Mineral Content of Range Grass

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The desire to lower cost of production, but maintain or improve animal performance, has range livestock producers interested in what minerals might be lacking in range forage so that they can provide their livestock these needed minerals. Some work has been done on determining the mineral content of grasses of the Northern Great Plains (Rauzi et al. 1969, Munshower and Neuman 1978, Grings et al. 1996) but it is not known if the results of these studies are applicable to rangeland grasses of northeast Wyoming. Objectives of this project were to determine the calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) contents of grasses found on Johnson County Wyoming ranches and relate the results to beef cattle and sheep mineral needs; and determine if ranch location and time of year had a significant affect on range grass mineral content. Goal of the latter two objectives was to determine when sampling of range grasses for mineral content should occur and the potential area of inference. Forage mineral analysis can be expensive so the minimum number of samples taken to obtain useful information is paramount in order for there to be a positive cost benefit ratio of this practice.

STUDY SITES AND METHODS

Initial sampling of range grasses occurred in May 2001 from pastures of the following ranches: Dave Hall's (Upper French Creek, 5 miles NW of Buffalo), Meikes' (Sussex area, 20 miles E of Kaycee), Jim Moore's (SE corner Johnson County and NW corner Converse County), Gene Vieh's Willow Creek Ranch at the Hole-in-the-Wall (30 miles SE of Kaycee), and Greg Cunningham's (12 miles NE of Kaycee - Reno Road). However, because of lack of funds for mineral analysis and drought conditions no further sampling was done until May 2002. Between mid-May and November 2002, 2003 and 2004 range grasses were periodically sampled from pastures at the above ranches, except in 2003 and 2004 at the Cunningham ranch due to its sale. In addition, sampling was done in March 2004 but not in 2005 due to a lack of forage because of drought conditions the previous growing season.

Current year's growth of prairie Junegrass, western wheatgrass, Sandberg's bluegrass, bluebunch wheatgrass, slender wheatgrass, needle-and-thread, green needlegrass, and threadleaf sedge – a grass like plant and henceforth included with the grasses – found within each of 10 sample hoops along a transect were clipped by species to a 1 inch stubble height. Total harvested herbage of each grass from a pasture transect was weighed, dried and weighed again to determine percent dry matter and forage yield. The dried material of each grass was ground and then analyzed for its Ca, P, K, Mg, S, Fe, Mn, Zn and Cu content by the University of Nebraska's Soil and Plant Analytical Laboratory. In addition, alfalfa/meadow brome grass hay and its regrowth at the Hall ranch, alfalfa hay either raised or purchased at the Meike, Moore, and Vieh ranches, and corn and forage sorghum silages raised at the Meike ranch were sampled in November 2004 and analyzed for their mineral, crude protein, and acid detergent fiber (ADF) contents.

A weighted average for each mineral of grasses from a pasture on a sampling date was determined by multiplying the mineral value of each grass by its percent of dry matter yield and then adding the values. For example: Western wheatgrass, needle-and-thread, prairie Junegrass, and threadleaf sedge were collected from a pasture in mid-May 2002 and they comprised 43, 37, 12, and 8%, respectively, of the total dry matter weight. Their Ca contents were 0.25, 0.15, 0.20, and 0.18%, respectively. Thus the weighted average for their Ca content would be 0.20% [(0.0025*0.43) + (0.0015*0.37) + (0.002*0.12) + (0.0018*0.08)] compared to a non-weighted average of 0.195% [(0.25+0.15+0.20+0.18)/4]. The difference in this example may appear small and inconsequential and the actual consumed amount of Ca by the animal may lie somewhere between these values. However, the assumption made is that the amount of each grass consumed by grazing livestock is in proportion to its availability. Though this assumption may not be fully accurate it is believed to be more accurate than using a non-weighted average to compare grass mineral contents to beef cattle and sheep mineral needs. In addition, dried material of each grass from a pasture and sampling date were composited by their % of dry matter yield and analyzed for mineral, crude protein and ADF contents. This was done to determine whether a composited sample – of which a rancher would submit for analysis – yielded similar mineral values as that obtained with a weighted average of individual samples. The ADF values were used to calculate forage net energy for maintenance (NEm) values.

The amount of mineral that a beef cow would potentially consume from range grass at each ranch (pasture averages) is shown in figures 1a – 9a and the amount a sheep ewe would potentially consume is shown in figures 1b – 9b. For the beef cow, mineral consumption amounts were based on the mineral and NEm contents of the grass as NEm influences the amount of forage a cow will consume. The minimum required amount of a mineral by the beef cow is also displayed in each figure and is based on her weight and stage of production. The depicted mineral requirements for the cow in the figures are for a 1250 pound March 1 calving cow with the calf weaned in mid-October.

Although NEm content of forage most likely influences the amount a sheep will consume of the forage, constants for each mineral to multiply by NEm of the forage have not been determined for sheep. Thus intake of a mineral by the ewe was based on its content in the grass multiplied by the estimated pounds of forage dry matter the ewe would consume at various production stages. As with the beef cow, the minimum amount required of a mineral by the ewe based on her weight and production stage is also displayed in each figure. The depicted mineral requirements are for 154 pound April 1 lambing ewe with lamb(s) weaned the first of September. Lactation values are an average of the required amounts for a single lamb suckling ewe and for one suckling twins.

RESULTS AND DISCUSSION

Phosphorus (P)

Range grass at the Hall ranch generally contained the highest amount of P over the entire study period at an average of 0.15% and those at the Vieh ranch the least at 0.09% (Table 1). Soils of the Vieh ranch may contain more Ca compared to the other ranches resulting in a greater fixation of P into calcium-phosphate compounds reducing the amount available for plant absorption (Bohn et al. 1985).

As grass matured and weathered P content declined significantly at all ranches from an average of 0.23% in May to 0.005% in March (Table 1). This decline in P content would result in the beef cow potentially not being able to consume an adequate amount of P to meet her needs after early June (Figure 1a). However, if little to no new growth is present, as was the case in early June 2004 due to drought conditions, then P content of the range grass may not be sufficient to meet her needs at this time of year as well. In addition, the amount of P that the sheep ewe would potentially consume from the grass at these ranches would not satisfy her needs (Figure 1b).

The amount of P supplement needed to satisfy the daily P requirement of the beef cow would range from an average of 0.015 pounds in early summer to 0.026 pounds by fall; to 0.53 pounds by late winter. This is assuming that the beef cow does not obtain additional P from other forage sources within the pastures. Likewise the amount of P supplement needed by the sheep ewe to meet her daily requirements would range from 0.004 pounds in May to 0.008 pounds by early summer; to 0.010 pounds during the summer; falling to 0.006 pounds by fall following weaning and again up to 0.01 pounds by late winter.

The alfalfa and alfalfa/meadow brome hays contained an adequate amount of P to meet the needs of the beef cow in all stages of production, except for the alfalfa hay from the Meike ranch which contained only enough to meet her needs when she was not in lactation (Table 1). Corn silage from the Meike ranch contained an adequate level of P to meet her needs in all production stages but the forage sorghum silage contained only enough P to meet her needs when not in lactation. However, for the corn and sorghum silages to meet the P needs of the cow they would have to make up half and two-thirds of her diet, respectively, when she was not in lactation and the corn silage would have to consist of 75% of her diet to meet her needs during lactation. Although the sorghum silage contained a similar amount of P as the corn silage its lower NEm content (0.49 compared to 0.68 Mcal/lb) is why it did not provide a sufficient amount of P to meet the needs of the cow when she was in lactation. The amount of P, as well as other minerals, consumed by the cow is related to the amount of NEm she consumes not necessarily the amount in pounds of dry matter. Because of her higher %P needs the sheep ewe would not be able to obtain an adequate amount of P to meet her needs from the hays and silages. Hay field regrowth at the Hall ranch contained no measurable amount of P thus supplementation with P would need to occur.

Calcium (Ca)

The amount of Ca the beef cow or sheep ewe would potentially consume from range grass at the ranches appeared to be sufficient to meet their needs (Figures 2a and 2b). Others (Rauzi et al. 1969, Sims and Taylor 1973, Munshower and Neuman 1978, Greene et al. 1987, Grings et al. 1996) have also found range grasses to contain an adequate amount of Ca to meet livestock nutrient needs.

Calcium content of range grass at the Vieh ranch had the highest average at 0.61% and was lowest at the Meike ranch with an average of 0.47% (Table 2). Grass Ca content apparently accumulates in grass tissue as the plants mature as their Ca content in May and June averaged 0.47% but averaged 0.62% in samples collected in the summer and fall. However, as the plants weather Ca content appears to decline as the average level in March was 0.34%.

The alfalfa/meadow brome hay and hay field regrowth from the Hall ranch, the alfalfa hays at the other ranches, and the corn and forage sorghum silages from the Meike ranch all contained an adequate amount of Ca to meet the needs of the beef cow and sheep ewe in all stages of production (Table 2).

Calcium: Phosphorus Ratios

The amount of Ca in the diet of a beef cow and sheep ewe needs to be at least 1.5 times greater than the amount of P in their diet but should not exceed 7 times that of P. Generally Ca: P ratios of range grass were greater than 1.5: 1 and less than 7: 1 (Table 3). However, when P content was very low or non-existent the Ca: P ratios were high. Correcting P deficiencies (Figures 1a and 1b) generally resulted in acceptable Ca: P ratios. However, if correction of a P deficiency did not result in an acceptable Ca: P ratio the supplying of additional P above the animal's stated needs may be necessary to correct the imbalance.

Calcium: Phosphorus ratios for the hays were all greater than 7: 1 indicating that additional P should be provided the livestock when these hays are fed, whereas ratios for the silages was within the acceptable range of 1.5 to 7 (Table 3). With no measurable P detected for the hay field regrowth at the Hall ranch there would be no ratio and P would need to be provided up to the animals needs and in balance with the amount of Ca they were obtaining from the regrowth.

Potassium (K)

Potassium content of range grass was somewhat similar among the ranches with grass at the Cunningham and Hall ranches having the highest average at 1.6% and that at the Meike ranch the lowest at an average of 1.25% (Table 4). Range grass K content declined significantly as plants matured and weathered from an average high of 2.03% in May to a low of 0.23% in March. Mengel and Kirkby (1987) reported that the bulk of the K ion is taken up during vegetative growth and as plants mature and no new tissue is developed, K leaches from the leaves.

