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The Professional Animal Scientist 32 (2016):736–749; http://dx.doi.org/10.15232/pas.2016-01539
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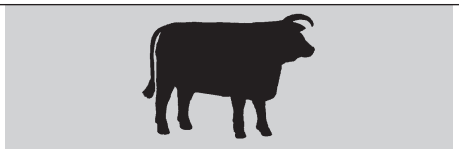

Management characteristics of beef cattle production in the Northern Plains and Midwest regions of the United States

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ABSTRACT

A comprehensive life cycle assessment of United States beef will provide benchmarks and identify opportunities for improvement. On-going region-specific data collection is characterizing cattle production practices for a more accurate assessment. This study reports production information obtained via online surveys and on-site visits from 2 of 7 regions: the Northern Plains (Nebraska, North Dakota, and South Dakota) and Midwest (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin). Ranch responses (n = 512) represented 1.6% of beef cows maintained in both regions with operation sizes varying from 1 to 12,500 cows. Feedlot responses (n = 120) represented 9.6 and 3.7% of cattle finished in the Northern Plains and Midwest, respectively. Ranch herd sizes increased and stocking rates decreased moving westward. Average animal BW increased from south to north. Also recorded were bull and replacement heifer numbers; housing facilities; feed production and use; and machinery, energy, and labor use. Feedlot characteristics including entering and final BW, background and finish feeding periods, crop area per animal, and labor were similar across the regions, but the Northern Plains reported larger feedlots than the Midwest. Diets were similar across regions except that slightly more distillers grain and less corn were fed in the Northern Plains. Ninety-three percent of feedlots produced most of their feed (corn grain, corn silage, and alfalfa). Cropland producing feed received most of the manure produced, but a few large feedlots reported composting and export. Information gathered provides production system characteristics and inventory for conducting a comprehensive United States beef life cycle assessment.

Key words: beef production, cattle management, ranch, feedlot, life cycle assessment

INTRODUCTION

The United States Beef Checkoff Sustainability Program was launched in 2010 with the goal of quantifying the sustainability of beef through a nationwide cradle-to-grave life cycle assessment (**LCA**). The purpose of the beef industry LCA is to establish benchmarks and identify opportunities for improvement. This initiative is necessary as the livestock industry seeks to meet the changing and increasing demands from a growing human population while balancing environmental responsibility, economic opportunity, and social diligence.

For a comprehensive and accurate assessment, region-specific data are needed to characterize beef cattle production and management nationwide. The country has been divided into 7 cattle producing regions according to climate and other regional differences. The data gathered are used to form representative operations within each region to develop farm gate partial LCA using a methodology developed by Rotz et al. (2013). Additionally, the production data are combined with information gathered from packing, marketing, and consumer segments of the beef value chain to complete a cradle-to-grave LCA (Stackhouse-Lawson et al., 2013).

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Production and management data have been gathered (Asem-Hiablie et al., 2015), and a farm gate assessment was completed (Rotz et al., 2015) for the Southern Plains region (Kansas, Oklahoma, and Texas). The carbon footprint of all beef produced was determined as 18.3 ± 1.7 kg of CO_2 equivalent/kg of carcass weight (**CW**). Fossil energy use, nonprecipitation water use, and reactive nitrogen loss were 51 ± 4.8 MJ/kg of CW, 2,470 ± 455 L/kg of CW, and 138 ± 12 g of N/kg of CW, respectively.

The objective of the current study was to survey and report beef cattle management and production practices for 2 more of the 7 regions: the Northern Plains (Nebraska, North Dakota, and South Dakota) and the Midwest (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin). This information is being used along with that reported for the Southern Plains and information that is currently under study in the western and eastern regions to characterize region-specific beef production systems throughout the United States. These region-specific production systems will be used to complete the comprehensive national LCA of beef.

MATERIALS AND METHODS

Surveys and Visits

Two voluntary surveys for ranch and feedlot operations were administered via the Internet in each of the states of the Northern Plains and Midwest regions. Specifically, survey questions were developed in consultation with state beef councils and state cattlemen's associations to capture region-specific management practices (Asem-Hiablie et al., 2015). Letters were sent to producers by either the beef council or cattlemen's association of each state, encouraging participation and providing a web address where the surveys could be completed. Visited operations were also arranged or recommended by representatives of the state councils, and visits were made with those who agreed to participate. Confidential data provided by each producer were collated and analyzed in a spreadsheet format. Survey questions are available as Supplementary Information (SI 1a and 1b; http://dx.doi.org/10.15232/pas.2016-01539).

For the purposes of this study, ranches are defined as any operation that predominately includes cattle on pasture or rangeland. This includes cow-calf to finish operations where calves are weaned, raised, and finished on the same operation. Feedlots are defined as operations where cattle are predominantly fed in confinement (open lot or barn) either for backgrounding on a high forage diet or finishing on a high concentrate diet. Although the terminology for different operations varies throughout these regions, for consistency, we use these terms as defined.

Background and stocker cattle both refer to the intermediate stage of development between weaning of the calf and finishing of the animal on a high concentrate diet. We refer to backgrounding as cattle predominately fed in confinement, whereas stockers are predominately on grazing land. There is overlap where stockers may be fed a diet of harvested feed, particularly during the winter months. Feeders are cattle on a ranch or feedlot fed a high concentrate diet to provide a finished carcass.

Ranches consisted of cow-calf only, cow-calf and stocker or backgrounding, cow-calf–to–finish, and stocker-to-finish operations. All responses from cow-calf ranches including survey and visits totaled 512: Northern Plains (275) and Midwest (237). Ranch visits numbered 19 in the Northern Plains and 18 in the Midwest. The numbers by state were Nebraska (5), South Dakota (6), and North Dakota (8), Illinois (2), Indiana (2), Iowa (4), Michigan (1), Minnesota (1), Missouri (5), and Wisconsin (3). Just a total of 4 ranch survey and visit responses were received from Indiana, so this state's data were combined with that of Illinois because they were considered to have similar management practices. According to the 2012 survey of the National Agricultural Statistics Service (NASS, 2015), the total number of beef cows in the Northern Plains and Midwest regions were about 4.22 and 3.80 million, respectively. Based upon this population, responses received in the surveys and visits represented approximately 2.4% of the beef cow inventory in the Northern Plains, 0.6% in the Midwest, and 1.6% of both regions. Response rates could not be determined because in addition to electronic mailing lists, links to the survey's web address were made available via periodicals and websites maintained by the beef council or cattlemen's association, making it impossible to obtain the total number of survey recipients.

Feedlot responses totaled 120 with 46 from the Northern Plains and 74 from the Midwest. The number of feedlot visits in each state were Nebraska (7), South Dakota (3), North Dakota (3), Indiana (1), Iowa (5), Illinois (2), Michigan (2), Minnesota (2), and Wisconsin (1). The 2012 cattle on feed inventories from NASS (2015) reported 3.12 and 2.94 million cattle at the end of the year for the Northern Plains and Midwest, respectively. Based upon the survey data with about 1.2 and 1.3 groups of cattle finished per year in the Northern Plains and Midwest, respectively, the surveyed cattle represented about 9.6% of the cattle finished in the Northern Plains and 3.7% of those finished in the Midwest.

For summarizing and comparing across operations, some data were expressed per animal. For cow-calf only operations, this number was the average number of cows maintained throughout the year. Although these operations normally included bulls and replacement heifers, these animals were considered proportional to the number of cows. When stockers and feeder cattle were included on the operation, they were included in the count. So the number of animals counted on a cow-calf–to–finish operation was the sum of cows, plus stockers and feeder cattle. On feedlots, the number of animals was the number of cattle finished per year.

Ranch and feedlot visits were conducted to collect survey data and more detailed information including that of equipment and energy use. Mean annual fuel use was determined as the sum of reported gasoline and diesel use in diesel equivalent expressed per animal (1 L of gasoline ≈ 0.877 L of diesel, California Energy Commission, 2015). Reported values of energy use varied widely among operations. Accurate estimates were difficult to obtain because home use and that used to produce cash crops were often combined with cattle production usage. Producers were asked to estimate the portion used for cattle production, and this was difficult for some. The numbers received provide guidance on typical or average energy use, but the wide range in values received reflects the uncertainty in quantifying this resource use.

