look at the reasons for that low ADG of 0.09 revealed that all of the Jewett steers in 2012 were sent to slaughter in July and August. A regression analysis revealed an 82% correlation between length of time on pasture and ADG for the Jewett cattle. Figure 5 shows the pattern of this correlation. Animals on pasture for a relatively short time prior to slaughter (less than 65 days) sometimes had negative ADG.

Figure 5. Average Daily Gain (ADG) vs. number of days on pasture; Jewett farm data for steers born in 2011 and 2012.



The reasons for this observation on the Jewett farm are not clear. There was no similar pattern at either the McMillin or the Grass farm (Figures 6 and 7):

Figure 6. Average Daily Gain (ADG) vs. days on pasture prior to slaughter, McMillin Farm

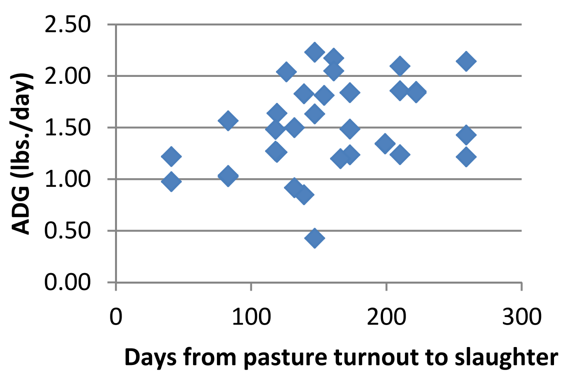
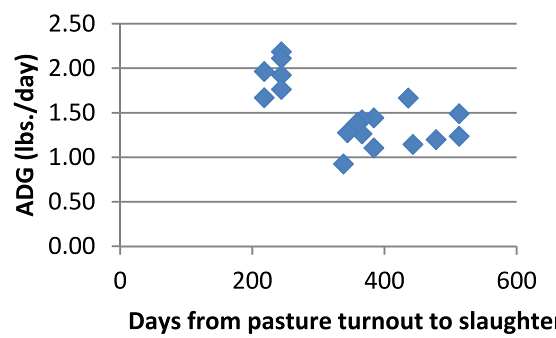


Figure 7. Average Daily Gain (ADG) vs. days on pasture prior to slaughter, Grass Meadows Angus/Gelbveih



There was a slight positive correlation of 35% between ADG and number of days from pasture turnout to slaughter on the McMillin farm. Generally, cattle that took longer to finish on the McMillin farm had a slightly higher rate of gain; but you don't see that dramatic shift at around 60 days from negative to positive ADG. For the Grass Meadows

Angus/Gelbveih cattle, the correlation between ADG and days was -66%, which means the cattle taking longest to finish had the lowest ADG. Two clusters can be clearly seen on the Figure 7 chart: earlier-finishing cattle with a higher rate of gain and longer-finishing cattle with a lower rate of gain.

So what's going on with the Jewett cattle? There isn't enough data from this study to be able to do more than speculate. The quality of the winter feed and the shift from winter feed to spring pasture may have had something to do with it. On the McMillin farm, winter feed was high quality: an average of 138 RFV (see Table 6). The winter feed was considerably lower quality on the Jewett farm, with an average RFV of 108. It could be that the shift from lower-quality winter feed to spring pasture required an adjustment period that the Jewett farm's steers then didn't have time to recover from before they were marketed in July and August. The summer beef sales were due to customer demand, but the Jewett farm has now ended the practice of summer beef sales based on these results.

This possibility of an adjustment period between winter feed and spring pasture is something that is deserving of more study, to try to find out the reasons why it might happen and ways to mitigate it.

Weather impacts on cattle

This project took place during some challenging years in terms of weather. In northeastern Minnesota, the spring of 2012 was a flood year. The city of Duluth, MN experienced severe flooding in mid-June of 2012. The Jewett, Brown, and Grass farms were affected to varying degrees by that same event. Flooding early in summer of 2012 was followed by three weeks of extreme heat in July, then drought in the late summer and fall. The McMillin farm also experienced the drought of 2012, and then severe winter-kill of alfalfa over the winter of 2012-2013. The spring of 2013 featured late, heavy snowfalls; very wet, cool conditions; and late onset of pasture.

