Examining the Impact of a Beef Marbling Tolerance of 40,
Ribeye Size and Marbling Texture

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Concerns have been expressed regarding the marbling tolerance of 100 for instrument marbling score overrides. The tolerance was deemed to be too wide to allow for the proper adjustment of inaccurate grades assigned by the camera thought to arise from carcasses having certain characteristics (*e.g.*, large or small ribeye areas, coarse marbling).

In response to this concern, the Standardization Branch conducted a multiple-plant study to examine the impact of a marbling tolerance of 40. Further, data was collected to ascertain what effect ribeye size and marbling texture might have on marbling overrides.

Methodology
Plants
The study was conducted at National Beef Packing Co. and Cargill Meat Solutions in Dodge City, KS and at Greater Omaha Packing Co. and Nebraska Beef, Ltd. in Omaha, NE. The study was conducted during two one-week periods in the April to May 2015 timeframe. Personnel consisted of two staff from the Standardization Branch (SB) as well as the Supervisory Agricultural Marketing Specialist (SAMS) for each selected plant. Three of the plants utilized instrument grading systems manufactured by e+v Technology GmbH & Co (e+v). Two of the plants used an e+v LED based system while the third plant used an e+v Xenon based system. The fourth plant used an instrument grading system manufactured by Research Management Systems, Inc. (RMS).

Carcass Selection and Review
Carcasses were reviewed over a one to three day period in each plant. Carcasses were reviewed over several time segments in each plant where the first and last carcass ID for each segment was recorded. One SB staff assessed the carcass and instrument marbling at the four plants while the other SB staff recorded the carcass IDs, override marbling assessments and marbling texture scores. SAMS reviewed and measured the ribeye area (REA) for each of the override carcasses. Instrument data was subsequently collected from each plant for the carcasses reviewed. One plant was unable to provide carcass ID-linked hot carcass weights or REA for 779 carcasses.

Statistical Analysis
All analyses used the procedures of SAS (SAS Inst. Inc.). Exploratory analyses were conducted using the MEANS, FREQ and UNIVARIATE procedures to characterize the review sample

distribution type as well as to characterize the reviewed carcasses. Analysis for differences was conducted using MIXED and GLM procedures. The main effects of plant (instrument), REA size and marbling texture were analyzed for differences between the instrument marbling and the SB assessed marbling. Mean separations were performed using Tukey-Kramer test, with a predetermined significance level of P<0.05.

Results

Override Marbling Tolerance

The study reviewed 7,685 carcass to determine the impact of a marbling tolerance of 40 on overriding instrument marbling score. Further, the effect of ribeye size and marbling texture were also examined to ascertain any impact on marbling score overrides, a concern of USDA graders. Means for hot carcass weight, ribeye area, instrument marbling score, instrument and override quality grades are shown in Table 1. The factors have values and variation similar to those of the 2011 National Beef Quality Audit: an 825 ± 102 lb. hot carcass weight (± standard deviation); ribeye area of 13.8 ± 1.8 in^2; marbling score of 440 ± 98; and a quality grade of Select^{93} ± 0.61 (1.93)[1]. The similarity of both value and variation for these carcass factors indicates that the carcasses reviewed were similar to the national carcass population.

The review of 7,685 carcasses resulted in 5.3% marbling overrides (Table 2). 92.6% of the overrides were downgrades of the instrument marbling score to a lower value. The magnitudes of the override differences were similar for both the downgrades and upgrades for three of the four plants. There was no difference between Plant A, Plant B and Plant C but Plant D was significantly different (P<0.05) from the other three. Concerning upgrades and downgrades, the small number of upgrades precludes any firm conclusion in regards to the similarity between the magnitude of downgrades and upgrades.

The percent of overrides by plant are presented in Table 3. Of the overrides, 89.6% had an override magnitude difference of 40 or more. Override percentages varied by plant as well as the percentage of overrides that equaled or exceeded a magnitude of 40. Marbling overrides that resulted in a change in quality grade varied by plant (Table 4). The inconsistency in qualifying overrides (≥ 40) was most likely related to two factors: one, chain speed and the positioning of the monitor relative to carcasses for each plant; and two, the e+v LED systems displayed the marbling score to three digits (391 for the LED based systems versus 390 for the Xenon based systems).