Except for winter grass, the amount of K the beef cow and sheep ewe would potentially consume from the grass would be adequate to meet their needs (Figure 3a and 3b). The average amount of K supplement that should be provided the cow and ewe to meet their needs when grazing winter range grass would be 0.19 and 0.015 pounds per day, respectively.

The hays, hay field regrowth, and silages would provide a sufficient amount of K to meet the needs of the beef cow and sheep ewe in all stages of production (Table 4). Feeding these hays to the sheep ewe and the beef cow to make up for the K deficiency of the native range pastures in late March would require a low of 0.8 and 8 pounds per day of the alfalfa/meadow brome hay from the Hall ranch and a high of 1.6 and 16 pounds per day of the alfalfa hay at the Vieh ranch, respectively. The ewe and cow would need to consume 1.1 and 11 pounds per day, respectively, of corn silage from the Meike ranch to meet their K requirements when grazing native range in late March. Whereas the ewe and cow would need to consume only 0.6 and 6 pounds per day, respectively, of the Meike ranch sorghum silage.

Magnesium (Mg)

Range grass at the Cunningham and Vieh ranches contained the highest average amount of Mg at 0.15% and was lowest in grass at the Hall, Moore, and Meike ranches at 0.10% (Table 5). The beef cow would potentially consume an adequate amount of Mg less than a third of the time from range grass at the Hall, Moore, and Meike ranches whereas she would obtain an adequate amount of Mg 100% of the time from grass at the Cunningham ranch and over 60% of the time at the Vieh ranch (Figure 4a). If sampling had occurred at the Cunningham ranch in 2003 and 2004 it is possible that there would have been dates in which the grass would not have provided an adequate amount of Mg to the cow. With regard to the sheep ewe, she would generally not have been able to consume an adequate amount of Mg to meet her needs from range grass at all the ranches (Figure 4b).

On average the beef cow would need to be supplemented with 0.005, 0.01, 0.013, 0.043, and 0.032 pounds per day of Mg in May, June, July/August, October/November, and in March, respectively, to meet her needs if she was grazing native range at these ranches, except possibly at the Cunningham ranch (Figure 4a). For the sheep ewe she would need to be supplemented on average 0.003, 0.002, 0.0015, and 0.0044 pounds of Mg per day in late spring, summer, fall, and late winter, respectively (Figure 4b).

The hays, hay field regrowth, and silages would provide a sufficient amount of Mg to meet the needs of the beef cow and sheep ewe in all stages of production (Table 5). Feeding these hays to the sheep ewe and the beef cow to make up for the Mg deficiency of the native range pastures in late March would require a low of 1 and 7 pounds per day of the alfalfa hay from the Meike ranch and a high of 2 and 14 pounds per day of the alfalfa/meadow brome hay from the Hall ranch, respectively. The ewe and cow would need to consume 1.8 and 13 pounds per day, respectively, of corn silage from the Meike ranch to meet their Mg requirements when grazing native range in late March. Whereas the ewe and cow would need to consume only 0.8 and 5.5 pounds per day, respectively, of the Meike ranch sorghum silage.

Sulfur (S)

Range grass S content was similar among the ranches (0.17%) and declined as plants matured from an average of 0.22% in May to an average of 0.08% in March (Table 6). Generally range grass provided an adequate amount of S to meet the needs of the beef cow and sheep ewe in late spring and summer, except in 2003 for the ewe (Figures 5a and 5b). Precipitation between April and June 2003 averaged 6.0 inches for the region compared to 3.2 and 2.9 inches in 2002 and 2004, respectively. This greater amount of spring precipitation resulted in two to three times more late spring/early summer grass growth in 2003 compared to 2002 and 2004 which apparently caused a dilution of S within plant tissue. The possible reason that grass S content was greater in August 2004 (0.20%) compared to August 2003 (0.13%) and late July 2002 (0.16%) may have been due to there being little grass growth prior to August 2004 because of drought conditions but July/August 2004 precipitation resulted in new grass growth in August.

The hays, hay field regrowth, and silages would provide a sufficient amount of S to meet the needs of the beef cow and sheep ewe in all stages of production (Table 6). Feeding these hays to the sheep ewe and the beef cow to make up for the S deficiency of the native range pastures in late March would require a low of 0.8 and 5.5 pounds per day of the alfalfa hay from the Meike ranch and a high of 1.8 and 12 pounds per day of the alfalfa/meadow brome hay from the Hall ranch, respectively. The ewe and cow would need to consume 0.5 and 3.5 pounds per day, respectively, of corn silage from the Meike ranch to meet their S requirements when grazing native range in late March. Whereas the ewe and cow would need to consume 1.1 and 7 pounds per day, respectively, of the Meike ranch sorghum silage.

Iron (Fe)

Range grass Fe content was well above the needs of the beef cow and sheep ewe at all ranches (Figures 6a and 6b – Note: 1 calorie = 1 millionth of a mega-calorie or 1 ppm). Iron content of grass at the Cunningham and Vieh ranches averaged 428 ppm compared to an average of 223 ppm at the Hall, Meike, and Moore ranches (Table 7). Grass Fe content at the ranches averaged 232 ppm between May and August but increased to an average of 544 ppm in the fall. However, as weathering of the grass occurred Fe content declined to an average of 252 ppm in March.

As with native range grass, the alfalfa/meadow brome hay and hay field regrowth at the Hall ranch, and the alfalfa hays at the other ranches, along with the corn and forage sorghum silages from the Meike ranch, would provide the beef cow and sheep ewe with an adequate amount of Fe to meet their needs in all stages of production (Table 7).

Manganese (Mn)

The Mn content of range grass averaged 70 ppm at the Vieh ranch compared to an average of 37 ppm at the other ranches (Table 8). The amount of Mn in grass at the Vieh ranch was always at a sufficient level to potentially provide the beef cow and sheep ewe with an adequate amount of Mn to meet their needs (Figures 7a and 7b). Generally range grass provided an adequate amount of Mn to meet the needs of the sheep ewe at the other ranches but did not provide an adequate amount to meet the needs of the beef cow, except in October and November when her Mn needs declined due to the weaning of the calf. An average of 175 ppm Mn per pound of supplemental feed would need to be provided the beef cow to meet her Mn requirements during the summer months and an average of 450 ppm in March.

The hays did not contain an adequate amount of Mn to meet the needs of the beef cow when she was in lactation (Table 8). However, hay field regrowth at the Hall ranch and the silages from the Meike ranch contained an adequate amount of Mn to meet the needs of the cow in all stages of production. Thus meeting the Mn needs of cows grazing native range pastures in March at the Hall, Meike, and Moore ranches would not be achieved by providing any of the hays but could be achieved with the silages (9 and 7.5 lb/day of corn or forage sorghum silage, respectively).

The sheep ewe would not obtain an adequate amount of Mn from the hays when in late gestation by an average of 7.4 ppm/lb of dry matter consumed (Table 8). However, due to her increase in dry matter intake when in early lactation (from 4.1 lb/day to 5.85 lb/day) she would acquire an adequate amount of Mn from the alfalfa/meadow brome hay from the Hall ranch and alfalfa hay from the Meike ranch but not from the alfalfa hays at the Moore and Vieh ranches by an average of 6.9 ppm/lb of dry matter. Grazing hay field regrowth at the Hall ranch the ewe would be able to obtain a sufficient amount of Mn to meet her needs in all stages of production. In addition, the silages would also provide the ewe with an adequate amount of Mn to meet her needs.

Zinc (Zn)

Range grass Zn content was similar among the ranches averaging 15 ppm and declined as plants matured from an average of 19.5 ppm in May to 9.7 ppm in March (Table 9). However, grass Zn content was not adequate to meet the Zn nutrient needs of the beef cow or sheep ewe throughout the study by an average of 28 and 21 ppm per pound of dry matter grass consumed, respectively. Rauzi et al. (1969) and Grings et al. (1996) found that the Zn content of western wheatgrass, common to the pastures at these ranches, was insufficient for a cow. The low concentrations of Zn in the grass may be due to its low mobility in neutral to alkaline soils and its low solubility in high pH soils, particularly when $CaCO_3$ is present (Mengel and Kirkby 1987).

None of the hays contained an adequate amount of Zn to meet the needs of the beef cow and sheep ewe in all production stages (Table 9). Grazing hay field regrowth at the Hall ranch the cow and ewe would obtain 300 and 10 ppm Zn per pound of dry matter consumed, respectively, but these amounts would be insufficient to meet their needs. The silages from the Meike ranch would not provide the cow with an adequate amount of Zn when in lactation, and the corn silage would not provide the ewe with an adequate amount of Zn in all production stages whereas the forage sorghum silage would.

Copper (Cu)

Copper content of range grass was similar among the ranches and sampling dates (Table 10), and was generally adequate to meet the needs of the beef cow and sheep ewe (Figures 9a and 9b). Although not reported here, grass molybdenum contents were low to non-existed, thus potential interference of Mo with Cu absorption by the animal should not be a problem.

The hays, hay field aftermath from the Hall ranch, and silages from the Meike ranch all would provide an adequate amount of Cu to meet the needs of the beef cow in all stages of production (Table 10). The alfalfa/meadow brome hay and the hay field regrowth from the Hall ranch, the alfalfa hay purchased by the Moore ranch, and the forage sorghum silage from the Meike ranch did not contain an adequate amount of Cu to meet the needs of the sheep ewe in late gestation. In addition, the hay field regrowth and the alfalfa hay at the Moore ranch would not provide an adequate amount of Cu to meet the needs of the ewe when in early lactation.

Net Energy maintenance (NEm)

The average NEm content of range grass was greatest at the Hall ranch at 0.63 mega calories per pound (Mcal/lb) and least at the Vieh ranch at 0.59 Mcal/lb (Table 11). As range grass matured and went dormant its NEm content declined from an average of 0.73 Mcal/lb in mid-May to 0.57 Mcal/lb in late October and early November. Although harvesting of range grass in March occurred only in 2004 its average NEm content of 0.50 Mcal/lb would indicate that it lost soluble sugars as it weathered.

Except in March and June 2004, range grass at all five ranches contained an adequate amount of NEm to meet the needs of the beef cow (Figure 10a). If the cow had not been in early lactation in March the grass would have provided her with an adequate amount of NEm. The lack of green forage in June 2004 due to the dry conditions is probably the reason range grass did not contain an adequate amount of NEm to meet the needs of the cow at this time of year. Apparently on a pound for pound basis the sheep ewe requires more NEm than the cow and as a result the amount of NEm she would obtain from the grass to meet her needs was borderline (Figure 10b).