These weather extremes took their toll on the cattle. Jane Jewett's steers marketed in 2012 averaged 72 lbs. lighter in carcass weight than the steers marketed in 2013; almost certainly due to the combination of flooding, tremendous growth of relatively low-quality forage, and heat that summer – you could almost watch the pounds melt off of the cattle. For the other farms, Figure 4 hints at a lingering effect of weather on the 2012-born calves. The age-weight index generally appears lower for 2012-born steers marketed in 2013 and later, than it does for 2011-born calves marketed in 2012. Edgar Brown stated that he had never seen such slow-growing cattle as his 2012-born steers.

No adjustments were made to the data on the basis of these weather issues. Weather extremes are predicted to become more common in the future, and the grass-fed beef systems have to be able to handle those extremes in order to be viable.

Economic Analysis

Economics of the four farms are analyzed separately since their winter feeding systems and land bases are all different. This economic analysis calculates costs of feeding a steer from birth to finish; thus the feeding cost for one year for a cow-calf pair is included in the total cost of producing the finished steer.

Winter feed costs

Winter feed costs are based on the relative feed value (RFV) in the stored forage sampled by each farm in winter of 2013.

A price formula for hay based on RFV was calculated from price data obtained from the Nov. 6 and Nov. 20, 2014 reports of the Mid-American Hay Auction in Sauk Centre, MN. Relative feed value and price had a linear relationship with a 75% correlation between RFV and price (Figure 8).

Hay price formula:

Price = (1.18*RFV) – 3.66

This price formula was used to bring some standardization to the analyses of the four farms. Calculated prices per ton of feed are shown in Table 6. These prices do not represent the actual costs incurred for winter feed by the farms. Each farm has its own methods of cost-cutting on winter feed: making hay on neighboring land for little or no rent; trading services for a portion of the hay cost; timing hay production for higher quality at the same production cost; etc.