Influence of Ribeye Area

The effect of ribeye size was examined to ascertain if there was any impact of large or small REA on marbling score overrides, a main concern expressed by USDA graders. To test the impact of small or large REA, the reviewed carcass sample was partitioned into 10th/90th and 25th/75th percentiles. The 10th/90th percentiles were composed of three partitions: 1, the smallest 10% of the REA; 2, the middle 80% of the REA; and 3, the largest 10% of the REA. Likewise, the 25th/75th percentiles were composed of three partitions: 1, the smallest 25% of

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[1] Journal of Animal Science 2012 90: 13: 5152-5158

the REA; 2, the middle 50% of the REA; and 3, the largest 25% of the REA. The two strategies for partitioning small/large REA were chosen to compare the results of the two since the $10^{th}/90^{th}$ percentile partitions had so few override carcasses in the 10th and 90th percentiles. The larger number of carcasses in the 25th and 75th percentiles allowed for a more robust analysis. However, comparisons were always performed for both to ensure that any conclusion from small or large REA was consistent. In the end, the same conclusions were reached with both.

Table 5 presents the number of carcasses in each partition as well as the mean marbling score. With both methods, the mean marbling scores were different (P<0.05) from the other partitions within each method and the marbling scores decreased with increasing REA. Marbling override difference was impacted by REA size with the smallest REA being different (P<0.05) from the larger partitions (Table 6). However, there were fewer overrides associated with the smaller REA as compared to the medium and large partitions. There was also a plant difference (P<0.05) in that the Plant D differed from the other three. This was a consequence of the equipment manufacture since the RMS system was found to be different (P<0.05) from the e+v systems. The marbling override differences as a function of REA size between the two manufactures are similar in that the smaller REA partition was associated with larger override differences than the two larger partitions (P<0.05; Table 7).

Figure 1 displays the marbling override difference as a function of REA. There does not appear to be a clear consistent trend associated with either the smaller or larger REA partitions other than the increased scatter as REA becomes smaller. The depicted scatter reflects the larger standard deviation (variability) of the 25th percentile partition (REA Size 1) of Tables 6 and 7. There were a higher number of overrides associated with the 75th percentile partition (REA Size 3); 7.7% of the 75th percentile partition carcasses reviewed. The other two partitions had 4.0% and 4.2% for 25th percentile and the middle partitions, respectively. A review of the histograms of the three partitions (Figure 2) suggests that the 75th percentile partition had more carcasses surrounding the Slight^{00} and Small^{00} grade lines than the 25th percentile partition.

The REA of carcasses deemed eligible for an override were assessed by SAMS. The difference between the instrument and SAMS assessed REA by plant is presented in Table 8. The average difference ranged from -0.03 to -0.65 in.^{2}. There was much larger range in the standard deviations, 0.25 to 1.12. The performance requirements[2] for operational accuracy, based on 200 or more observations, specifies an R^2 of 0.85 or greater, 95% of the observations within 2.0 in.^{2} and the residual standard deviation should be within 1.00 in.^{2}. Only one of the instrument plants had sufficient numbers to assess conformity, Plant A, and all parameters met the requirements. With respect to the other instrument plants, Plant B and Plant C met the residual standard deviation and 95% of the observations within 2.0 in.^{2} requirements. The instrument at Plant D did not meet the requirements. With respect to instrument approval, an actual mean REA was based on the average from three experts or from acetate traced REA readings. As such, the performance of three out of the four instruments is consistent with the

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[2] USDA. Procedures for Approval and Use of Instrument Systems for Beef Carcass Ribeye Measurement, 2003

prior approvals. However, the results for the Plant D instrument warrant a more thorough examination to ascertain if the performance is compliant with the performance standards.

Influence of Marbling Texture
The effect of marbling texture was examined to ascertain if there was any impact on marbling score overrides. The main concern expressed by USDA graders indicated that course marbling results in higher instrument marbling scores than what the marbling should be. This would suggest that as marbling became coarser, overrides would become more frequent and the marbling override difference would become larger. Table 9 summarizes the marbling override difference and the instrument marbling score by downgrades/upgrades, marbling texture and instrument manufacturer. For downgrades, marbling override difference was not influenced by marbling texture with the e+v instrument. In contrast, fine marbling texture was associated with a larger marbling override difference (P<0.05) than with medium or coarse marbling texture with the RMS instrument. More overrides were associated with the Small/Modest degree of marbling where marbling transitions from fine to medium texture. This was followed by the Slight/Small degree of marbling that encompasses the Slight[00] and Small[00] grade lines. The small number of upgrades precludes reaching any conclusion for either instrument manufacturer.