Statistics

Descriptive statistics of cattle operation data were computed at state and regional levels. Summaries of management practices by state were explored for trends across the Northern Plains and Midwest regions. Responses from the Northern Plains were further grouped into east, central, and west areas to elucidate patterns in management practices from the wetter east to the drier semiarid west. Two areas in South Dakota were specifically defined as east or west of the Missouri river. For North Dakota and Nebraska, 3 areas were generally defined as the eastern, central, and western third of the state and the respondent decided which area best defined their location.

Statistically significant differences ($P < 0.05$) in selected management variables were tested among areas using the SURVEYREG procedure with the LSMEANS statement and PDIFF option of SAS version 9.4 (2013, SAS Institute Inc., Cary, NC). The experimental unit for each area was a beef cow or finished animal. Sampling weights for each region, defined as the number of brood cows in a population represented in the survey response, were taken as the ratio of the total number of cows in each region (NASS, 2015) compared with our survey totals for that region. A STRATA statement was used to account for the grouping of survey responses into east, central, and west areas within the Northern Plains. Due to more uniformity in the climate throughout the region, the Midwest was considered as one group.

RESULTS AND DISCUSSION

Ranches

The number of cows represented by survey responses received from each state were generally correlated with cow numbers in those states (r = 0.67). A ranking by state for the number of beef cows reported in the survey was Nebraska (66,480), South Dakota (22,662), North Dakota (13,418), Iowa (10,684), Missouri (3,546), Minnesota (3,430), Illinois (2,628), Wisconsin (1,825), Michigan (871), and Indiana (178). Although this ranking follows the general trend for cow numbers in those states (NASS, 2015; Figure 1), Nebraska is somewhat overrepresented and Missouri is underrepresented relative to the other states in terms of total cow numbers. Given the large number surveyed, these differences in representation do not affect the characterization of ranches in each state.

Ranch Types and Sizes. Responses from both regions indicated that 98% of the ranches surveyed maintained cows, whereas the remaining 2% raised stockers only or both stockers and feeders (Table 1). About 37% of the cows were on cow-calf only operations, and this was relatively consistent across the 2 regions (Table 1). The remainder raised calves after weaning, with 27% selling them as stockers and 37% feeding them through finish. There was a trend toward more finishing of cattle on operations in the Midwest, with more producing stockers only in the western Northern Plains (Table 1). Within the Midwest, the states maintaining the most cows on cow-calf only operations were Missouri (59%) and Illinois and Indiana (61%) (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). Throughout Michigan, Minnesota, and Wisconsin, 50 to 65% of cows were reported on cow-calf to finish operations.

Herd size in these regions ranged from 1 to 12,500 cows. About half of the ranches fell into the category of small operations, with herd sizes of 100 cows or less, but the number of brood cows on these small ranches made up only 21% of the total brood cows surveyed (Table 1). Herd size increased significantly ($P < 0.05$) between the Midwest and eastern, central, and western Northern Plains (100, 144, 303, and 565, respectively;

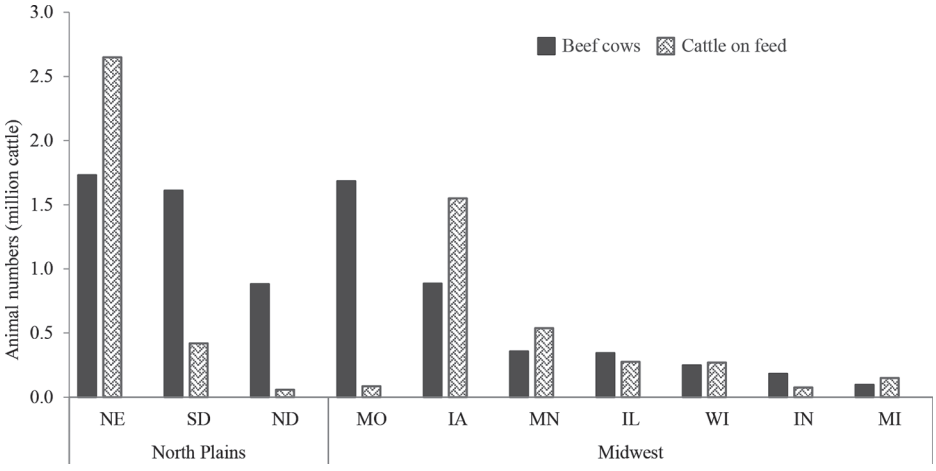

Figure 1. Inventory of beef cows and cattle on feed reported for states in the Northern Plains and Midwest regions in the 2012 national census of agricultural animals (NASS, 2015).

Table 2). The majority of operations in the Midwest (73%) had small herds, with only 19% being small in the western portion of the Northern Plains. The proportion of cows on small operations declined from 35% in the Midwest to 2% in the western Northern Plains (Table 1). Comparatively, NASS (2015) beef cow inventory data also reported a higher proportion of animals on small operations in the Midwest than the Northern

Table 1. Beef cattle ranch survey results for the Midwest (n = 237) and the east (n = 75), central (n = 76), and west (n = 124) Northern Plains[1]

			Northern Plains			
Ranch characteristic	**Units**	**Midwest**	**East**	**Central**	**West**	**Full regions[2]**
Ranches with cows	% of ranches	97.9	98.7	97.4	98.4	98.0
Small ranch, 100 cows or less	% of ranches	72.6	56.0	27.6	18.5	52.3
	% of cows	34.8	18.0	6.3	2.0	21.4
Cow-calf only	% of cows	37.8	39.8	32.9	35.0	36.6
Cow-calf and stocker	% of cows	20.2	25.9	31.4	42.0	26.8
Cow-calf to finish	% of cows	41.9	34.4	35.7	23.0	36.7
Ranches with stockers	% of ranches	39.2	60.0	53.9	56.5	47.7
Small ranch, 100 stockers or less	% of ranches	46.7	62.1	22.8	28.3	40.6
	% of stockers	12.3	27.7	3.6	5.1	11.2
Cow-calf and stocker	% of stockers	59.3	98.2	48.3	92.3	66.9
Stocker only	% of stockers	40.7	1.8	0.0	7.7	21.8
Stocker to finish only	% of stockers	0.0	0.0	51.7	0.0	11.3
Grass finished cattle	% of finished cattle	1.5	0.0	0.4	1.8	1.1
Growth implants used	% of ranches	39.5	35.0	47.7	38.3	40.5
Portion of stockers	% of stockers	58.8	43.9	68.7	53.4	58.3
Type of housing (some use >1 type)						
None (on pasture or range only)	% of ranches	64.1	22.7	44.7	66.1	55.0
Open lot	% of ranches	24.1	63.5	52.6	28.2	35.9
Bedded pack or compost barn	% of ranches	13.5	10.7	3.9	4.1	9.6
Free stall barn	% of ranches	4.2	12.3	3.9	6.5	5.5
Harvested pasture land	% of ranches	63.8	42.6	44.6	50.0	54.8
Portion harvested each year	% of land	15.2	10.1	10.4	14.2	12.0
Clipped but not harvested	% of land	56.7	13.1	10.5	18.4	16.7
Pasture reestablishment	% of ranches	33.9	11.8	2.9	10.4	20.7
Little or no reestablishment	% of land	55.2	69.3	97.3	85.5	80.4
Reestablishment period	years	9.3	12.3	11.3	12.0	10.5
Small grain grazed	% of ranches	18.0	12.1	22.0	21.5	18.7
	ha/animal	0.12	0.44	0.27	0.53	0.3
Crop residue grazed	% of ranches	72.7	86.9	79.1	41.1	70.9
	ha/animal	0.62	1.57	1.09	0.69	0.85
Purchased forage	kg of DM/d per animal	3.9	3.0	2.8	2.5	3.2
Purchased concentrate	kg of DM/d per animal	1.39	1.02	0.93	0.86	1.16
Nitrogen fertilizer use	% of ranches	60.7	46.7	6.6	2.9	38.1
Fertilizer used	% of land	43.1	36.1	1.5	1.5	4.8
Amount used by those that fertilize	kg of N/ha	57.3	66.6	39.2	43.3	52.4
Phosphate fertilizer	% of ranches	34.6	25.5	0.0	1.0	20.7
Fertilizer used	% of land	22.0	31.3	0.0	0.2	2.5
Amount used by those that fertilize	kg of P_2O_5/ha	36.7	24.5	—	67.2	32.0
Potash fertilizer	% of ranches	36.3	16.0	0.0	1.1	20.3
Fertilizer used	% of land	31.3	2.8	0.0	0.9	1.1
Amount used by those that fertilize	kg of K_2O/ha	51.5	23.1	—	44.8	35.7
Lime use	% of land	38.0	0.0	0.0	0.0	1.6
Other feed crops grown	% of ranches	70.9	62.9	75.4	42.6	66.4
	ha/animal	0.43	0.47	0.33	0.35	0.40

[1]Midwest responses include Iowa (n = 117), Illinois (n = 33), Indiana (n = 4), Michigan (n = 13), Minnesota (n = 26), Missouri (n = 17), and Wisconsin (n = 27). Northern Plain responses include Nebraska (n = 133), South Dakota (n = 72), and North Dakota, (n = 71).