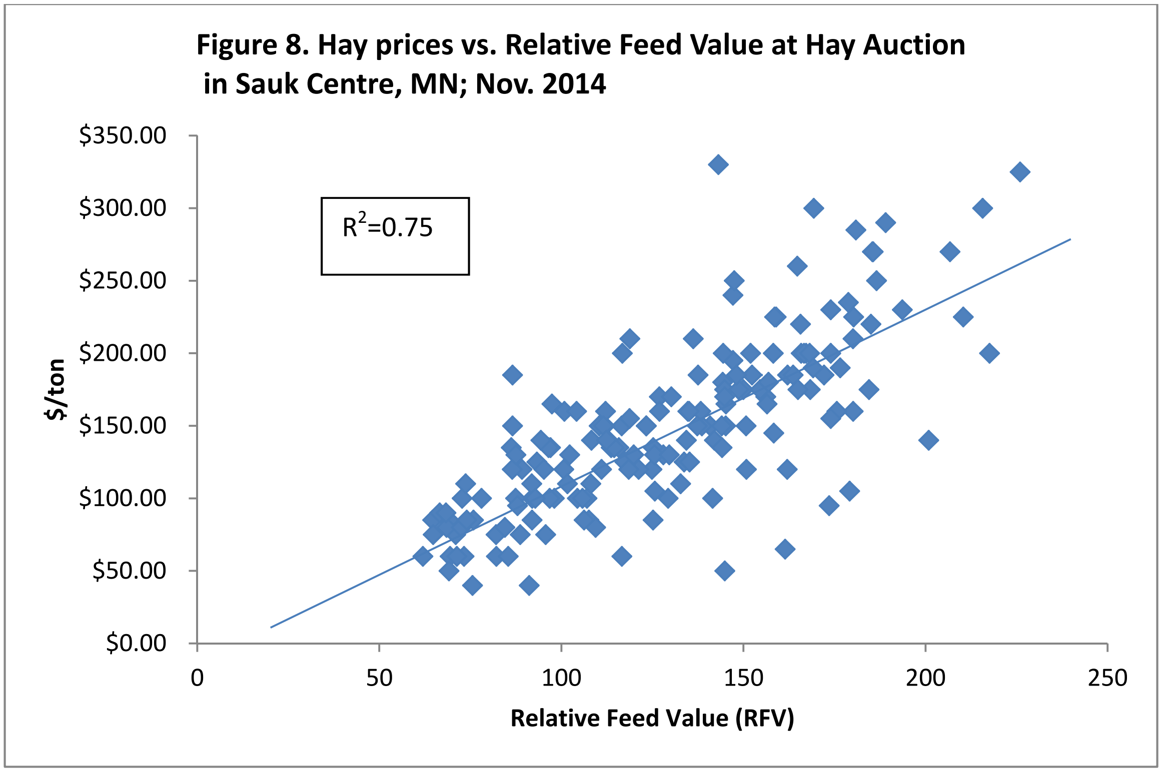


Figure 8. Hay prices vs. Relative Feed Value at Hay Auction
in Sauk Centre, MN; Nov. 2014
R^2=0.75
$/ton
$350.00
$300.00
$250.00
$200.00
$150.00
$100.00
$50.00
$0.00
0
50
100
150
200
250
Relative Feed Value (RFV)

Table 6. Average forage quality and calculated price per ton based on relative feed value (RFV) for the four farms: $/ton = (RFV*1.18)-3.66			
Farm	**Type of forage**	**RFVƗ**	**Price/ton‡**
Grass Meadows			
	AVERAGE	105	$ 120.24
McMillin	Alfalfa hay	162	$ 187.50
	Other hay	133	$ 153.28
	Haylage	120	$ 137.94
	AVERAGE	138	$ 159.18
Jewett	Mixed grass hay	108	$ 123.78
Brown	Mixed grass hay	90	$ 102.54

Ł Results from sampling of stored forage done in March and April 2013

‡ Calculated from Hay Auction reports at Sauk Centre, MN on Nov. 6 and Nov. 20, 2014. http://www.midamericanauctioninc.com/hay-sale-results

Days on hay (or other stored feed)

- Assumed to be one entire winter feeding season for the cow in the cow/calf phase of steer production

- For steers, days on feed were obtained from averages of the farm's reported birth dates and slaughter dates for steers in the study and the farm's winter feeding season, thus:

    - If slaughtered after Oct. 15 but before Jan. 1 of 2nd winter on hay:

      Days on hay = Days of winter feeding season for first winter + (Julian slaughter date – Julian date for onset of winter feeding)

    - If slaughtered after Jan. 1 of 2nd winter on hay but before spring pasture season:

Days on hay = Days of winter feeding season for first winter + (365 – Julian date for onset of winter feeding) + Julian slaughter date

- If fall-born calves, their first winter while suckling their dam did not count toward their days on hay; it was assumed included in the cow's winter hay consumption.

Table 7. Averages by farm for length of winter feeding season and total days on hay for finished steers		
Farm	**Days of winter feeding season**	**Total days on hay for steers**
Grass Meadows	204	381
McMillin	204	227
Jewett	202	206
Brown	221	348

Cost of land

The opportunity cost of having cropland in pasture or hay instead of renting it out for crop production; or of using pasture for one's own cattle instead of renting it out:

Table 8. 2014 cropland and pasture cash rents for Minnesota counties where the four farms are located.			
Farm	**County**	**Cropland cash rent/acre ł**	**Pasture Cash Rent/Acreǂ**
Grass Meadows	Pine	$ 38.50	$10
McMillin	Wabasha	$222.00	$35
Jewett	Aitkin	$32.50	$10
Brown	Carlton (northern Pine)	$31.00	$10