The hays, hay field regrowth, and silages would provide an adequate amount of NEm for the beef cow in all stages of production and for the sheep ewe in late gestation but not necessarily in early lactation (Table 11).

Protein

The average crude protein content of range grass was greatest at the Hall ranch at 9.7% and least at the Meike ranch at 7.5% (Table 12). As with NEm, as range grass matured and went dormant it declined in crude protein content from an average of 14.7% in mid-May to 6.9% in late October and early November. Average crude protein content of March 2004 range grass was 3.9% indicating that weathering leaches nitrogen (precursor to crude protein) from the grass.

Generally the beef cow was able to obtain an adequate amount of degradable protein from range grass, except in late March and early June 2004 (Figure 11a). Degradable protein is that part of crude protein (72%) that the rumen microbes use as their protein source and in turn provide the cow and ewe with microbial protein to meet their protein needs. Delaying calving to later in the spring (May) may rectify the protein deficiency problem that occurred in March 2004, but would not necessarily have made any difference in June 2004 due to drought conditions.

The sheep ewe generally would not have obtained an adequate amount of degradable protein from range grass at all the ranches to meet her needs (Figure 11b). As with NEm, the ewe apparently requires more protein on a pound for pound basis than the cow and thus drought conditions the region experienced during this study may have hindered her ability to obtain an adequate amount of protein. However, other forage plants, such as forbs and shrubs, may have provided additional protein to the ewe as she is more adapted at utilizing these types of plants compared to the cow.

The hays would provide the beef cow and sheep ewe with an adequate amount of degradable protein in all stages of production (Table 12). Hay field regrowth at the Hall ranch and the silages from the Meike ranch would not have provided the cow with an adequate amount of degradable protein when in lactation, and would not have provided an adequate amount to the ewe in any stage of production.

SUMMARY

Mineral content of range grass was generally similar among the ranches. However, grass at the Vieh ranch usually contained higher amounts of Mg, Fe and Mn compared to the other ranches but also the lowest amounts of P and Cu. Soils textures and pH of the sampled pastures at each ranch were determined but mineral contents were not. Soil textures ranged from silt loam to sandy loam with soil pH ranging from 7.0 to 8.3. Pasture soils at the Vieh ranch were derived from the Chugwater formation (red color) and these soils apparently have a different mineral composition compared to soils of pastures at the other ranches.

Concentrations of P, K, Mg, S and Zn declined in range grass as it matured and weathered, whereas that for Ca, Fe and Mn increased as the plants matured but as they weathered over the winter these concentrations declined as well.

Range grass Ca and Fe contents were adequate to meet the needs of the beef cow and sheep ewe on all sampling dates, whereas Zn levels were not. Grass P contents were not adequate to meet the needs of the sheep ewe, except in May 2001 and 2002 at the Hall ranch, and only adequate to meet the needs of the beef cow in the spring when there was new grass growth. Potassium content of range grass was generally adequate to meet the needs of the beef cow and sheep ewe, except in March 2004. Grass Mg levels were generally not adequate to meet the needs of the beef cow and especially were not adequate to meet the needs of the sheep ewe. The amount of S the beef cow and sheep ewe would obtain from consumption of the range grasses were adequate to meet the needs of the beef cow and generally adequate for the sheep ewe, except in late fall and winter. Grass Mn content was generally not adequate for the beef cow and only occasionally adequate for the sheep ewe, except for grass at the Vieh ranch which was adequate on all sampling dates for both the cow and ewe. Grass Cu content was generally adequate to meet the needs of the beef cow and sheep ewe.

The alfalfa/meadow brome hay raised at the Hall ranch and the alfalfa hays either raised or purchased at the Meike, Moore, and Vieh ranches all provided an adequate amount of Ca, K, Mg, S, Fe, Cu, NEm, and protein to meet the needs of the beef cow and sheep ewe in all stages of production. In addition, these hays provided an adequate amount of P to meet the needs of the cow in all production stages, and enough Mn to meet her needs when not in lactation and generally enough Mn to meet the needs of the ewe in early lactation but not late gestation.

Late summer regrowth of an alfalfa/meadow brome hay field at the Hall ranch in November 2004 contained an adequate amount of all minerals, except P and Zn, to meet the needs of the beef cow and sheep ewe in all production stages. However, the Cu level of this feed may not have been adequate to meet the needs of the ewe during late gestation. The regrowth also contained an adequate level of NEm for the cow but not enough for the ewe in early lactation. Crude protein content of the regrowth would provide enough degradable protein to meet the needs of the cow when not in lactation but not enough for the ewe in all stages of production.

The corn silage raised at the Meike ranch contained an adequate amount of all minerals, except Zn for the beef cow when in lactation and Cu for the sheep ewe when in late gestation, to meet their needs in all stages of production. This silage also contained a sufficient amount of NEm to meet the needs of the cow in all production stages but not enough to meet the needs of the ewe when in early lactation. Crude protein content of the corn silage was sufficient to meet the needs of the cow when not in lactation but not that of the ewe in any stage of production.

The forage sorghum silage raised at the Meike ranch contained an adequate amount of all minerals, except P and Zn for the beef cow when in lactation and P for the sheep ewe in all production stages and Cu during late gestation. As with corn silage the sorghum silage contained an adequate amount of NEm to meet the needs of the cow in all stages of production but not enough to meet the needs of the ewe when in early lactation, and its crude protein content was sufficient only for the cow when not in lactation and was not sufficient for the ewe in any stage of production.

Based on the results of this study range livestock producers in Johnson County and the surrounding region may want to consider providing a custom mineral supplement that contains P, Mg and Zn, with Mn and Cu added for cattle and possibly Mn and S added for sheep. However, prior to having a custom mineral mix developed range livestock producers should collect range grass from a few of their pastures, especially in early and late spring, and late fall, and have them analyzed for their mineral content. Late spring sampling would determine if there is a potential for grass tetany, an imbalance between Ca and K with Mg. Late fall and early spring sampling would provide useful information for all minerals, especially when a number of them decline as plants mature and go dormant with further decline as the grass weathers. It is recommended that the livestock producer share the mineral results with a reputable livestock nutritionist so that an appropriate mineral supplementation mix can be developed that meets their livestock needs. In addition, other feed sources raised or purchased such as hays and silages should also be analyzed for their mineral content. These feed sources could serve as a supplement for some of the minerals that may be lacking in dormant range grass.