[2]Average of the 4 areas weighted by the portion of cows maintained in each area. Cow numbers for the Midwest and districts of the Northern Plains were from the 2012 and 2007 surveys of the National Agricultural Statistics Service, respectively (NASS, 2015).

Plains, although at higher percentages (65 and 23%, respectively). Missouri had larger herd sizes than the rest of the Midwest, with 41% of this state's ranches reporting cow herds of less than 100 (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). According to NASS (2015) data, both Missouri and Iowa maintained the largest herd sizes.

There was also a trend for larger operations moving southward through the Northern Plains; average herd sizes in Nebraska and South Dakota were significantly greater ($P < 0.05$) than those in North Dakota (Supplemental Table S2; http://dx.doi.org/10.15232/pas.2016-01539). Interestingly, a northward increasing trend in herd size was found in the Southern Plains, with average sizes of 155, 222, and 364 brood cows for Texas, Oklahoma, and Kansas, respectively (Asem-Hiablie et al., 2015). Thus, the

Table 2. Summary of management practices used on beef cattle ranches (cow-calf only, cow-calf and stocker, and cow-calf to finish) in the Midwest (n = 237) and eastern (n = 75), central (n = 76), and western (n = 124) areas of the Northern Plains[1]

Management characteristic	Region	Mean	Median	Minimum	Maximum	SD	Responses
Brood cows maintained (No. of cows)	Midwest	100[a]	60	2	900	125	232
	East Northern Plains	144[b]	80	2	800	158	74
	Central Northern Plains	303[c]	200	1	1,800	316	74
	West Northern Plains	565[d]	280	3	12,500	1,292	123
	Full region	250	100	1	12,500	684	502
Cows per bull (ratio)	Midwest	17.7[a]	17.0	—	75.0	12.0	232
	East Northern Plains	18.3[a]	20.0	—	37.5	9.2	70
	Central Northern Plains	21.7[ab]	21.3	—	58.3	12.0	71
	West Northern Plains	22.9[b]	20.8	—	80.0	13.0	117
	Full region	19.0	20.0	—	80.0	12.4	506
Replacement heifers per cow (ratio)	Midwest	0.23[a]	0.20	0	1.50	0.18	231
	East Northern Plains	0.25[a]	0.18	0	1.50	0.24	74
	Central Northern Plains	0.34[a]	0.20	0	4.0	0.63	74
	West Northern Plains	0.24[a]	0.20	0	4.29	0.38	123
	Full region	0.25	0.20	0	4.29	0.35	501
Stockers (No. of animals)	Midwest	168[a]	35	2	6,000	597	150
	East Northern Plains	97[a]	35	1	600	146	45
	Central Northern Plains	447[ab]	150	6	9,500	1,464	41
	West Northern Plains	379[b]	163	1	3,500	576	70
	Full region	243	60	1	9,500	741	306
Average brood cow weight (kg)	Midwest	606[a]	612	408	1,043	73	232
	East Northern Plains	608[a]	601	499	862	69	74
	Central Northern Plains	600[a]	590	522	726	47	74
	West Northern Plains	582[b]	590	454	748	53	122
	Full region	600	590	408	1,043	65	501
Average annual stocking rate for cows (ha/cow-calf pair)	Midwest	1.14[a]	0.81	0.10	16.19	1.37	211
	East Northern Plains	2.86[ab]	1.67	0.40	60.70	7.44	64
	Central Northern Plains	3.30[b]	3.14	0.61	7.28	1.45	66
	West Northern Plains	6.84[c]	6.07	0.20	20.23	3.74	114
	Full region	3.11	1.62	0.10	60.70	4.2	481
Average annual stocking rate for stockers (ha/stocker)	Midwest	0.77[a]	0.40	0.10	2.83	0.71	26
	East Northern Plains	1.42[b]	1.11	0.40	3.24	0.91	10
	Central Northern Plains	1.71[b]	1.62	0.40	4.05	0.95	20
	West Northern Plains	4.38[c]	3.64	0.40	12.14	2.80	40
	Full region	2.54	1.72	0.10	12.14	2.48	96
Labor to feed and maintain cattle (person-h/animal per year)	Midwest	22.7[a]	15.4	0.04	208.0	26.1	212
	East Northern Plains	16.3[b]	10.7	0.74	91.0	16.7	60
	Central Northern Plains	12.8[bc]	9.6	0.07	67.2	14.0	62
	West Northern Plains	11.1[c]	7.8	0.56	59.4	10.3	107
	Full region	17.6	11.5	0.04	208.0	21.0	441

[a–d]Values of a management characteristic with different superscripts are significantly different ($P < 0.05$).

[1]Midwest responses include Iowa (n = 117), Illinois (n = 33), Indiana (n = 4), Michigan (n = 13), Minnesota (n = 26), Missouri (n = 17), and Wisconsin (n = 27). Northern Plain responses include Nebraska (n = 133), South Dakota (n = 72), and North Dakota (n = 71).

largest herds appear to occur near the geographic center of the 6 states classified as the Northern and Southern Plains regions.

Of the operations maintaining stocker cattle, a similar trend in size was found across the regions, with significantly greater ($P < 0.05$) herd sizes in the western areas of the Northern Plains than the eastern Northern Plains and Midwest (Table 2). Stocker-only operations raised 41% of the stockers in the Midwest and 2 and 8% of the stockers in the east and west Northern Plains, respectively, with none in the central area. Considering the small number of stocker-only operations responding to the survey, conclusive trends were not observed.

Many ranches maintained stocker cattle after weaning. The average number of stockers maintained per ranch varied from a low of 97 in the east Northern Plains to a high of 447 in the central Northern Plains, and large herds were found throughout the regions (Table 2). The portion of ranches raising stockers in the Midwest ranged from 24% in Illinois and Indiana to 54% in Minnesota (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). All stockers in Michigan were raised on small ranches. In contrast, less than 1% of the stockers in Missouri were raised on small ranches, and these ranches made up only 10% of the state's ranches with stockers (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). Michigan had the smallest stocker herd sizes, with a reported mean of 35 and maximum of 75 stockers (Supplemental Table S3; http://dx.doi.org/10.15232/pas.2016-01539). No stocker-to-finish operations were reported in the Midwest (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539).

Cattle Management. The reported mean brood-cow BW for the regions was 600 ± 65 kg (Table 2). A decreasing trend was observed from North Dakota (611 ± 56.7 kg) through South Dakota (594 ± 72 kg) to Nebraska (586 ± 46 kg), with a significant difference between Nebraska and North Dakota ($P < 0.05$). Notably, this continued a decreasing southward trend observed previously in the Southern Plains with reported cow BW of 567 ± 55 kg in Kansas, 558 ± 54 kg in Oklahoma, and 525 ± 36 kg in Texas. In the Midwest, cows in Minnesota were heaviest, and Missouri cows were the lightest (Supplemental Table S3; http://dx.doi.org/10.15232/pas.2016-01539).

The mean cow:bull ratio for all operations in the Northern Plains was 19:1, with a maximum of 80:1. Five percent of ranches in the Northern Plains with cows reported no bulls. For cow-calf only operations in this region, the mean cow:bull ratio was 21:1, with east, central, and west reporting 18 (n = 33), 22 (n = 30), and 23 (n = 55), respectively. Cow-calf only operations in the Midwest had a mean cow:bull ratio of 18:1, with none reporting no bulls. The mean cow:bull ratio for the states in the Midwest ranged between 16:1 and 32:1, with Wisconsin and Missouri reporting the minimum and maximum, respectively (Supplemental Table S3; http://dx.doi.org/10.15232/pas.2016-01539). The cow:bull ratio was significantly lower in the Midwest than in the Northern Plains ($P < 0.05$).