Ł From Cropland Rental Rates for Minnesota Counties. September 2014. Gary Hachfeld, William Lazarus, Dale Nordquist and Rann Loppnow. University of Minnesota Extension. http://www.cffm.umn.edu/publications/pubs/farmmgttopics/rentalrates.pdf

ǂ There was very little information available about pasture rents in these areas. In Pine and Aitkin counties, the $10/acre represents a typical hay stumpage rate for hayfields, so most likely overestimates the rental cost of pastures. For Wabasha county, the $35/acre for pasture is an estimate based on rents seen by graziers in southwest Wisconsin (Vance Haugen, UWEX St. Croix County, personal communication); and verified as a reasonable estimate by Bill McMillin.

Beef carcass price

The USDA-reported range of prices for Select grade grass-fed beef carcasses on November 20, 2014 was $295 to $350 per cwt. The midpoint of this range was used in the economic analysis: $322.50 per cwt. Similar to the standardization of hay costs by RFV, this standard beef price does not represent the actual price received by the farmers, who each used different marketing strategies.

Agricultural Marketing Service Grass-Fed Beef Price report:
http://www.ams.usda.gov/mnreports/nw_ls110.txt

Cost of production and net income calculations

Table 9. Grass Meadows farm: Cost of production and net income per steer	
Average RFV of hay	105
Price/ton	$ 120.24
Average days on pasture/year	161
Average days on hay/year	204
Winter feed for 1400-lb. cow (3% of body wt./day) = ((1400 lbs.*0.03)* 204 days)/2000 lbs./ton	4.28 tons
First winter feed for 536-lb. steer (average of fall weaning wt. and spring pre-pasture wt.) at 3% of body wt./day = ((536 lbs. * 0.03)*204 days)/2000 lbs./ton	1.64 tons
Second winter feed for 1,129-lb. steer (average live wt. at slaughter) at 3% of body wt./day = ((1,129 lbs. * 0.03)*177 days)/2000 lbs./ton	3.00 tons
Total cost of winter feed = (4.28 tons + 1.64 tons + 3.00 tons)*$120.24	$ 1,072.54
Cropland opportunity cost = (120 acres * $38.50/ac)/120 cow-calf-steer groups	$ 38.50
Pasture opportunity cost = (280 acres * $10/ac)/120 cow-calf-steer groups	$ 23.33
Total feeding costs per steer produced	$ 1,134.37
Income per steer based on average carcass weight = 571 lbs. @ $322.50/cwt	$ 1,841.48
Net per steer	$ 707.11
Net per pastured acre devoted to cattle =($707.11 * 120 head)/280 acres	$ 303.05
Net per pastured + harvested acre devoted to cattle =($707.11 * 120 head)/400 acres	$ 212.13

Table 10. McMillin farm: Cost of production and net income per steer and per acre.	
Average RFV of hay	138
Price/ton	$ 159.18
Average days on pasture/year	161
Average days on hay/year	204
Winter feed for 1400-lb. cow (3% of body wt./day) = ((1400 lbs.*0.03)* 204 days)/2000 lbs./ton	4.28 tons
First winter feed for 875-lb. steer (average of fall weaning wt. and spring pre-pasture wt.) at 3% of body wt./day = ((875 lbs. * 0.03)*204 days)/2000 lbs./ton	2.68 tons
Second winter feed for 1,204-lb. steer (average live wt. at slaughter) at 3% of body wt./day = ((1,204 lbs. * 0.03)*23 days)/2000 lbs./ton	0.42 tons
Supplemental summer feed when pastures ran low; about 50% of intake during July, 1400-lb. cows and 1000-lb. steers = ((1400 lbs. + 1000 lbs.)*0.015*30 days)/2000 lbs./ton	0.54 tons
Total cost of winter feed = (4.28 tons + 2.68 tons + 0.42 tons)*$159.18	$ 1,174.75
Total cost of summer feed =0.54 tons haylage @ RFV 120 * $137.94	$74.49
Cropland opportunity cost = (8 acres * $222/acre)/30 cow-calf-steer groups	$ 59.20
Pasture opportunity cost = (32 acres * $35/acre)/30 cow-calf-steer groups	$ 37.33
Total feeding costs per steer produced	$ 1,345.77
Income per steer based on average carcass weight = 675 lbs. @ $322.50/cwt	$ 2,176.88
Net per steer	$ 831.11
Net per pastured acre devoted to cattle =($831.11 * 30 head)/40 acres	$ 623.33
Net per pastured + harvested acre devoted to cattle =($831.11 * 30 head)/75 acres	$ 332.44