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Table 1: Phosphorus content (%) of grass from native range pastures at five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	0.30	0.24	0.24	0.25	0.17
2002:					
Mid-May	0.31	0.23	0.22	0.23	0.18
Early June	0.28	0.21	0.18	0.22	0.17
Late June	0.20	0.14	0.15	0.17	0.11
Late July	0.15	0.08	0.10	0.16	0.07
Late October	0.12	0.08	0.05		0.06
2003:					
Mid-May	0.24		0.20	0.25	0.19
Late June	0.16		0.12	0.16	0.09
Mid-August	0.08		0.10	0.10	0.03
Early Nov.	0.01		0.02	0.01	0.05
2004:					
Late March	0.00		0.01	0.00	0.01
Early June	0.13		0.10		0.12
Late August	0.15		0.07	0.14	0.05
Mid- Nov.	0.00		0.01	0.01	0.01
Alfalfa hay[6]			0.12	0.21	0.20
Alfalfa/Brome Grass hay[7]	0.17				
Hay field regrowth[8]	0.00				
Corn silage[9]			0.20		
Sorghum[9] silage			0.19		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 2: Calcium content (%) of grass from native range pastures at five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	0.53	0.44	0.40	0.44	0.55
2002:					
Mid-May	0.50	0.38	0.41	0.46	0.59
Early June	0.44	0.36	0.44	0.48	0.53
Late June	0.54	0.44	0.40	0.53	0.51
Late July	0.59	0.49	0.37	0.47	0.73
Late October	0.68	0.43	0.37		0.86
2003:					
Mid-May	0.43		0.37	0.48	0.52
Late June	0.44		0.47	0.53	0.54
Mid-August	0.47		0.66	0.71	0.67
Early Nov.	0.36		0.33	0.61	0.67
2004:					
Late March	0.33		0.28	0.35	0.38
Early June	0.56		0.48		0.50
Late August	0.76		0.66	0.86	0.72
Mid- Nov.	0.83		0.49	0.81	0.74
Alfalfa hay[6]			1.53	1.95	2.00
Alfalfa/Brome Grass hay[7]	1.25				
Hay field regrowth[8]	1.53				
Corn silage[9]			0.35		
Sorghum[9] silage			0.96		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 3: Calcium/Phosphorus ratio of grass from native range pastures at five ranches in Johnson County, Wyoming, and from hay and silages. Calcium/Phosphorus ratios in brackets are for corrected phosphorus deficiencies.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	1.8	1.8	1.7	1.8	3.5
2002:					
Mid-May	1.6	1.7	1.7	2.0	3.4
Early June	1.6	1.7	2.0	2.3	3.6
Late June	2.8	3.3 (2.9)	2.6 (2.4)	3.2	5.1 (3.0)
Late July	3.9 (3.7)	6.9 (3.1)	3.6 (2.0)	4.2	10.7 (5.0)
Late October	6.2	6.7 (3.9)	6.1 (3.0)		22.9 (8.9)
2003:					
Mid-May	1.6		1.6	1.8	3.2
Late June	2.7 (2.5)		3.4 (2.6)	2.9	6.0 (3.3)
Mid-August	5.6 (2.7)		5.8 (3.6)	6.7 (3.8)	26.9 (3.5)
Early Nov.	15.9 (2.7)		19.8 (2.8)	51.9 (7.0)	282.1 (5.2)
2004:					
Late March	8 (1.7)		60.8 (1.5)	44.0 (1.6)	179.9 (1.8)
Early June	5.3 (4.0)		4.8 (3.1)		4.2 (3.2)
Late August	5.0		9.9 (4.5)	11.9 (4.9)	7.6 (6.3)
Mid- Nov.	8 (6.4)		29.0 (4.0)	45.5 (11.2)	35.8 (6.3)
Alfalfa hay[6]			13.0 (10.2)	9.3	10.0
Alfalfa/Brome Grass hay[7]	7.36				
Hay field regrowth[8]	8 (8.9)				
Corn silage[9]			1.7 (2.3)		
Sorghum[9] silage			5.0 (4.7)		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 4: Potassium content (%) of grass from native range pastures at five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	2.20	2.22	2.24	1.87	1.88
2002:					
Mid-May	2.39	2.21	1.92	1.90	2.00
Early June	2.26	1.93	1.92	2.02	1.95
Late June	2.12	1.98	1.89	1.86	1.86
Late July	1.58	1.22	1.22	1.53	1.46
Late October	1.22	0.96	0.52		1.21
2003:					
Mid-May	1.80		1.80	1.96	1.99
Late June	1.38		1.52	1.50	1.40
Mid-August	1.30		1.22	1.32	0.97
Early Nov.	0.41		0.26	0.44	0.78
2004:					
Late March	0.22		0.21	0.24	0.26
Early June	1.64		1.48		1.68
Late August	2.25		0.99	1.49	0.92
Mid- Nov.	0.67		0.26	0.56	0.54
Alfalfa hay[6]			1.96	2.32	1.26
Alfalfa/Brome Grass hay[7]	2.48				
Hay field regrowth[8]	1.10				
Corn silage[9]			1.75		
Sorghum[9] silage			3.15		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 5: Magnesium content (%) of grass from native range pastures at five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	0.16	0.18	0.11	0.11	0.15
2002:					
Mid-May	0.12	0.17	0.14	0.12	0.15
Early June	0.13	0.16	0.17	0.11	0.14
Late June	0.15	0.19	0.13	0.12	0.13
Late July	0.11	0.14	0.08	0.11	0.15
Late October	0.08	0.11	0.07		0.19
2003:					
Mid-May	0.12		0.14	0.12	0.16
Late June	0.07		0.14	0.11	0.13
Mid-August	0.08		0.13	0.09	0.13
Early Nov.	0.05		0.06	0.04	0.16
2004:					
Late March	0.05		0.06	0.04	0.07
Early June	0.06		0.11		0.13
Late August	0.12		0.13	0.10	0.14
Mid- Nov.	0.08		0.08	0.04	0.14
Alfalfa hay[6]			0.45	0.32	0.37
Alfalfa/Brome Grass hay[7]	0.23				
Hay field regrowth[8]	0.28				
Corn silage[9]			0.25		
Sorghum[9] silage			0.59		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 6: Sulfur content (%) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	0.26	0.21	0.19	0.20	0.23
2002:					
Mid-May	0.27	0.23	0.22	0.22	0.25
Early June	0.23	0.18	0.17	0.19	0.22
Late June	0.19	0.17	0.15	0.17	0.18
Late July	0.19	0.15	0.13	0.15	0.17
Late October	0.20	0.19	0.14		0.19
2003:					
Mid-May	0.20		0.18	0.21	0.20
Late June	0.15		0.14	0.15	0.17
Mid-August	0.12		0.14	0.14	0.13
Early Nov.	0.08		0.08	0.11	0.15
2004:					
Late March	0.07		0.08	0.08	0.10
Early June	0.19		0.17		0.20
Late August	0.27		0.18	0.17	0.18
Mid- Nov.	0.17		0.12	0.17	0.15
Alfalfa hay[6]			0.37	0.30	0.23
Alfalfa/Brome Grass hay[7]	0.17				
Hay field regrowth[8]	0.17				
Corn silage[9]			0.59		
Sorghum[9] silage			0.28		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 7: Iron content (ppm) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	206	218	157	150	334
2002:					
Mid-May	230	217	197	161	375
Early June	140	281	133	144	297
Late June	230	283	139	148	238
Late July	211	461	273	184	558
Late October	579	1103	392		435
2003:					
Mid-May	116		94	110	221
Late June	165		189	176	305
Mid-August	173		200	234	432
Early Nov.	192		226	417	621
2004:					
Late March	151		153	304	399
Early June	201		160		180
Late August	182		191	210	557
Mid- Nov.	422		312	774	1059
Alfalfa hay[6]			344	164	306
Alfalfa/Brome Grass hay[7]	114				
Hay field regrowth[8]	138				
Corn silage[9]			428		
Sorghum[9] silage			781		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 8: Manganese content (ppm) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	48	45	39	39	71
2002:					
Mid-May	41	36	36	37	69
Early June	34	37	32	38	51
Late June	32	33	34	31	44
Late July	39	47	40	34	78
Late October	57	60	39		61
2003:					
Mid-May	35		30	39	56
Late June	31		29	31	48
Mid-August	31		37	41	64
Early Nov.	34		29	36	86
2004:					
Late March	31		26	33	65
Early June	30		34		49
Late August	40		42	34	113
Mid- Nov.	47		40	55	124
Alfalfa hay[6]			32	24	22
Alfalfa/Brome Grass hay[7]	31				
Hay field regrowth[8]	97				
Corn silage[9]			56		
Sorghum[9] silage			67		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 9: Zinc content (ppm) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	23.2	18.8	16.3	28.8	18.0
2002:					
Mid-May	19.7	19.8	17.8	18.6	20.5
Early June	17.3	17.1	13.5	15.9	16.6
Late June	14.5	19.2	17.8	18.6	20.5
Late July	12.5	19.0	13.2	14.9	12.4
Late October	13.9	17.3	10.4		12.5
2003:					
Mid-May	15.5		18.1	19.6	18.6
Late June	12.4		13.7	14.3	14.7
Mid-August	11.4		14.5	13.0	10.8
Early Nov.	8.9		7.9	10.7	11.5
2004:					
Late March	9.1		7.2	15.9	6.7
Early June	14.1		14.1		13.8
Late August	15.5		13.3	15.9	13.3
Mid- Nov.	9.8		9.1	16.4	11.3
Alfalfa hay[6]			19.4	14.7	10.8
Alfalfa/Brome Grass hay[7]	14.3				
Hay field regrowth[8]	9.6				
Corn silage[9]			23.8		
Sorghum[9] silage			36.3		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 10: Copper content (ppm) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	13.7	12.3	11.0	10.5	11.6
2002:					
Mid-May	10.3	9.3	9.3	8.0	7.9
Early June	10.0	10.7	8.7	7.7	8.9
Late June	11.0	9.8	8.6	8.7	8.1
Late July	12.4	12.0	8.0	9.6	7.9
Late October	13.2	14.8	11.4		11.4
2003:					
Mid-May	7.4		8.4	8.1	7.9
Late June	9.3		10.1	9.6	8.6
Mid-August	11.4		15.5	11.3	8.8
Early Nov.	7.7		7.5	10.9	7.5
2004:					
Late March	12.3		8.0	12.0	5.6
Early June	9.4		9.3		7.2
Late August	11.8		8.4	9.7	8.5
Mid- Nov.	10.2		7.3	9.2	8.7
Alfalfa hay[6]			11.8	7.7	14.3
Alfalfa/Brome Grass hay[7]	9.0				
Hay field regrowth[8]	7.9				
Corn silage[9]			9.5		
Sorghum[9] silage			15.1		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 11: Net Energy maintenance content (Mcal/lb) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	0.72	0.73	0.65	0.74	0.69
2002:					
Mid-May	0.81	0.71	0.73	0.76	0.73
Early June	0.74	0.68	0.67	0.71	0.67
Late June	0.65	0.65	0.62	0.66	0.61
Late July	0.65	0.62	0.54	0.65	0.69
Late October	0.64	0.58	0.54		0.68
2003:					
Mid-May	0.76		0.70	0.74	0.70
Late June	0.63		0.63	0.63	0.59
Mid-August	0.56		0.59	0.58	0.49
Early Nov.	0.53		0.51	0.54	0.48
2004:					
Late March	0.48		0.59	0.45	0.46
Early June	0.65		0.66		0.65
Late August	0.70		0.64	0.62	0.57
Mid- Nov.	0.55		0.61	0.58	0.52
Alfalfa hay[6]			0.69	0.70	0.71
Alfalfa/Brome Grass hay[7]	0.66				
Hay field regrowth[8]	0.59				
Corn silage[9]			0.68		
Sorghum[9] silage			0.49		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

Table 12: Crude protein content (%) of grass from native range pastures from five ranches in Johnson County, Wyoming, and from hay and silages.

Average Date	Hall[1]	Cunningham[2]	Meike[3]	Moore[4]	Vieh[5]
2001: Mid-May	18.6	13.6	10.8	14.0	15.1
2002:					
Mid-May	18.8	13.9	15.5	15.0	16.2
Early June	15.3	11.4	11.3	11.2	12.1
Late June	10.6	8.9	7.2	7.6	7.9
Late July	9.9	8.0	5.9	8.6	6.2
Late October	10.6	9.6	6.9		14.3
2003:					
Mid-May	11.5		12.4	15.4	14.6
Late June	8.8		7.3	9.7	8.6
Mid-August	4.8		5.8	6.4	5.0
Early Nov.	2.1		4.7	4.5	5.9
2004:					
Late March	2.7		2.7	6.2	3.9
Early June	11.2		10.1		12.4
Late August	15.7		9.7	8.9	7.9
Mid- Nov.	6.2		5.8	5.5	6.1
Alfalfa hay[6]			16.6	18.5	18.1
Alfalfa/Brome Grass hay[7]	12.9				
Hay field regrowth[8]	5.3				
Corn silage[9]			7.7		
Sorghum[9] silage			8.4		

[1]Hall: Two pastures – sandy loam soils.
[2]Cunningham: Three pastures – silt loam soils.
[3]Meike: Two pastures – sandy loam soils.
[4]Moore: Four pastures (three summer and one winter – winter sampled at three locations in November 2003 and 2004, and March 2004) – sandy loam and loam soils.
[5]Vieh: Three pastures – silt loam and loam soils.
[6]Meike's – average of 1st and 2nd harvests from one field in 2004; Moore's – average of 2003 and 2004 harvest from Clearmont area; Vieh's – 2003 harvest from Riverton area.
[7]Average of the 1st and 2nd harvests of two alfalfa/Regar meadow bromegrass fields in 2004.
[8]From one of the above fields in November 2004, primarily Regar meadow bromegrass.
[9]2004 harvests sampled in November 2004.