Other Areas of Influence
An analysis of the 10s digit of both the SB staff and instrument marbling scores was conducted to ascertain areas of attention. Table 11 presents a cross-tabulation table that shows where the most frequent overrides occurred between the SB staff and the instrument. The predominant areas of overlap occurred at 60-00 (expert-instrument), 70-10 and 80-20. It was expected that 90-30 would also be one of the predominant occurrences but 90-30 area occurred 1% of the time. The areas of 80-30 and 80-40 occurred at a much higher frequency than 90-30. As the bottom of Table 10 shows, the 10s digit of the instrument was equally distributed across all digits while the expert's distribution was located predominantly in the 50 to 80 digits range. It was anticipated that the expert's predominant override areas would have been in the 60 to 90 range, the cells marked by bold lines. The 90s digit will need to be an area of focus to ensure that all marbling scores are treated equitably.

Economic Impact of the Proposed 40 Unit Override
The economic impact of the propose instrument override was assessed by determining carcass value. The grade distribution was used to establish the fiscal impact by using carcass premiums and discounts that are published weekly by the USDA Livestock, Poultry, and Grain Market News. Table 11 presents the grade distributions using four different approaches: the instrument quality grade before overrides are applied; the quality grade for all of the recorded overrides; the quality grade for only those overrides that were actually 40 and greater; and, the quality grade for those overrides that were 50 and greater. Of the recorded overrides, 10.4% were less than 40 so an override of 50 or greater was added based on the thought that an override of 50 would be easier to estimate than 40. Further, an override of 50 resulted in 99.3% of the overrides being grade changes rather than 95.6% for an override of 40 (Table 4). A premium and discount per 1,000 carcasses was also estimated since a number of plants have

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capacities in multiples of 1,000. There was variation between plants. Some of this was due to the frequency of overrides but some of this was also due to the carcasses that were graded during the review and their grade distribution.

Summary
A review of 7,865 carcasses resulted in 5.3% overrides using an override tolerance of 40. However, only 89.6% of those overrides were actually 40 or greater. The percentage of overrides did differ by plant and by instrument system. There was a slight effect due to REA size with smaller ribeyes having a higher override difference then the two larger REA sizes. With respect to marbling texture, there was no difference of texture with the e+v systems. The RMS system had larger override differences for the fine textured marbling.

Table 1. Means, standard deviations, and minimum and maximum values for USDA carcass grade traits for the carcasses reviewed.

Factor	Mean	Std Dev	Minimum	Maximum	N
Hot Carcass Weight	871	119	363	1,377	6,908
Ribeye Area	13.8	1.7	8.2	21	6,903
Marbling Score	502	117	180	1,050	7,685
Instrument Quality Grade	1.89	0.52	0	3	7,685
Override Quality Grade	1.84	0.55	0	3	7,685

Hot carcass weight: pounds.
Ribeye area: square inches.
Marbling Score: Traces 200, Slight 300, Small 400, Modest 500, Moderate 600, Slightly Abundant 700
Quality Grade: No Roll 0, Select 1, Choice 2, Prime 3.

Table 2. Override occurrence, means, standard deviations, and minimum and maximum values for the marbling override difference magnitude by plant. Note, upgrades are displayed using a negative value.

Plant	# Carc	Overrides	Upgrades Avg	Std	Min	Max	n	Downgrades Avg	Std	Min	Max	n
Plant A	2,229	148	-49	29	-82	-25	3	55	23	21	198	145
Plant B	2,070	85	-48	25	-80	-20	4	59	27	30	200	81
Plant C	1,899	42	-49	22	-113	-15	16	52	55	1	297	26
Plant D	1,491	130	-30	35	-10	-70	3	76	42	0	360	123
Total	5,460	257					23					230

Table 3. Percentages of overrides and qualifying overrides by plant.

Plant	Overrides	<40	≥ 40
Plant A	6.6%	14.9%	85.1%
Plant B	4.1%	3.5%	96.5%
Plant C	2.2%	31.0%	69.0%
Plant D	8.7%	3.1%	96.9%
All	5.3%	10.4%	89.6%

Table 4. Percentage of marbling overrides that resulted in a quality grade change by plant.