The mean heifer replacements per cow reported for both regions was 25% (Table 2), with the Northern Plains and the Midwest reporting 27 and 23%, respectively. The lowest replacements (19%) in the Midwest were found in Iowa and Missouri (Supplemental Table S3; http://dx.doi.org/10.15232/pas.2016-01539). An increase in replacements from the south to north was observed in the Northern Plains (Supplemental Table S2; http://dx.doi.org/10.15232/pas.2016-01539). Higher than normal replacement rates may be due to rebuilding of herd sizes reduced by recent droughts or harsh winter conditions, or herd expansion to meet a high cattle market. A few operations appeared to be selling a higher-than-average number of replacement heifers to capture a premium market price for those animals. There were also a few ranches that reported no replacement heifers, which indicated the sale of all calves and purchase of replacement animals when needed.

A wide range in stocking rates was reported for cow-calf pairs across the regions (Table 2). Similar to the Southern Plains (Asem-Hiablie et al., 2015), decreasing precipitation from east to west was associated with decreasing mean stocking rates from the Midwest across the eastern, central, and western areas of the Northern Plains. Among all states, South Dakota reported the lowest mean stocking rate of 7.5 ha/cow-calf pair (Supplemental Table S2; http://dx.doi.org/10.15232/pas.2016-01539). In the Midwest, the highest and lowest mean stocking rates of 0.75 and 1.7 ha/cow-calf pair were reported from Illinois and Minnesota, respectively (Supplemental Table S3; http://dx.doi.org/10.15232/pas.2016-01539). Stocker stocking rates in the Northern Plains also decreased moving westward (Table 2). Both cow-calf and stocker stocking rates were higher in the Midwest, where greater precipitation produced higher yields of cool-season Midwestern grasses and legumes.

Similar animal housing facilities were found in the 2 regions (Table 1). Some ranches used more than one type of housing, especially for the purposes of calving. About 15% of respondents reported using some type of barn or shed on their operation, with most of these located in the Midwest and eastern Northern Plains. These were about equally divided between free stall barns and some type of bedded pack barn. About 55% of all operations reported using no enclosure, where cattle were maintained on pasture or rangeland all year. Many of these respondents noted the use of windbreaks or other areas to offer protection from harsh winter weather. Open lots were found on the majority of operations in the eastern and central areas of the Northern Plains, with fewer in the Midwest and western part of the Northern Plains. Responses from Missouri indicated that most cattle were maintained on pasture

and open lots with no other housing (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539).

According to the responses received, the number of operations finishing some portion of their cattle on an all forage diet were few, with 8 in the Northern Plains (10% of those finishing cattle) and 18 in the Midwest (18% of those finishing cattle). About half of these reported finishing all of their cattle on grass, with the remainder finishing only a portion of the herd. Grass finishing operations were small in size, finishing 100 or fewer cattle per year. Grass finishing represented about 1% of the reported cattle finished in both regions.

About 41% of the ranch operations indicated that growth promoting implants were used, and this represented 58% of the stocker cattle produced (Table 1). The central Northern Plains reported slightly higher use, with 48% of the ranches using growth implants on 69% of the stockers produced. There appeared to be a decrease from south to north in the percentage of respondents using growth implants; Nebraska, South Dakota, and North Dakota reported 47, 38, and 25%, respectively. Reported implant use among ranch respondents in the Midwest ranged from none in Michigan to 53% in Iowa (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). The portion of stockers reported to receive implants also ranged from a low of 1% in Wisconsin to a high of 96% in Illinois and Indiana.

About half of the responding operations in the regions reported the purchase of forage to supplement that produced on their operation. Of those that purchased forage, the average amount used was 3.2 kg of DM/d per animal, and this amount was relatively consistent across the regions (Table 1). For the operations reporting the purchase and use of concentrate feeds, average use per animal was 0.92 kg of DM/d in the Northern Plains and 1.39 kg of DM/d in the Midwest. By-products such as distillers grain, corn gluten, soy hulls, and beet pulp were often fed depending on availability and proximity of the source to ranches.

Crop Production and Grazing Practices. Based on reported stocking rates and animal numbers, the estimated area in pasture and rangeland used by Northern Plains respondents ranged from 1 to 10,200 ha, with an average of 2,650 ha (n = 247). Ranches were smaller in the Midwest, with grazing area ranging from 2 to 5,780 ha and averaging 158 ha, with 98% having sizes of less than 1,000 ha (n = 212). In the Northern Plains, grazing land primarily consisted of native warm-season grasses, "tame" cool-season grasses, and annual forage crops, whereas in the Midwest these were mainly cool-season grasses and annual forages. Additional land used to produce feed crops averaged 166 ha/ranch in the Northern Plains and 59 ha/ranch in the Midwest.

About half of the ranches harvested some portion of their pasture land for winter feed, with a slightly greater portion in the Midwest than in the Northern Plains. The amount harvested was about 12% of all pasture and rangeland, and this portion was relatively consistent across the regions (Table 1). Of the remaining pastureland in the Midwest, 57% was reported to be clipped at some time during the year for weed and forage quality control. Large portions of grazing land were reported to be clipped in Illinois and Indiana (98%, n = 34) as well as Missouri (71%, n = 16), but Minnesota and Michigan clipped just 8% (n = 22) and 18% (n = 10), respectively (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). Much less clipping was practiced in the drier climate of the Northern Plains, with 10 to 18% of the grazing land mowed without harvest each year (Table 1).

The practice of reestablishing pastures was more common in the Midwest than in the Northern Plains (Table 1). When pastures were reestablished, the average establishment period (pasture stand life) was close to 11 years, and this was consistent across the regions (Table 1). Of the ranches that reestablished their pasture, those in Illinois and Indiana reported the lowest average reestablishment period of 7 yr, whereas the rest of the states in the Midwest reported an average of 8 to 11 yr. Tillage practices were similar across the regions, with 69% of ranches reporting the use of no-tillage pasture establishment (1 pass), 21% using a minimum tillage system (2 or 3 passes), and 10% using conventional tillage (4 or more passes).

In addition to the use of pasture and rangeland, annual small grain crops (e.g., winter wheat, cereal rye, oat, and barley) and crop residue (primarily corn stalks) were also grazed. Collectively, 19% of the ranches in the regions grazed small grain, and this was relatively consistent except for the eastern Northern Plains, where less was reported (Table 1). When small grain crops were grazed, mean land use was about 0.3 ha/animal across the study regions, and values ranged from 0.12 in the Midwest to 0.53 in the western area of the Northern Plains. Grazing of crop residue was reported by about 70% of ranches, with greater use in the Midwest and eastern areas of the plains and less in the drier climate of the western Northern Plains (Table 1). When grazing crop residue, the land used averaged 0.6 ha/animal in the Midwest and 1.2 ha/animal in the Northern Plains.

Fertilizer use on pasture land was reported predominantly in the Midwest (61% of respondents) and eastern Northern Plains (47% of respondents), with little or no use reported in the central and western parts of the Northern Plains (Table 1). Urea was the main form of nitrogen used and was applied by 70% of the respondents who reported nitrogen use (n = 157). Ammonium sulfate and urea ammonium nitrate were used by 12 and 8% of ranches applying nitrogen, respectively. About 6% reported the use of manure other than that deposited by the grazing animals. For those that applied nitrogen fertilizer, the average application rate was 52 kg of N/ha with a higher rate in the eastern side of these regions com-

pared with the western side (Table 1). Phosphate and potash fertilizers were essentially only used in the Midwest and the eastern area of the Northern Plains (Table 1). For those using these fertilizers in the Midwest, mean application rates of P_2O_5 and K_2O were 37 and 52 kg/ha, respectively. In the eastern Northern Plains, similar applications of each fertilizer were reported at 25 kg of P_2O_5/ha and 23 kg of K_2O/ha. Lime use was not reported by any ranch in the Northern Plains. In the Midwest, about 38% of the pastureland was reported to receive lime, and Missouri reported the highest use.