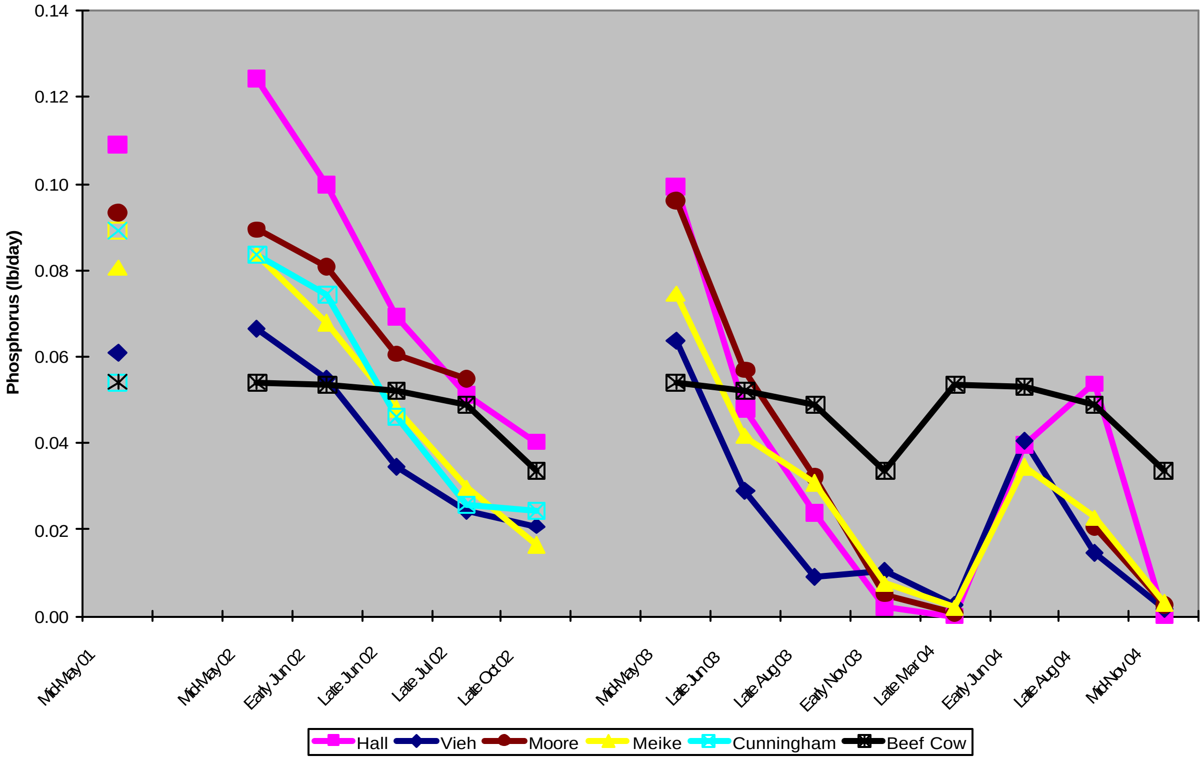

Figure 1a: Amount of phosphorus a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

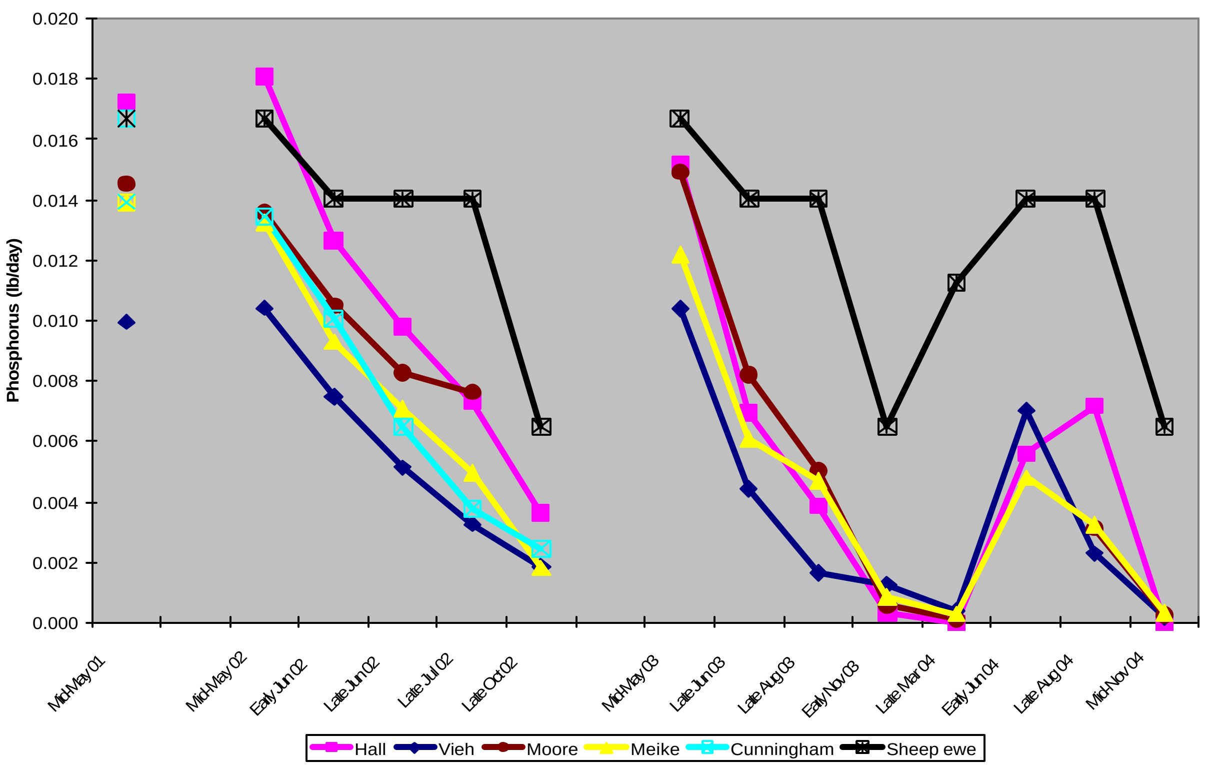

Figure 1b: Amount of phosphorus a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

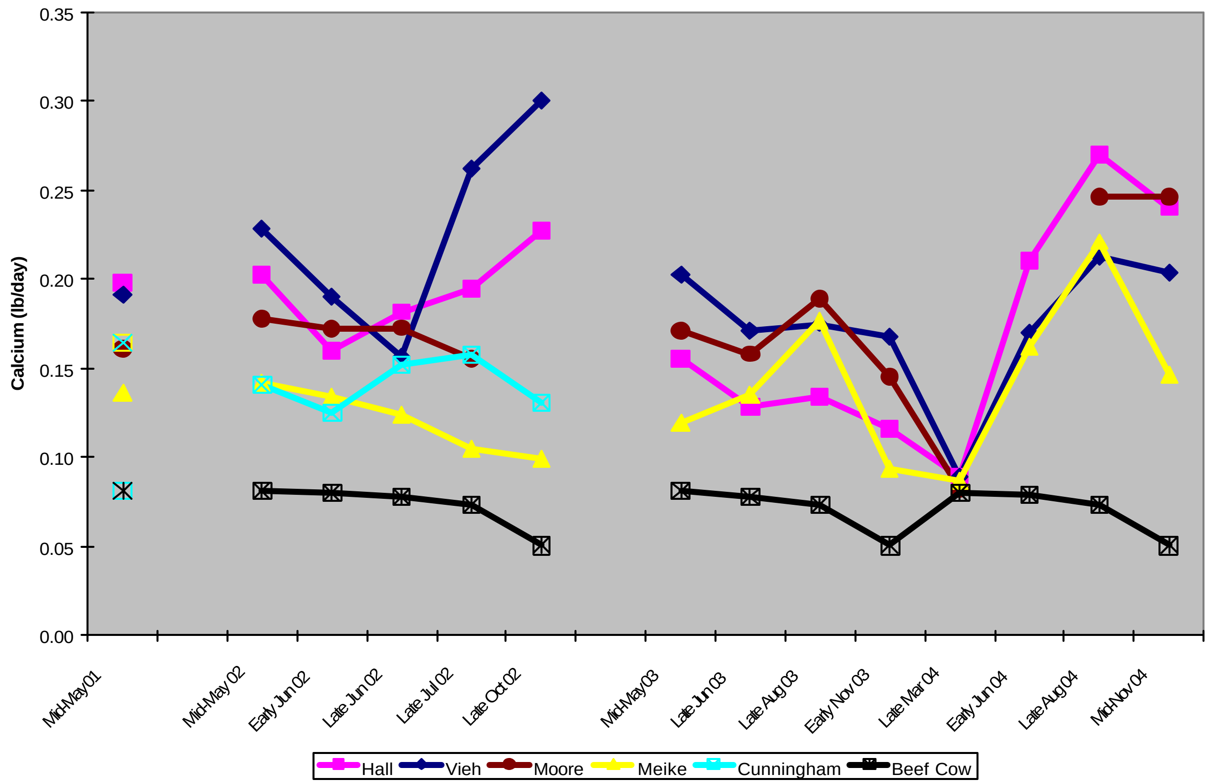

Figure 2a: Amount of calcium a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

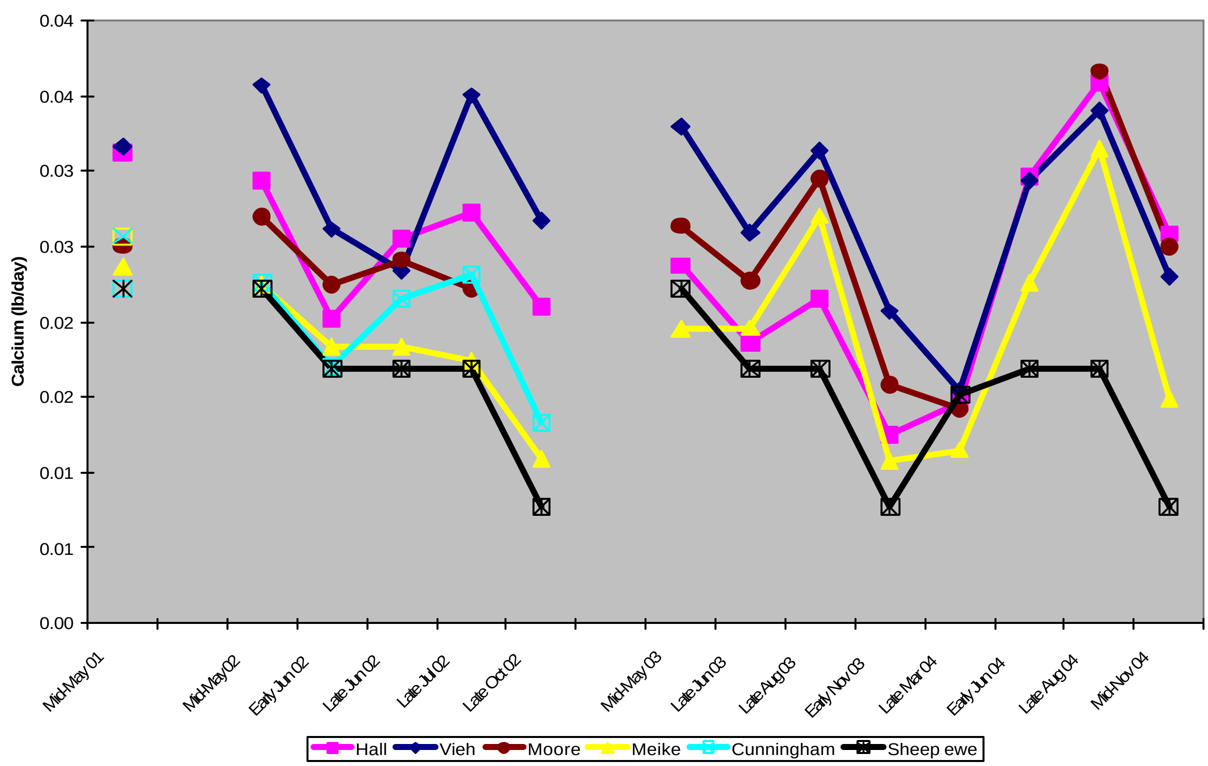

Figure 2b: Amount of calcium a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County ranches and the minimum amount she requires in her diet.