Plant	Override Grade Change
Plant A	98.0%
Plant B	97.6%
Plant C	81.0%
Plant D	96.2%
All	95.6%

Table 5. Means and standard deviations for the instrument marbling score stratified by ribeye area size.

REA Size	10th/90th Percentile			25th/75th Percentile		
	n	Mean	Std Dev	n	Mean	Std Dev
1	659	514[a]	126	1,633	507[a]	127
2	5,595	502[b]	120	3,553	496[b]	118
3	649	445[c]	88	1,717	455[c]	97

a, b, c Least squares means within a column lacking a common superscript letter differ ($P < 0.05$)
Marbling Score: Traces 200, Slight 300, Small 400, Modest 500, Moderate 600, Slightly Abundant 700
Ribeye size: 10th/90th percentile, 1 11.7 in^2 or smaller, 2 middle, 3 16.1 in^2 or larger; 25th/75th percentile, 1 12.6 in^2 or smaller, 2 middle, 3 14.9 in^2 or larger

Table 6. Means and standard deviations for the marbling override magnitude and instrument marbling scores stratified by override direction and ribeye area size.

Override Direction	REA Size	Marbling Override Difference		Instrument Marbling		
		Mean	Std Dev	Mean	Std Dev	N
Down grade	1	76	44	503	139	56
	2	55	32	470	122	140
	3	58	23	429	95	126
Up grade	1	-48	22	453	156	9
	2	-53	27	524	153	11
	3	-33	17	443	133	6

Ribeye size: 1 25th percentile (12.6 in^2 or smaller), 2 middle 50%, 3 75th percentile (14.9 in^2 or larger)

Table 7. Means and standard deviations for the marbling override magnitude stratified by override direction and ribeye area size by instrument manufacture.

Override Direction	REA Size	E+V			RMS		
		Mean	Std Dev	N	Mean	Std Dev	N
Down grade	1	67	37	36	92	52	20
	2	51	32	109	69	31	31
	3	57	21	107	67	33	19
Up grade	1	-52	19	8	-10	–	1
	2	-55	25	9	-40	42	2
	3	-33	17	6	-	-	-

Ribeye size: 1 25th percentile (12.6 in^2 or smaller), 2 middle 50%, 3 75th percentile (14.9 in^2 or larger)

Table 8. Means and standard deviations of the difference between instrument and measured ribeye areas, and the percentage of the differences within the instrument performance requirement by plant.

	Instrument REA minus Measured REA		Within	
Plant	**Mean**	**Std Dev**	**2 inches^2**	**N**
Plant A	-0.09	0.73	96.2%	266
Plant B	-0.65	0.90	96.0%	100
Plant C	-0.03	0.25	100.0%	73
Plant D	-0.33	1.12	88.2%	68

Table 9. Means and standard deviations for the marbling override magnitude stratified by override direction and marbling texture by instrument manufacture.

Override Direction	Texture	E+V Mean	Std Dev	N	Marbling	Std Dev	RMS Mean	Std Dev	N	Marbling	Std Dev
Down grade	1	57	25	79	391	41	98	58	40	447	40
	2	56	32	160	430	61	66	28	82	572	82
	3	50	11	13	555	171	64	27	5	726	5
Up grade	1	-47	24	7	417	117	-	-	-	-	-
	2	-50	24	13	466	130	-70	-	1	660	-
	3	-46	8	3	548	236	-10	0	2	665	7

Texture: 1 Fine marbling, 2 medium marbling, 3 coarse marbling

Table 10. Instrument and expert ten's digit cross-tabulation.

Instrument 10's Digit

Expert's 10's Digit	0	10	20	30	40	50	60	70	80	90	Total
0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
30	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
40	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	2%
50	2%	2%	1%	0%	1%	1%	1%	0%	0%	1%	8%
60	9%	6%	4%	3%	1%	2%	1%	1%	1%	1%	29%
70	4%	12%	8%	4%	3%	2%	1%	1%	0%	0%	34%
80	1%	3%	8%	5%	3%	1%	1%	1%	0%	1%	23%
90	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%
Total	18%	24%	21%	12%	10%	6%	4%	2%	1%	3%	100%

All Cx Reviewed (n=7,685)

| 11%	10%	12%	9%	10%	9%	9%	10%	10%	10%

Table 11. Economic impact of the carcass premiums and discounts that would result from the change in quality grade distributions. Int QG, the instrument quality grade before overrides are applied; Ovr QG, the quality grade for all of the recorded overrides; Ovr 40 QG, the quality grade for only those overrides that were actually 40 and greater; and, Ovr 50 QG, the quality grade for those overrides that were 50 and greater.