In both regions, other feed crops were grown on some ranches to feed cattle. In the Northern Plains, this included a greater percentage of ranches in the east and central than the western area. When additional feed was produced, the average land area cultivated was similar across the entire region at 0.4 ha/animal (Table 1). Almost all individual Midwest states except Missouri indicated that 50% or more of responding ranches grew other feed crops to maintain animals (Supplemental Table S1; http://dx.doi.org/10.15232/pas.2016-01539). In the Midwest, the largest crop areas cultivated per animal were 0.9 and 0.7 ha in Wisconsin and Michigan, respectively, whereas the rest of the states reported between 0.2 and 0.4 ha/animal. In the Northern Plains, alfalfa was the most common feed crop grown on 60% of the ranches followed by corn grain and corn silage on 41% of ranches. Corn was more common in the Midwest, grown on 72% of the ranches and used as feed in the form of dry grain, high-moisture grain, and silage. Other feed crops occasionally recorded from both regions were barley, oats, sorghum (as both silage and hay), soybeans, millet, rye, triticale, and turnips.

The reported labor required to feed and maintain cattle increased with herd size ($r = 0.76$), with a trend toward less labor per animal with larger herds ($r = -0.21$). Mean labor use was significantly greater in the Midwest ($P < 0.05$) than the Northern Plains (Table 2), with a trend for decreasing labor moving from east to west across the regions. Very small ranches (less than 10 brood cows) often reported more labor per cow than larger operations, and as noted above, more small ranches were found in the Midwest. Seed stock operations also reported higher than normal labor hours per animal due to extra handling activities. Although the survey specifically asked for the labor required to feed and maintain cattle, the values entered may have included labor for planting and harvesting crops, perhaps crops other than those used on the ranch. The uncertainty in this response may have increased the values provided, particularly in the Midwest, where large crop areas beyond that needed to produce feed for the herd were often found.

Equipment. Information on equipment use was obtained through ranch visits. Those visited in the Northern Plains consisted of 10 cow-calf only operations (135 to 1,800 brood cows), 7 cow-calf and stocker operations (140 to 1,074 brood cows and 10 to 1200 stockers), a stocker-only operation (2,000 stockers) and a cow-calf – to – finish operation (160 brood cows, 10 stockers, and 10 feeder cattle). In the Midwest, 14 of the operations visited were cow-calf only operations ranging in size from 35 to 900 brood cows. Also visited were 2 cow-calf and stocker operations (93 and 400 brood cows, 80 and 1,000 stockers), a cow-calf–to–finish operation (300 cows, 250 stockers, and 50 feeder cattle), and a stocker-only ranch with 6,000 cattle.

Ranch equipment typically included tractors, all-terrain vehicles (**ATV**), semitrucks and trailers, and smaller trucks (pickups to triaxial cattle trucks). Skid-steer loaders and payloaders were also reported. Other crop production equipment were found on ranches that produced their own cattle feed. These included brush removal, plowing, planting, spraying, harvesting, and hay-making equipment. In general, equipment used in the Midwest and eastern area of the Northern Plains were similar in size and type. These included larger farm tractors, field equipment (e.g., tillage implements, planters, hay tools, and harvesters), payloaders, and trucks.

Many of the ranch operators grew more crops than required to feed their cattle, with additional crops marketed as commodities. As much as possible, the effects of commodity feeds were removed, and only crops produced as on-farm feedstuffs were included in the assessment. A confounder related to equipment use though was that diversified producers with a large grain enterprise in addition to their cattle business generally had more and larger equipment compared with a producer that only marketed cattle.

Tractors ranged in size from 52 to 276 kW in the Northern Plains and 24 to 130 kW in the Midwest. In the Northern Plains, there was an average of 3 to 4 tractors per ranch. A tractor was used for every 59 to 500 brood cows maintained on cow-calf only operations, 35 to 755 animals on cow-calf and stocker operations, and 90 cattle on the cow-calf–to–finish operation. In the Midwest, one tractor was reported for every 24 to 450 cows on cow-calf only ranches, for every 87 and 700 cattle on cow-calf and stocker operations, and every 300 cattle on the cow-calf–to–finish operation. On the stocker-only operation, one tractor was used per 3,000 stockers. There was an average of 3 ATV per ranch in the Northern Plains and 2 ATV per ranch in the Midwest. No apparent relationship was found between herd size and tractor or ATV use.

On average, there were between 3 and 4 pickup and light duty trucks per ranch in the Northern Plains, whereas in the Midwest, there were 2 or 3. No relationship was found between herd size and the number of trucks used. Semitruck and trailers were often custom hired, but when present on ranches, one trailer was observed for every 200 to 1,000 cattle on the operation.

When horses were present as service animals for herd management activi-

ties, a horse was used for each 33 to 118 cows on cow-calf only ranches and 88 to 378 cattle on cow-calf and stocker operations in the Northern Plains. In the Midwest, one horse was used for every 125 cows and 87 to 700 cattle on cow-calf only and cow-calf–stocker operations, respectively. On the Midwest's stocker-only operation, there were 1,000 stockers per horse.

Energy Use. Due to the uncertainty producers had in monitoring energy use, reported values varied widely among ranches. On cow-calf only operations in the Northern Plains (n = 5), average use was 35 L of diesel equivalent/cow, with a reported range from 7 to 49 L/cow. On Midwest cow-calf only operations, combined mean fuel use was reported as 61 L of diesel equivalent/cow, with a range of 42 to 81 L/cow (n = 5). Cow-calf and stocker operations in the Northern Plains reported a mean of 46 L of diesel equivalent/animal, with a range of 21 to 76 L/animal (n = 4), whereas the cow-calf–to–finish operation reported 38 L of diesel equivalent/animal. In the Midwest, 25 L/animal was reported for a cow-calf–to–finish operation. The stocker-only operation in the Midwest reported fuel use of 8 L/animal. Annual liquid petroleum gas use was reported on only a few operations in both regions, and this was used primarily for heating indoor facilities.

The reported mean annual electricity use in the Northern Plains was 183 kWh/cow, ranging from 11 to 555 kWh/cow, on cow-calf only operations (n = 6) and 119 kWh/animal (17 to 279 kWh/animal) on cow-calf and stocker ranches (n = 4). Reported mean annual electricity use on Midwest cow-calf only operations was 75 kWh/cow, ranging from 17 to 218 kWh/cow (n = 9). Two cow-calf and stocker operations reported 30 and 31 kWh/animal. Meanwhile, a cow-calf–to–finish and stocker-only operation each reported 91 and 5 kWh/animal, respectively, in the Midwest. High electricity use was associated with pump operation for irrigation on ranches producing feed crops.

Feedlots

A total of 120 feedlot responses were received, with 46 from the Northern Plains and 74 from the Midwest. The responses included 26 feedlot visits, 13 from each region. Of the responses from the Northern Plains, 26, 12, and 8 were from Nebraska, South Dakota, and North Dakota, respectively. Sixty-five percent of the responses from the Northern Plains were from central and eastern Nebraska and eastern South Dakota. Responses in the Midwest were as follows: Iowa (43), Michigan (11), Minnesota (8), Illinois (6), Wisconsin (5), Indiana (1), and none from Missouri. The number of animals represented in each state by our survey were highly correlated (r = 0.98) with the reported number of animals on feed in each state (Figure 1; NASS, 2015), with Nebraska and Iowa having the highest representation and Indiana and Missouri the lowest.

Feedlot Sizes and Types. The major difference in feedlots across the 2 regions was size. Significantly larger feedlots were reported in the Northern Plains than the Midwest ($P < 0.05$), with mean and maximum capacities of 4,956 and 45,000 cattle in the Northern Plains and 1,412 and 10,000 cattle in the Midwest (Table 3), respectively. Considering our previous survey of the Southern Plains, which reported feedlot mean and maximum capacities of 39,220 and 115,000 cattle (Asem-Hiablie et al., 2015), feedlot size decreased moving north through the Great Plains states. Cattle finished annually averaged 125 ± 60% of their one-time capacities on feedlots in both the Northern Plains and the Midwest regions, suggesting that on average, a little over one cycle of cattle were finished each year. A few feedlots in Iowa and Wisconsin reported finishing between 250 and 300% of their capacities annually.

Feedlot capacities varied across states and regions, with responses from the major feeder states reflecting trends reported in the national agricultural census, where Nebraska had the second highest number of cattle on feed (2.75 million) in the United States in 2012 (Figure 1; NASS, 2015). The current survey reported Nebraska as having the largest feedlots in the Northern Plains (capacities ranging between 9,000 and 45,000 cattle). These large operations were concentrated in the east and center of the state. Within the Midwest, Iowa was the only state reporting feedlots with capacities of 5,000 or more cattle.