Table 11. Jewett farm: Cost of production and net income per steer and per acre.	
Average RFV of hay	108
Price/ton	$123.78
Average days on pasture/year	163
Average days on hay/year	202
Winter feed for 1400-lb. cow (3% of body wt./day) = ((1400 lbs.*0.03)*202 days)/2000 lbs./ton	4.24 tons
First winter feed for 849-lb. steer (average of fall weaning wt. and spring pre-pasture wt.) at 3% of body wt./day = ((849 lbs. * 0.03)*202 days)/2000 lbs./ton	2.57 tons
Second winter feed for 1,038-lb. steer (average live wt. at slaughter) at 3% of body wt./day = ((1,038 lbs. * 0.03)*4 days)/2000 lbs./ton	0.06 tons
Total cost of winter feed = (4.24 tons + 2.57 tons + 0.06 tons)*$123.78	$ 850.37
Cropland opportunity cost = (31 acres * $32.50/acre)/12 cow-calf-steer groups	$ 83.96
Pastureland opportunity cost = (40 acres * $10/acre)/12 cow-calf-steer groups	$ 33.33
Total feeding costs per steer produced	$ 967.66
Income per steer based on average carcass weight = 528 lbs. @ $322.50/cwt	$1,702.80
Net per steer	$ 735.14
Net per pastured acre devoted to cattle = ($735.14 * 12 head)/71 acres	$ 124.25
Net per pastured + harvested acre devoted to cattle =($735.14*12 head)/121 acres	$ 72.91

Table 12. Brown farm: Cost of production and net income per steer and per acre.	
Average RFV of hay	90
Price/ton	$102.54
Average days on pasture/year	144
Average days on hay/year	221
Winter feed for 1400-lb. cow (3% of body wt./day) = ((1400 lbs.*0.03)*221 days)/2000 lbs./ton	4.64 tons
First winter feed for 643-lb. steer (average of fall wt. and spring pre-pasture wt.) at 3% of body wt./day = ((643 lbs. * 0.03)*221 days)/2000 lbs./ton	2.13 tons
Second winter feed for 1135-lb. steer (average live wt. at slaughter) at 3% of body wt./day = ((1135 lbs. * 0.03)*127 days)/2000 lbs./ton	2.16 tons
Total cost of winter feed = (4.64 tons + 2.13 tons + 2.16 tons)*$102.54	$ 915.68
Pasture opportunity cost = (60 acres * $10/acre)/19 cow-calf-steer groups	$ 31.58
Total feeding costs per steer produced	$ 947.26
Income per steer based on average carcass weight = 617 lbs. @ $322.50/cwt	$ 1,989.83
Net per steer	$ 1,042.57
Net per pastured acre devoted to cattle = ($1,042.57 * 19 head)/60 acres	$330.15
Net per pastured + harvested acre devoted to cattle = ($1,042.57 * 19 head)/160 acres	$123.80

Discussion of economic analyses

An interesting feature of these analyses is that they appear to contradict the conventional wisdom about grass-fed beef production:

- Keep the cattle on pasture for as many days per year as possible
- Do whatever you can to limit feeding of stored forage
- A second winter's feeding is detrimental to profitability
- Forage quality of the winter feed is very important

The McMillin farm was clearly far in the lead in terms of profitability per acre devoted to cattle, and second in terms of profitability per steer. This farm had a fairly high stocking rate of 1.8 AU per acre of pasture for the summer grazing season and made use of supplemental haylage to feed animals in summer to avoid overgrazing. This farm generally limited feeding of steers to one winter and achieved carcass weights of 675 lbs. through use of high-quality forage; generally around 140 RFV.