| Source | No Roll | Se | Ch | Pr | Premium/Discounts per: | | | Difference from Int QG |
					CWT	800 lb Cx	1,000 Hd	
Int QG	0.47%	18.60%	72.64%	8.30%	$ (1.21)	$ (9.68)	$ (9,684)	$ -
Ovr QG	0.99%	21.54%	69.79%	7.69%	$ (1.79)	$ (14.34)	$ (14,344)	$ (4,660)
Ovr 40 QG	1.00%	21.21%	70.10%	7.69%	$ (1.76)	$ (14.05)	$ (14,050)	$ (4,367)
Ovr 50 QG	0.92%	20.16%	71.13%	7.79%	$ (1.59)	$ (12.73)	$ (12,734)	$ (3,050)

LM_CT169 5-Area Weekly Wtd Average Direct Slaughter Cattle - Premiums and Discounts for the week of 6/01/2015: Prime, $14.44; Choice, $0.00; Select, $(12.31); and Standard, $(25.46).
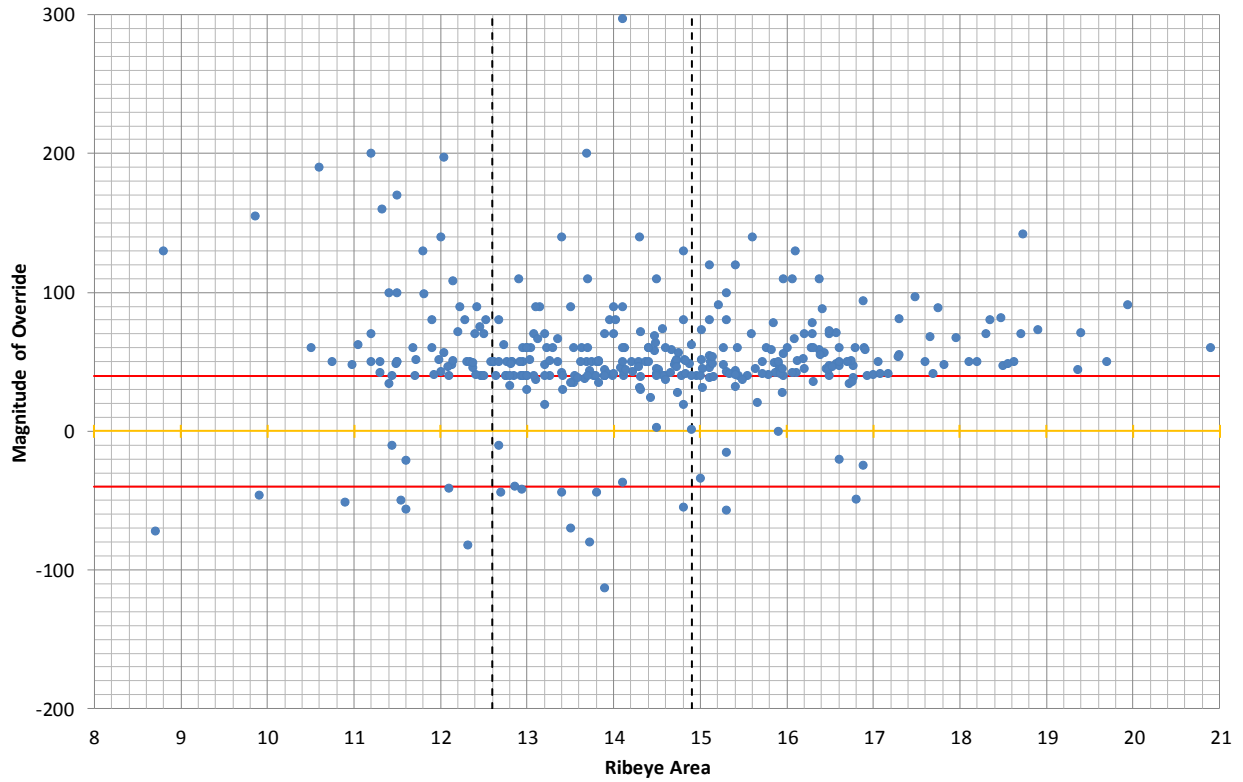
Figure 1. Scatter graph of the relationship between marbling score override magnitude and ribeye area. The gold horizontal line represents a condition when the override magnitude would be zero. The two horizontal lines represent an override of 40 and -40. The two vertical dotted lines represent the ribeye area cutoffs for the 25th and 75th percentiles for ribeye area for the carcasses reviewed.