The Northern Plains reported 11% of operations as backgrounding only, half of which were in the western part of the region. No backgrounding-only operations were reported in the Midwest, and only 13% of operations throughout this region backgrounded all of their finished cattle. Some participating feedlots maintained stockers on grazed forage as part of their operations (Table 4). This represented only 2.6% of the cattle finished in both regions (Table 4).

Holsteins culled from dairies were finished on 14% of reporting operations in the Northern Plains, and 5 to 50% of the cattle finished on these feedlots were Holstein. With more dairy farms in the Midwest, 32% of feedlots reported finishing some Holsteins, representing an average of 57% of the cattle finished on those operations. A tenth of these operations in the Midwest maintained Holsteins only, and these were located in Michigan and Iowa. Holsteins made up 9% of the cattle finished in the Midwest and 5% of those finished in the Northern Plains (Table 4).

Cattle Management. The mean entering BW on feedlots reported for the Northern Plains and Midwest were 303 ± 40 kg and 290 ± 63 kg, respectively (Table 3). In general, feedlots bringing in lighter weight cattle backgrounded their cattle. The mean final BW reported was 612 ± 34 kg and 617 ± 46 kg for the Northern Plains and Midwest, respectively. South Dakota had the highest entry and finish BW within its region aside from which no other observable trends across states or regions were observed.

The mean portion of the cattle herd backgrounded was significantly higher in the Northern Plains than in the Midwest ($P < 0.05$; Table 3). About 72% of the operations in the Northern Plains and 32% in the Midwest reported backgrounding 50 and 20%, respectively, of cattle finished. The feedlot with the longest backgrounding period of 225 d was an all-Holstein cattle operation. The average backgrounding feed rations reported are shown in Figure 2. A lower mean DMI was reported for backgrounding cattle in the Midwest compared with the Northern Plains ($P < 0.05$), and slightly more corn grain and forage and less distillers grain were reported for diets in the Midwest than the Northern Plains. About 16 to 30% of DMI was from distillers grain, and 9 to 12% came from various other by-product feeds.

Cattle were on finishing rations for periods ranging from 70 to 420 d. Finishing periods were generally longer in the Midwest than the Northern Plains ($P < 0.05$), partly due to more finishing of Holstein cattle (Table 4). The operations reporting the longest finishing periods of 420 and 406 d were Holstein finishing operations located in Michigan, with low entering BW of 91 and 159 kg, respectively. The mean finishing DMI were similar for the Northern Plains and Midwest (Table 3). Rations were similar across the regions, with about half of the ration being corn grain, 15% some form of forage, 2% minerals, and the remaining third being distillers grain and other by-product feeds (Figure 2b). There was an indication of feeding less distillers grain and more other by-product feeds in the Midwest. The reported mean CP contents in finishing diets were similar in both regions as well (Table 3).

Use of growth-enhancing technology was common, with 95% of cattle produced in both regions receiving

Table 3. Summary of feedlot and feeding characteristics from survey responses in the Midwest and Northern Plains[1]

Location and Management characteristic	Unit	Mean	Median	Range		SD	Responses
				Minimum	Maximum		
Midwest							
Maximum capacity	cattle	1,412[a]	900	5	10,000	1,883	74
Cattle finished:capacity	ratio	1.3	1.3	0.2	3.0	0.62	72
Stocker cattle grazed[2]	cattle	316	95	10	2300	669	11
Entering weight	kg	290	303	91	386	63	72
Finished weight	kg	617	617	431	692	46	71
Portion backgrounded	%	19.9[a]	0	0	100	36	71
Backgrounding period	d	88	90	28	140	34	18
Backgrounding feed intake consumption	kg of DM/d per animal	7.7[a]	8.2	3.2	10.5	2.3	15
CP of backgrounding diet	%	14.1	13.3	11.8	20.0	2.2	15
Finish period	d	175[a]	161	70	420	73	62
Finishing feed intake	kg of DM/d per animal	10.5	10.4	8.2	13.6	1.2	53
CP of finish diet	%	13.6	13.1	11.2	23.0	2.0	54
Labor use	h/animal per year	5.0	3.06	0.7	29.34	5.78	57
Northern Plains							
Maximum capacity	cattle	4,956[b]	2,750	10	45,000	7,715	46
Cattle finished:capacity	ratio	1.2	1.1	0.3	2.4	0.60	38
Stocker cattle grazed[2]	cattle	693	250	10	2600	867	14
Entering weight	kg	303	295	234	386	39.6	41
Finished weight	kg	612	613	499	680	33.7	38
Portion backgrounded	%	50.2[b]	40	0	100	44.4	40
Backgrounding period	d	98	85	30	225	51.7	27
Backgrounding feed intake consumption	kg of DM/d per animal	8.9[b]	9.1	6.1	11.8	1.7	20
Finish period	d	137[b]	135	84	280	37.7	28
Finishing feed intake	kg of DM/d per animal	10.9	11.1	8.9	12.2	0.9	19
CP of finish diet	%	14.1	13.5	12.0	17.2	1.5	23
Labor use	h/animal per year	4.6	1.9	0.5	26.2	6.22	29

[a,b]Mean values of a management characteristic with different superscripts are significantly different between regions ($P < 0.05$).

[1]Midwest responses include Iowa (n = 43), Michigan (n = 11), Minnesota (n = 8), Illinois (n = 6), Wisconsin (n = 5), and Indiana (n = 1). Northern Plain responses include Nebraska (n = 26), South Dakota (n = 12), and North Dakota, (n = 8).

[2]For operations reporting the grazing of stocker cattle, 85% in Midwest and 70% in Northern Plains did not graze any cattle.

some type of technology and only 5% reported as finished "natural," i.e., without any growth-enhancing technology (Table 4). Overall, 24% of responding feedlots in both the Midwest and Northern Plains (n = 93) finished some cattle without the use of growth-enhancing technologies, but the portion finished "natural" was normally less than 50%. Only 4% of all operations reported finishing 90% or more of their cattle without any technology. Growth-enhancing technologies used in the Northern Plains (n = 29) included implants (83% of feedlots), ionophores (mostly monensin, 96%), β-agonists (45%), and tylosin (10%). In the Midwest (n = 68), growth-enhancing technologies included implants (93% of feedlots), ionophores (usually monensin, 87%), β-agonists (28%), tylosin (12%), and estrus synchronizing hormones (melengestrol acetate, 6%). A ranch in the Midwest also reported probiotic use.

Feed Production Practices. In both regions, over 90% of respondents reported the production of feed crops on their operations, with a crop area of 0.066 ha/animal finished in the Northern Plains and 0.243 ha in the Midwest (Table 4). The few operations that reported unusually high cultivated crop areas per finished animal (1.14 and 1.51 ha in the Northern Plains and Midwest, respectively) also operated at 8.3 and 50.0% of their full capacity during the study year with fewer animals to feed. Some operations, especially in the Midwest, reported feed production in excess of

Table 4. Summary of feedlot management characteristics from survey responses in the Midwest and Northern Plains[1]

Characteristic	Units	Midwest	Northern Plains	Overall
Feed crops produced	% of operations	91	94	93
Corn grain	ha/animal finished[2]	0.207	0.039	0.108
Corn silage	ha/animal finished	0.017	0.013	0.015
Alfalfa	ha/animal finished	0.006	0.009	0.008
Small grain	ha/animal finished	0.006	0.003	0.004
Grass and miscellaneous crops	ha/animal finished	0.007	0.002	0.004
Total cropland	ha/animal finished	0.243	0.066	0.139
Housing facilities	% of operations	99	98	98
Open lot	% of operations	47	95	75
Bedded back or hoop barn	% of operations	61	5	28
Free stall or slatted floor barn	% of operations	20	0	8
Stocker cattle maintained on pasture	% of operations	16	30	24
Portion of cattle finished on operation[3]	% of finished cattle	36	36	36
Portion of cattle finished in region	% of finished cattle	2.4	2.7	2.6
Holstein cattle finished	% of operations	32	14	21
Portion finished on operation[4]	% of finished cattle	57	18	34
Portion finished in region	% of finished cattle	8.6	4.9	6.6
Cattle finished natural	% of operations	15	31	24
Portion finished on natural operations[5]	% of finished cattle	40	53	48
Portion finished in region	% of finished cattle	4.7	4.6	4.6
Manure removal				
Once per year	% of operations	8	37	25
Twice per year	% of operations	27	27	27
3 or 4 times per year	% of operations	19	23	21
More than 4 times per year	% of operations	46	13	27
Manure use				
Applied to feed producing cropland	% of manure	92	38	60
Applied to nonfeed crops	% of manure	8	14	12
Processed and sold as compost	% of manure	0	49	29

[1]Midwest responses include Iowa (n = 43), Michigan (n = 11), Minnesota (n = 8), Illinois (n = 6), Wisconsin (n = 5), and Indiana (n = 1). Northern Plain responses include Nebraska (n = 26), South Dakota (n = 12), and North Dakota, (n = 8).