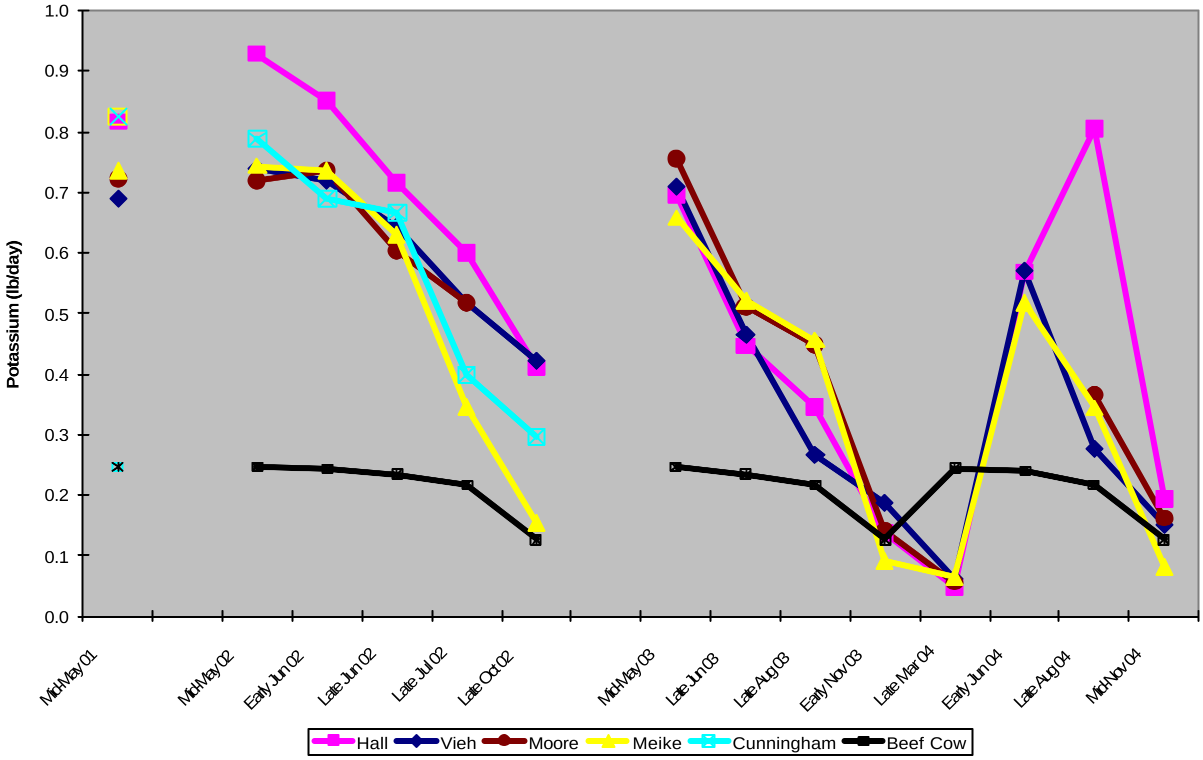

Figure 3a: Amount of potassium a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

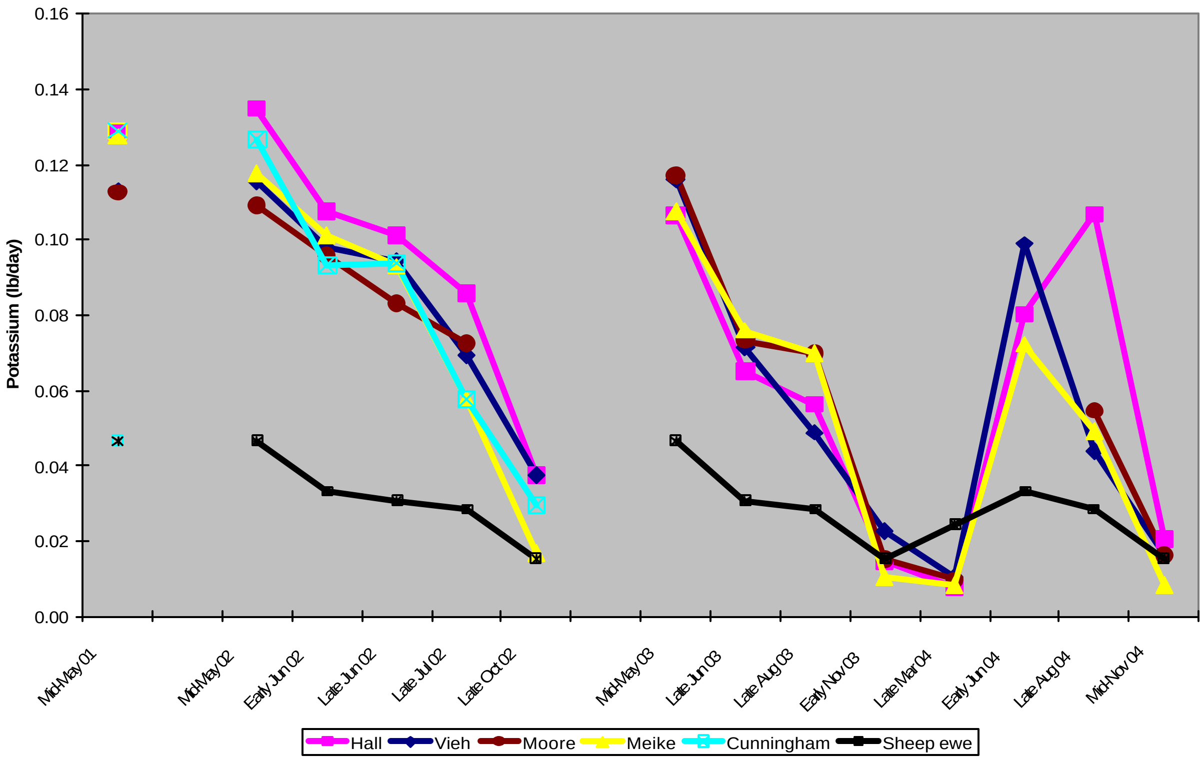

Figure 3b: Amount of potassium a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

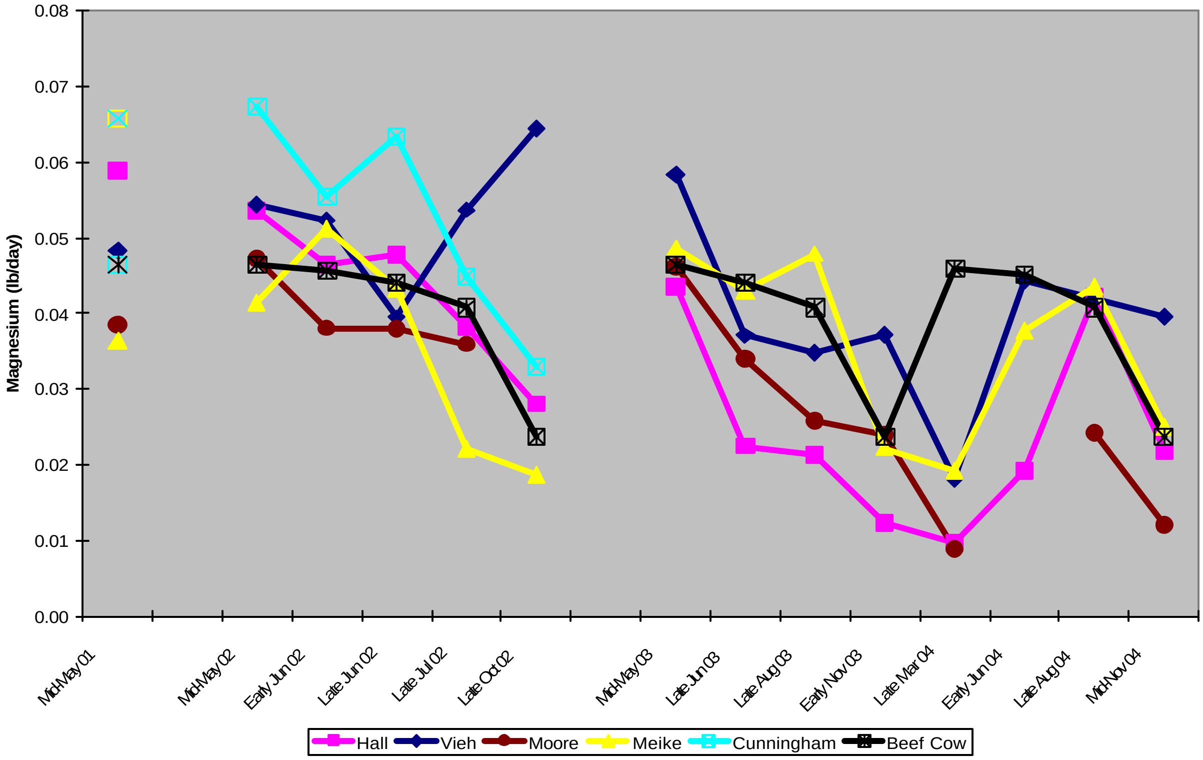

Figure 4a: Amount of magnesium a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