25th Percentile

Middle 50%
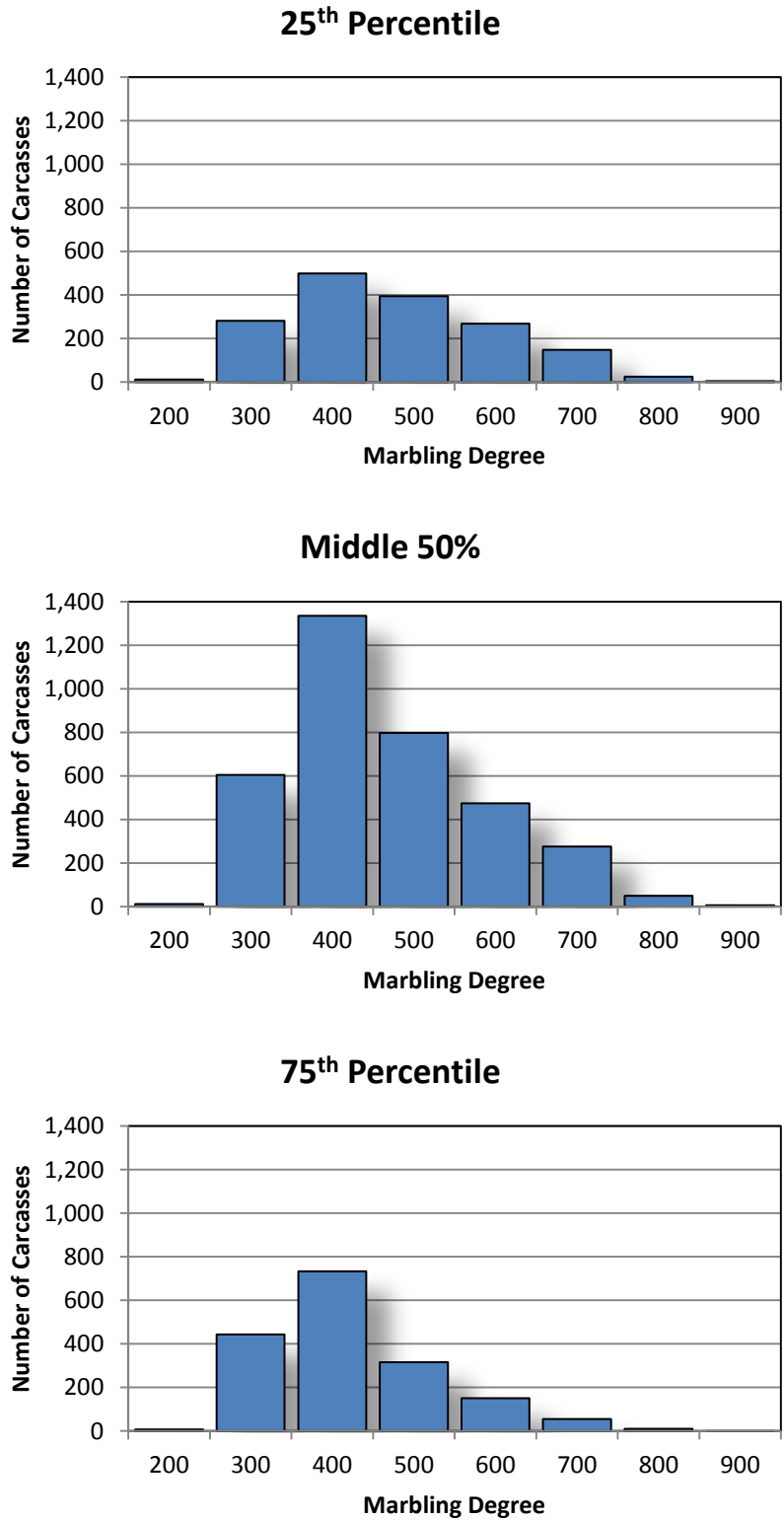
75th Percentile

Figure 2. Histograms of carcass numbers as a function of marbling degree. Ribeye size: 25th percentile (12.6 in2 or smaller), 75th percentile (14.9 in2 or larger).