[2]Hectares produced per finished animal for all operations producing crops.

[3]The portion of total cattle finished that are grazed on those operations that include grazing of stockers.

[4]The average portion of Holsteins in the herd on those operations that include Holstein cattle.

[5]The portion of cattle finished without growth-promoting technologies on operations that finish some or all of their cattle without these technologies.

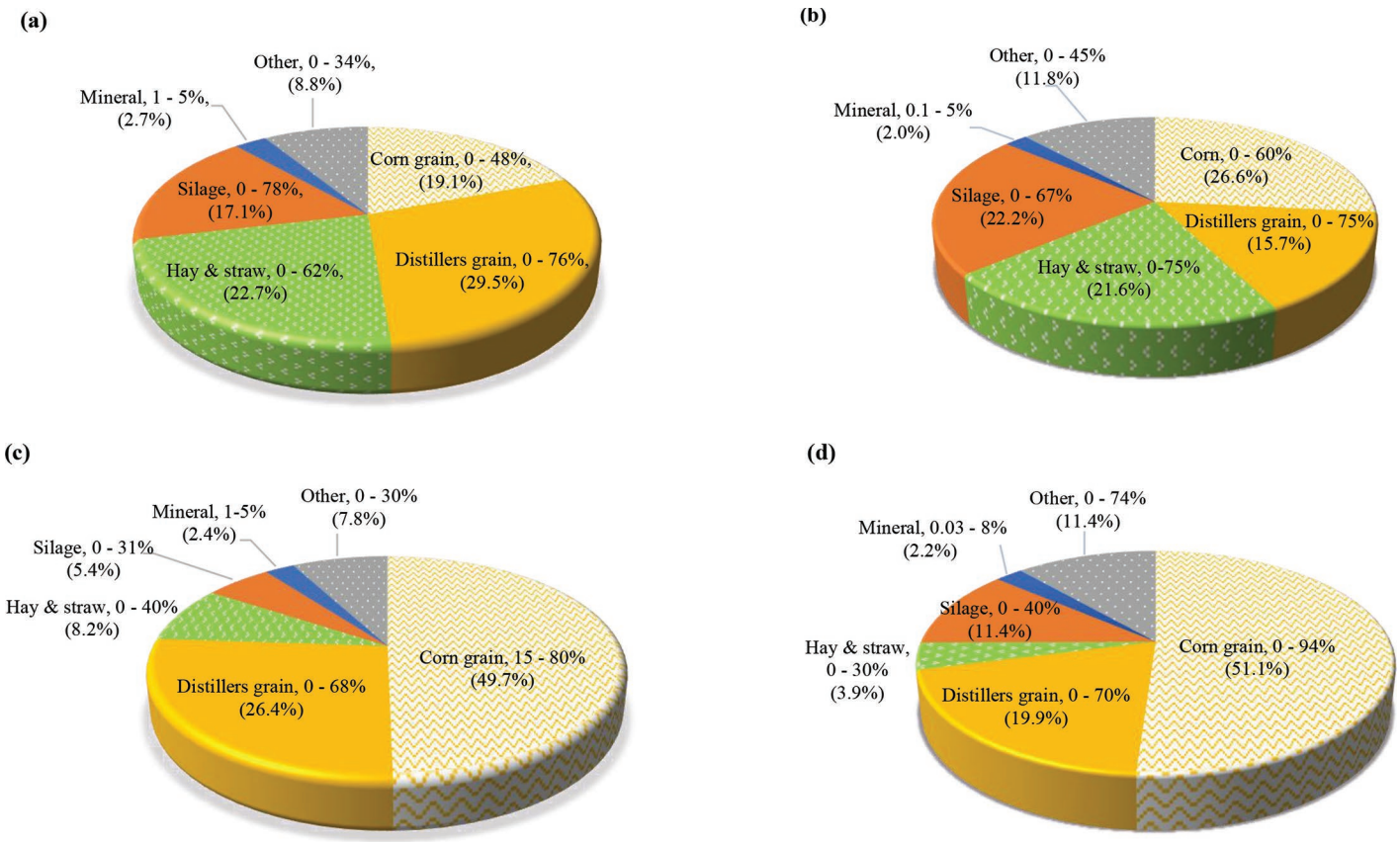

Figure 2. Range (mean) of backgrounding diet constituents making up total DMI averaged over all participating feedlots in (a) the Northern Plains and (b) the Midwest. Range (mean) of finishing diet constituents making up total DMI averaged over all participating feedlots in (c) the Northern Plains and (d) the Midwest. Color version available online.

what was needed for their animals. Because these values were primarily for cash crop sales, they were removed from our analysis of the total land area cultivated.

Corn grain, corn silage, and alfalfa were the major crops grown in both regions for cattle feed (Table 4). Corn grain was cultivated by 71 and 97% of feedlots growing feed in the Northern Plains (n = 31) and Midwest (n = 62), respectively, whereas corn silage was produced by 42% in the Northern Plains and 60% in the Midwest. Alfalfa was produced by 52 and 35% of feedlots in the Northern Plains and Midwest, respectively. The average area of corn grain produced per finished animal was much greater in the Midwest than the Northern Plains, but production values per animal for corn silage, alfalfa, grass, and small grains were similar across both regions (Table 4). Based upon the feeding data reported in the survey and typical crop yields in these regions, reported land areas in each crop would meet the feed needs of the cattle produced. An exception was the lower corn grain production in the Northern Plains, which indicates that a substantial amount of corn grain is purchased by many of these feedlots. In the Midwest, the reported corn grain area was about double that required for feed.

Annual soil amendment use on cropland was primarily used on the 3 major crops of participating feedlots. The use of N fertilizer in the Northern Plains was reported by 74% of corn grain growers, 80% for corn silage, and 25% for those producing alfalfa. When used, nitrogen fertilizer was applied to corn grain, corn silage, and alfalfa at average rates of 163 ± 56, 154 ± 64, and 42 ± 34 kg/ha, respectively. When nitrogen was applied on corn, anhydrous ammonia, urea, or both were used on most (90%) of the operations, with less use of urea ammonium nitrate (20%) and ammonium sulfate (12%). In the Midwest, about 70% of those producing corn reported the use of N fertilizer, with an average application rate of 160 ± 50 kg/ha for both grain and silage. Types of fertilizer used were anhydrous ammonia (45% of feedlots), urea ammonium nitrate (41%), urea (30%), and ammonium sulfate (10%). Among alfalfa growers, 19% used some N fertilizer at an average rate of 56 ± 60 kg/ha. Manure use as fertilizer was reported by 15% of corn grain producing feedlots and 5% of corn silage growers in these regions; this was mostly applied as water from runoff retention ponds. A few Midwestern feedlots applied swine manure.

In both the Northern Plains and Midwest regions, about half of the producers reported the use of phosphate fertilizer on corn land, with 30 to 40% use on alfalfa. For those applying phosphate fertilizer, the mean application rate on corn land was 48

± 25 kg of P_2O_5/ha in the Northern Plains and 55 ± 28 kg of P_2O_5/ha in the Midwest. On alfalfa, 38% reported the use of phosphate in the Northern Plains at an average rate of 69 ± 25 kg/ha. In the Midwest, 29% applied phosphate on alfalfa land at an average rate of 84 ± 78 kg/ha. Potash use was reported by 27% of corn grain producers and 38% of corn silage producers in the Northern Plains at mean rates of 19 ± 25 and 24 ± 25 kg of K_2O/ha, respectively. In the Midwest, potash was applied to corn land by about half of the operations at a mean rate of 69 ± 34 kg of K_2O/ha. For alfalfa, 25% of those producing the crop in the Northern Plains applied potash at a rate of 69 ± 25 kg of K_2O/ha, and in the Midwest 60% used potash at an average rate of 204 ± 154 kg of K_2O/ha. Soil pH was not a constraint in the Northern Plains; just one feedlot in eastern Nebraska reported lime application. Lime use was more common in the Midwest, where 30% of corn grain, 40% of corn silage, and 42% of alfalfa producing operations applied lime at reported average annual rates of 2.5 ± 0.6, 2.5 ± 0.9, and 2.2 ± 1.9 t/ha, respectively.