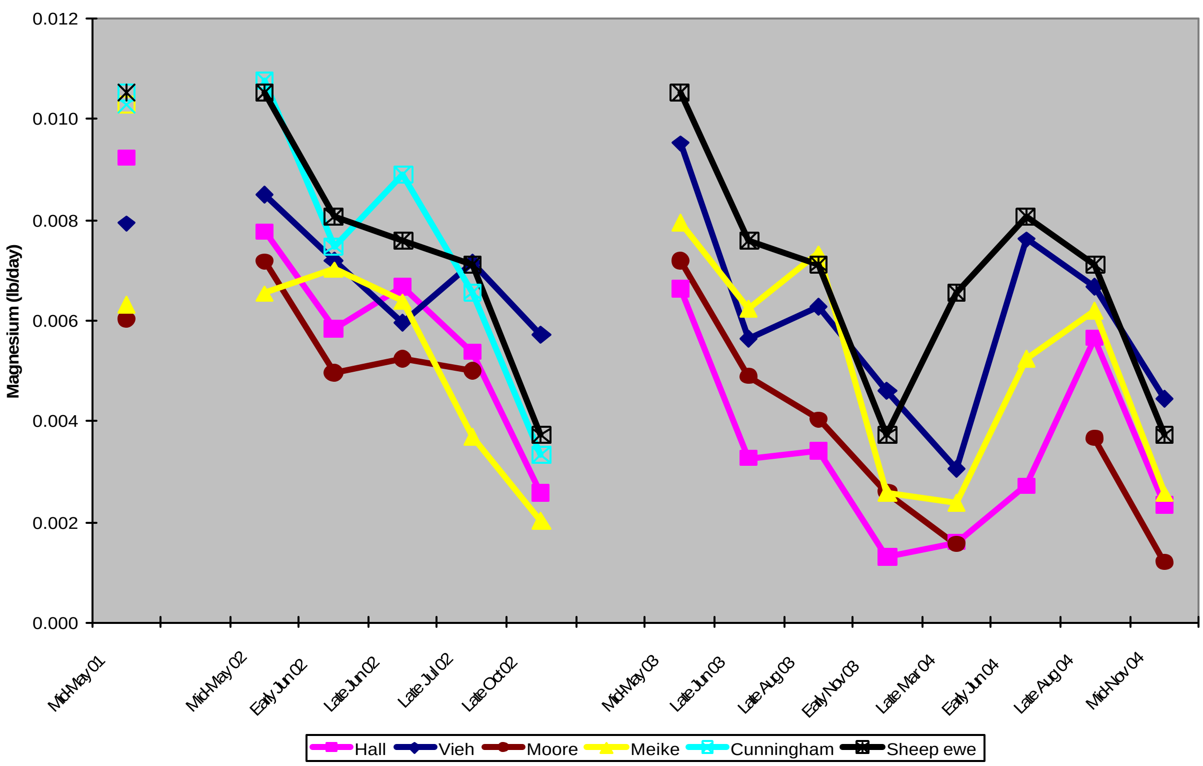

Figure 4b: Amount of magnesium a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County ranches and the minimum amount she requires in her diet.

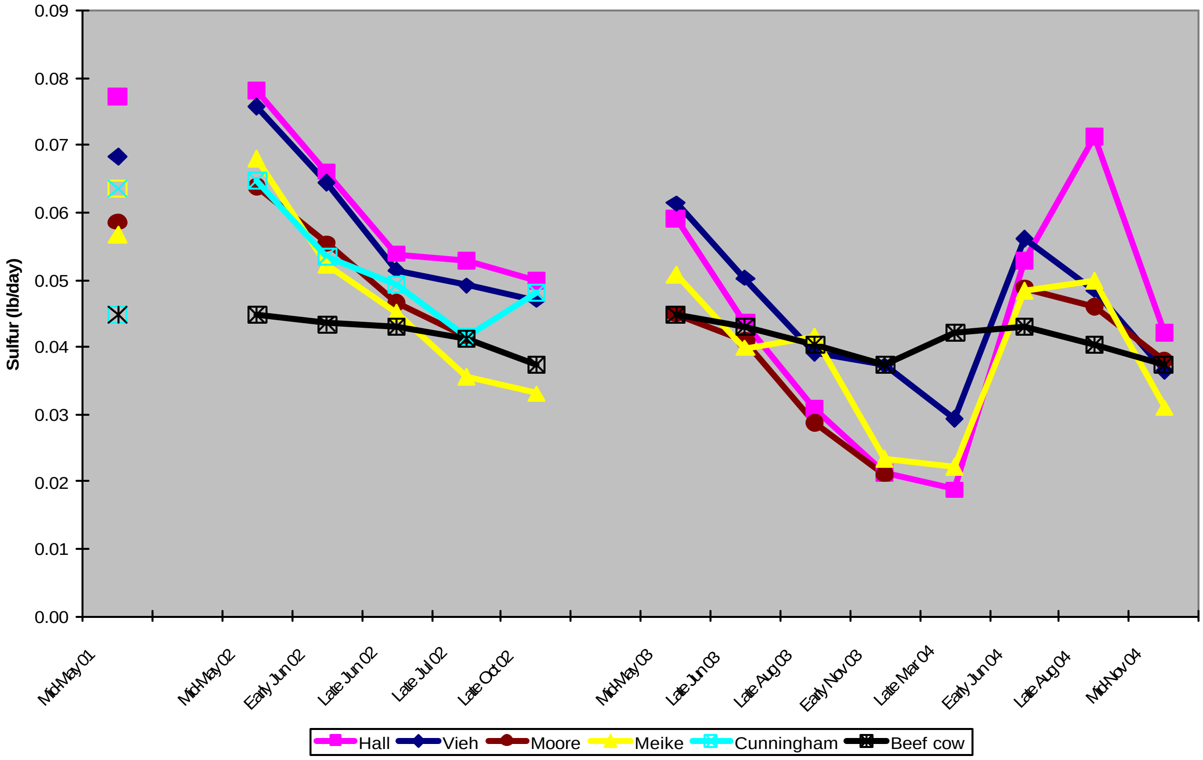

Figure 5a: Amount of sulfur a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

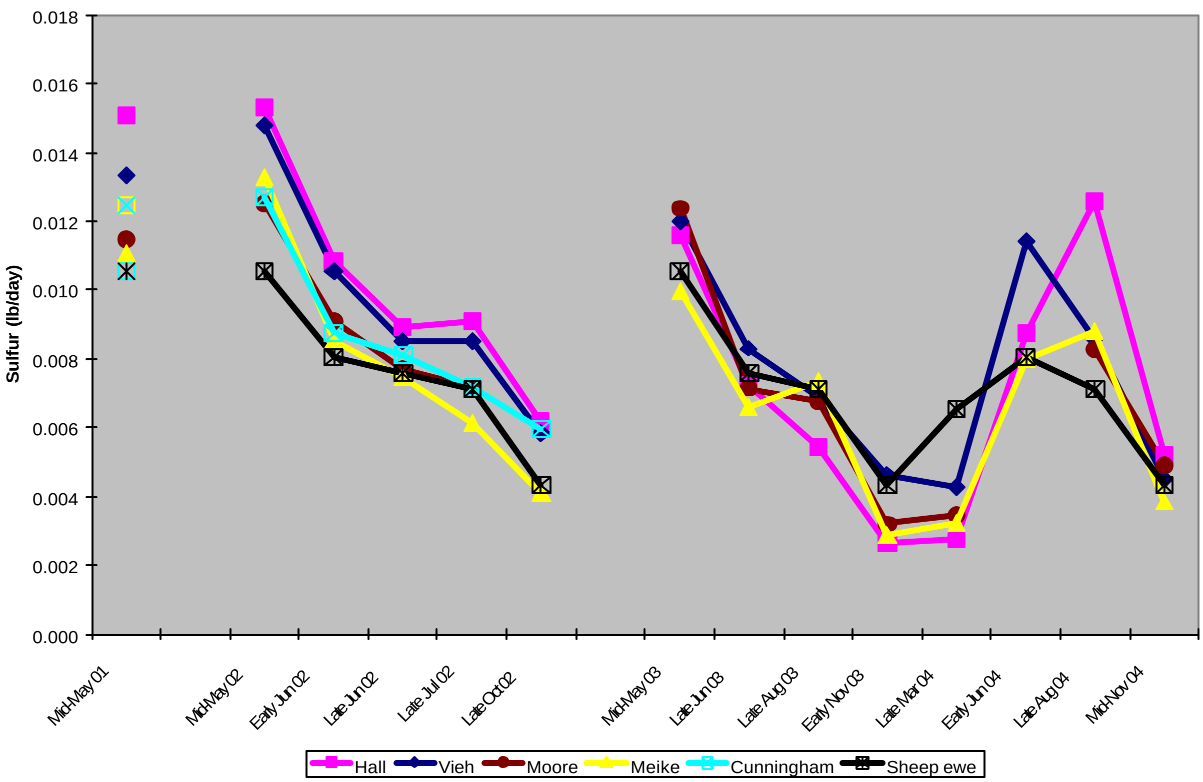

Figure 5b: Amount of sulfur a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