The Brown farm was first in terms of profitability per steer. This farm used a stocking rate of about 0.67 AU per acre of pasture (which is fairly high for the low-productivity soils of northeastern Minnesota) and had the shortest grazing season. It kept steers on feed through 127 days of a second winter feeding season in order to reach average carcass weights of 617 lbs. The winter feed on this farm had an average RFV of 90.

The Grass Meadows farm had a stocking rate for its steers of about 1 AU per acre of pasture. Winter feed for cattle averaged 106 in RFV. This farm was lowest in terms of profitability per steer, but only slightly lower than the Jewett farm which had a much lower stocking rate and similar length of grazing season. In terms of profitability per acre devoted to cattle, Grass Meadows came in second behind the McMillin farm.

The Jewett farm had a low stocking rate of 0.39 AU per acre of pasture and a 163-day grazing season (which is fairly long for northeastern Minnesota), and limited feeding of steers to one winter. Winter feed had average RFV of 108. This farm came in third in terms of profitability per steer, and last in terms of profitability per acre.

The results from this project seem to suggest that strategies for the most profitable grass-fed beef production, at least for some farms, may include:

- Use the highest stocking rate that you can on pastures, maximize pasture forage utilization, and use supplemental feed during the grazing season if needed to avoid over-grazing pastures.
- Feed stored forage as needed, and don't worry about minimizing stored forage use.
- Feed as long as needed to reach a carcass weight above 600 lbs.
- Obtain inexpensive forage, let the cows sort out what they like, and don't worry too much about the quality.

Thoughts on the future of grass-fed beef

- There is a need for new life cycle, environmental impact, and economic analyses of grass-fed beef that take into account the potential of high-producing farms with modern genetics, and that properly account for the effect of heritage breeds and low-productivity pastures on the performance of grass-based beef production systems. Results from this project show an obvious difference in performance between modern Angus genetics + medium-to-high quality stored forage, and Scottish Highlander genetics + low-quality stored forage. Any analysis with an environmental component should also take into account the benefits of a perennial forage crop in reducing soil erosion and nutrient leakage from agricultural landscapes.

- In order for grass-fed beef producers to make progress with their systems, there needs to be information available about the range of performance levels of grass-based production systems. Then producers will be able to see how their operation measures up to others, and can begin to make the changes necessary to improve. It would be useful to have a grass-fed beef data collection and reporting service. The cost of each data point in this project was high, at $25 per point. An established data collection service that reported useful information back to the farmers on an annual basis would not need to pay for the data submitted.

  Data to collect, in order of importance:

  - Birth date and carcass weight are the easiest data to collect, and by themselves could form the basis of a reporting scheme. Farmers can easily track birth dates by making notes on a calendar or sheet of paper. Carcass weights are nearly always obtained by farmers who direct market or by those who sell to branded marketers like Thousand Hills Cattle Company. Live weights are often not obtained by small-scale farmers because they do not own a scale. Carcass weight can be estimated from live weight if necessary, or vice versa, by using a standard percentage for carcass yield. The birth date and carcass weight allow calculation of the Age-Weight index used in this report.

  - Total days on hay. This is important for economic analysis because it allows calculation of the cost of stored forage needed to finish the animal. A farmer with records of birth date, slaughter date, start date of spring grazing and start date of winter feeding can generate this number.

  - Live weight. This would allow calculation of the percentage of carcass yield for the animal, which would be needed for a true accounting of the amount of meat produced in the grass-fed system.

- This project showed that there is potential for the animals in a grass-based system to approach the performance of animals in a feedlot system. There should be further research focused on maximizing the performance of grass-based beef production systems.

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