Irrigation was used most heavily in the Northern Plains, where 50% of those producing corn and 20% of those producing alfalfa used irrigation. Reported maximum annual irrigation amounts were 254 ± 102, 234 ± 158, and 398 ± 96 mm for corn grain, corn silage, and alfalfa, respectively. In the Midwest, irrigation use was reported by about 10% of the feedlots who produced corn at maximum rates of 150 to 760 mm/yr. Just one feedlot each reported using irrigation for alfalfa at maximum rates of 127 and 635 mm/yr.

Among feedlots producing feed crops in the Northern Plains, no tillage (defined as one pass for seeding only) crop establishment was used by 43% of grain crop producers and 27% of forage crop producers. Second in popularity among respondents in the Northern Plains was minimum tillage, defined as 2 or 3 passes, which was used on 43 and 20% of feedlots producing grain and forage crops, respectively. In the Midwest, minimum tillage was most common and practiced by 64 and 57% of respondents producing grain and forage crops, respectively. About 14% of grain crop growers in both regions, and 7 and 4% for those producing forage crops in the Northern Plains and Midwest, respectively, used conventional tillage practices (more than 3 passes).

Dry hay, when produced in the Northern Plains (n = 24 feedlots) was mostly stored uncovered outdoors as indicated by 89% of respondents; 15% of respondents reported indoor storage. In the Midwest, dry hay was stored indoors, uncovered outdoors, or covered outdoors by 69, 49, and 16% of producers, respectively (n = 45). All alfalfa, grass, and corn silage produced in the Northern Plains (n = 29) was reported to be stored in bunker silos or piles with covers used on 89% of the corn silage and 55% of the alfalfa or grass silage facilities. For the 23 feedlots who produced alfalfa or grass silage in the Midwest, 57% used covered bunkers or piles, 26% bags, 17% tower silos, 9% uncovered bunkers or piles, and 4% bale silage. Corn silage was stored in covered bunkers or piles (44% of feedlots), uncovered bunkers or piles (16%), bags (15%), and tower silos (10%). Corn grain in the Northern Plains was harvested and stored dry by 15 feedlots using grain bins (80%) or covered piles (8%). High moisture grain was used on 26% of Northern Plains operations and stored mostly in bunker silos (92% of feedlots) or tower silos (16%). In the Midwest, dry corn grain was stored by half of feedlots and mostly (95%) in grain bins, covered piles, or both (8%). High moisture grain produced on half of Midwest feedlots was stored in bunker silos (66%), tower silos (61%), or both.

Manure Management. Complete manure removal from individual pens was done once or twice annually by the majority of respondents (64%) in the Northern Plains (Table 4). In the Midwest, 46% of the responding feedlots removed manure at least 4 times a year. Ninety-two percent of the manure from feedlots in the Midwest was reported to be applied to cropland producing feed, with the remainder applied to other types of crops. No operation in this region reported composting with export of manure. In the Northern Plains, 49% of the manure produced was reported to be composted and sold from the operation. This primarily occurred on a few large operations. Of the remaining manure, 73% was applied to cropland producing cattle feed, with 27% applied to other cropland.

Labor Requirement. The mean annual labor required per animal produced was similar for both regions (4.6 person-h in the Northern Plains and 5.0 person-h in the Midwest), with a large variation among feedlots. No trend was observed with feedlot size. In the Northern Plains, feedlots that backgrounded cattle required more labor per animal finished as shown by a mean of 2.0 person-h/animal on finishing-only operations.

Equipment. Equipment use information for feedlots was obtained only from on-site visits. Thirteen operations in each region, including 3 backgrounding feedlots in the Northern Plains, were visited. The type, size, and number of equipment used on feedlots varied depending on the use of custom-hired operations. A similar observation was made in the Southern Plains (Asem-Hiablie et al., 2015). Common equipment in both regions were tractors, ATV, semitrucks and trailers, and smaller trucks (pickup; single, tandem, and triaxial), skid-steer loaders, and payloaders. Also reported in the Northern Plains were earth moving equipment (excavator and grader) and a 220-kW forage harvester. In the Midwest, tractor-operated grain drilling, corn planting, spraying, and baling equipment as well as feed wagons and manure spreaders were also reported by some feedlots.

On the average, there were 3 tractors per operation. Tractor sizes ranged from 81 to 272 kW in the Northern Plains and 23 to 206 kW in the Midwest. No relationship was found between tractor number and

size and the size of the operation. Most feedlots had 1 or 2 payloaders. Payloaders ranged in size from 74 to 110 kW in the Northern Plains and 48 to 118 kW in the Midwest. One payloader was reported for every 695 to 17,827 animals fed in the Northern Plains and 250 to 3,250 animals fed in the Midwest. Skid-steer loaders (about 60 kW) were used to feed an average of 6,127 cattle per loader in the Northern Plains and 2,296 cattle in the Midwest.

On average, there were 4 trucks per feedlot in the Northern Plains and 2 in the Midwest. Most feedlots in the Midwest reported 1 feed truck, whereas those in the Northern Plains had up to 3. There were often 2 or 3 ATV per feedlot in the Northern Plains and 1 per operation in the Midwest. Reported vehicle use was very variable with 88 to 8,103 cattle fed per pickup truck, 350 to 7,000 cattle fed per feed truck and 332 to 8,914 cattle fed per ATV. Semitrucks and trailers were mostly custom hired except for the feedlots who owned them; the reported use was 2,258 to 6,300 cattle per semitruck or trailer.

Energy Use. Annual energy use information was also obtained from feedlot visits in both regions. Mean annual fuel use was estimated at 11 L of diesel equivalent/animal fed in the Northern Plains with a range of 5 to 16 L of diesel equivalent/animal (n = 4). This was slightly greater than that found for larger feedyard operations in the Southern Plains (Asem-Hiablie et al., 2015). In the Midwest, fuel use information was available from 3 feedlots finishing 96, 350, and 738 cattle per year, with reported usage of 99, 112, and 10 L of diesel/animal fed, respectively. The smallest feedlot with higher fuel use grew all its feed and finished about one-fourth of its reported capacity. The wide variation in reported values was related to the amount of feed produced by the feedlots and the custom operations used.

Natural gas was primarily used for processing cattle feed. The reported consumption was given as 8 and 86 m^3/finished animal on 2 feedlots of the Northern Plains who finished 6,800 and 12,600 cattle annually, respectively. In the Midwest, no reported natural gas use was obtained from feedlot visits. Propane use of 0.5 and 1.3 L/animal was also reported from 2 feedlots in the Northern Plains who finished 4,520 and 5,170 cattle, respectively. A facility finishing 96 animals in the Midwest reported propane use of 11 L/animal.

Reported mean electricity use was 45 kWh/animal fed and ranged from 14 to 114 kWh/animal fed in the Northern Plains (n = 7). On Midwestern feedlots, a range of 4 to 49 kWh/animal fed and an average of 17 kWh/animal fed was reported (n = 12). Whereas the mean reported electricity use in the Northern Plains was similar to electrical use in the Southern Plains (about 35 kWh/animal; Asem-Hiablie et al., 2015), the value reported in the Midwest was less. The lower use in the Midwest may be related to less use of irrigation.

IMPLICATIONS

Regional characterization of cattle production systems is providing the basis for a comprehensive LCA to help quantify the sustainability of United States beef. This study reports data gathered from ranches and feedlots in 2 of 7 United States cattle producing regions: the Northern Plains and Midwest. The relative number of cows and finished animals reported from the 10 states studied compared well with the 2012 beef cattle rankings of NASS (2015) and hence appropriately represent these regions. The major differences in production practices (stocking rates; crop and pasture yields; and irrigation, fertilizer, and energy use) occurred between the wetter climate in the Midwest and the semiarid climate on the west side of the Northern Plains. Ranch herd sizes also increased westward, and the largest feedlots were found in the southwest portion of the 2 regions. These differences continued trends previously found in a survey of the Southern Plains (Asem-Hiablie et al., 2015).

ACKNOWLEDGMENTS

This study was funded in part by The Beef Checkoff and the USDA's Agricultural Research Service. The authors thank the producers and members of the National Cattlemen's Beef Association for their help in providing information supporting this analysis.

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