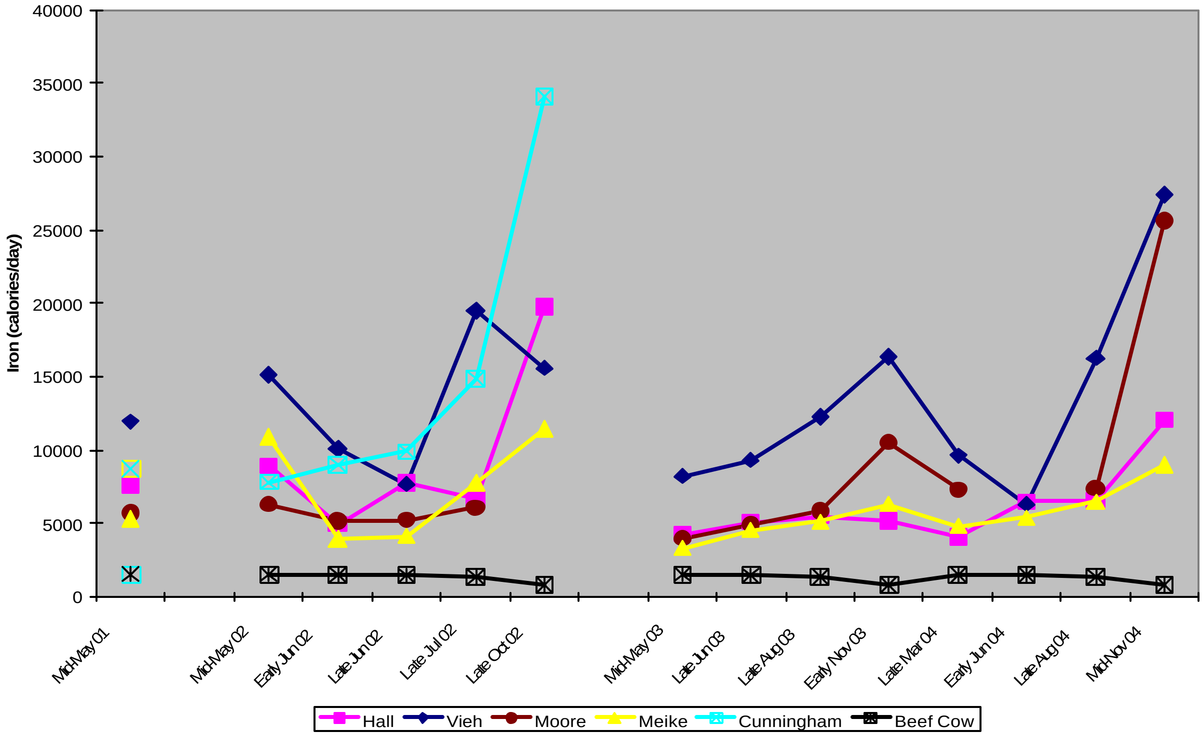

Figure 6a: Amount of iron a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

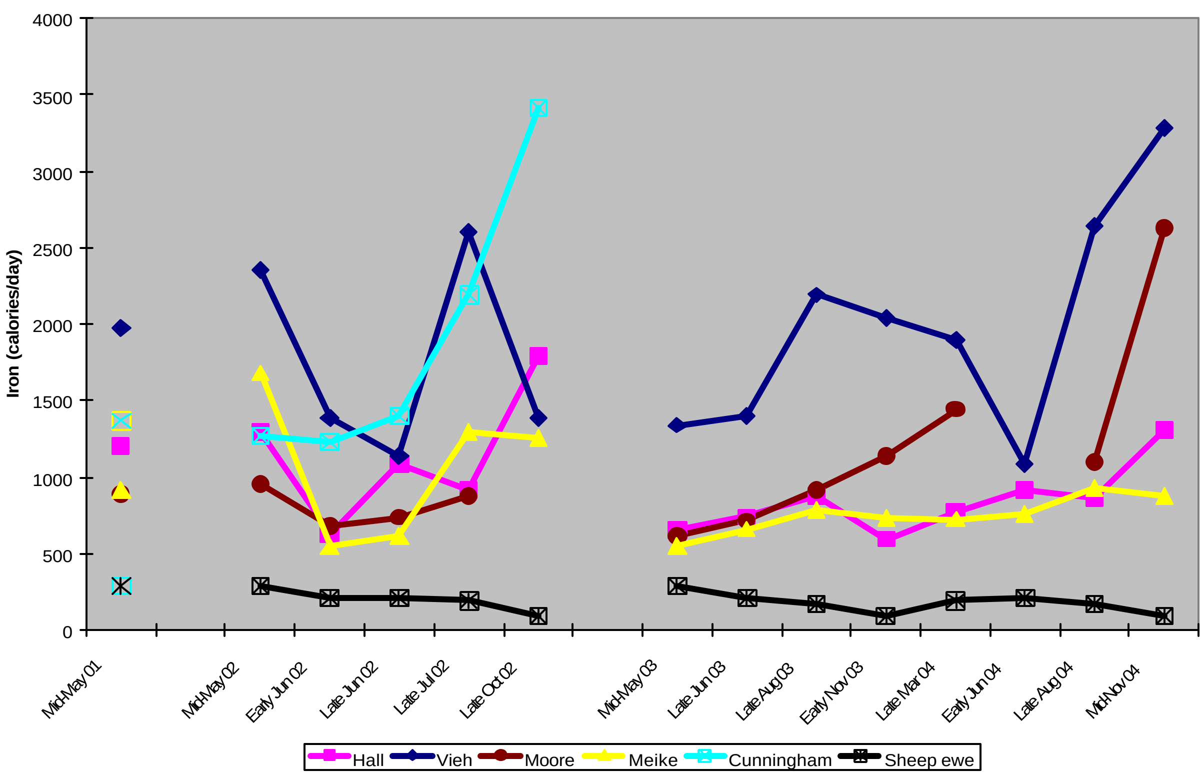

Figure 6b: Amount of iron a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

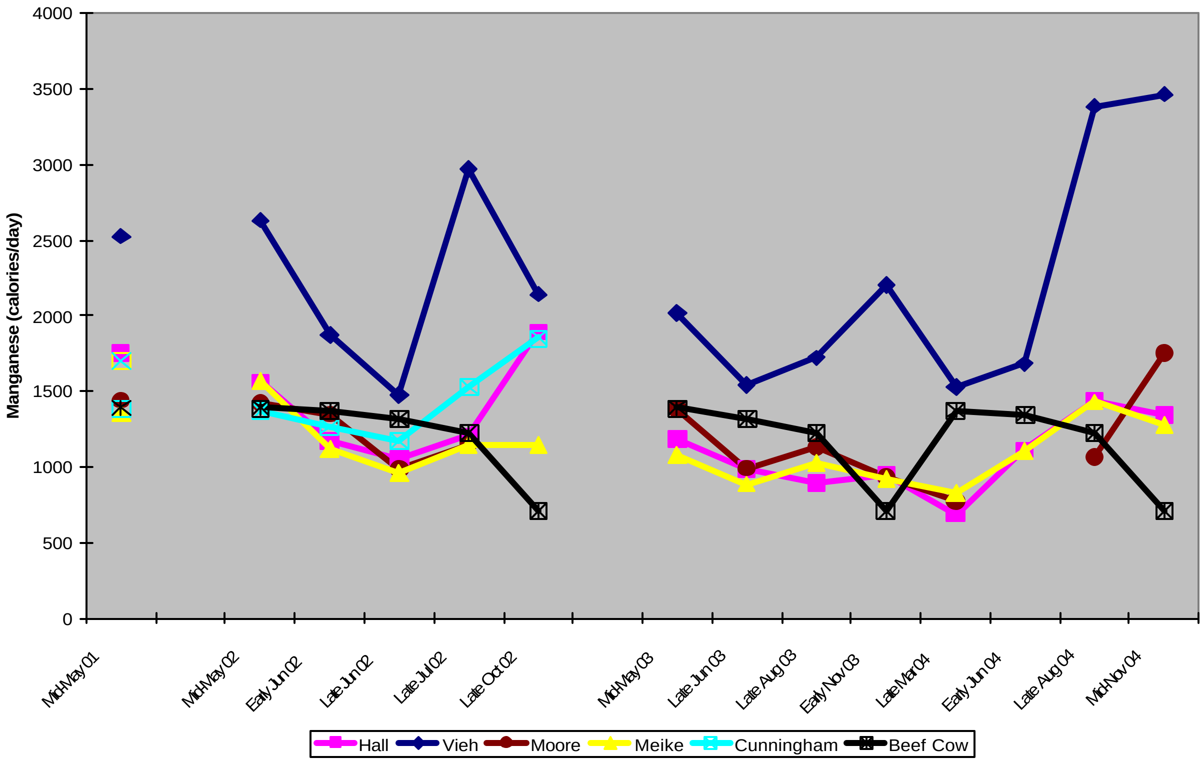

Figure 7a: Amount of manganese a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

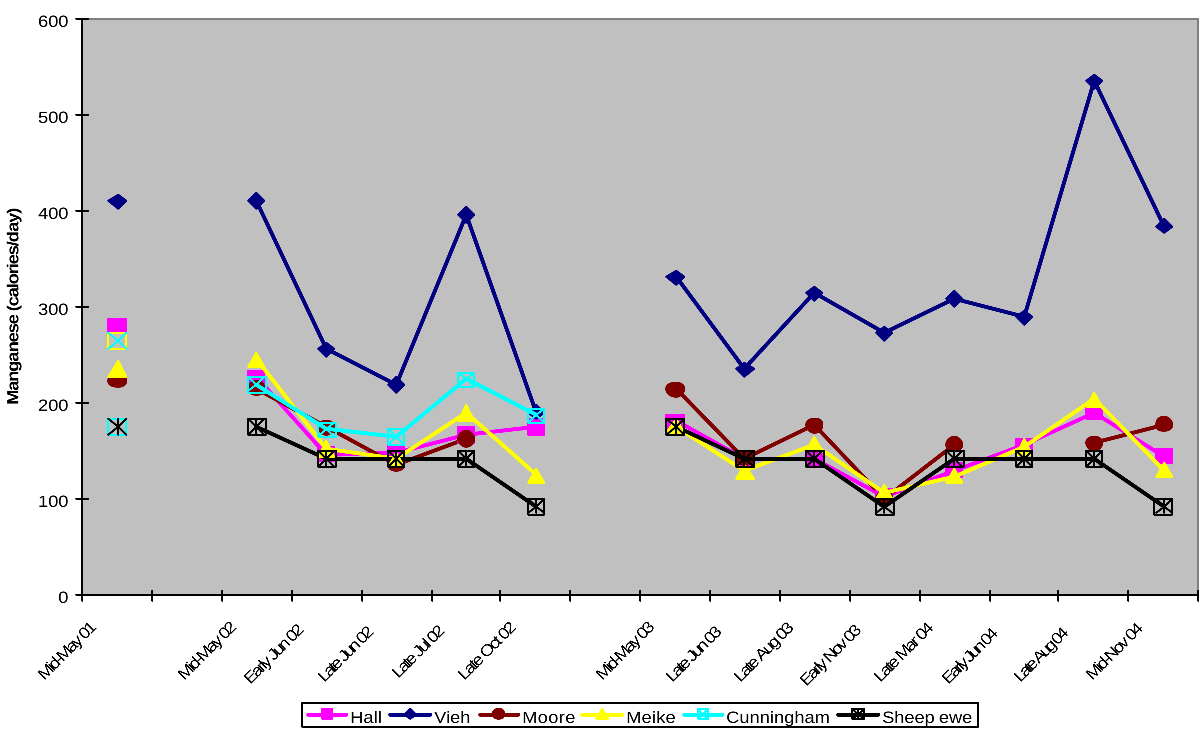

Figure 7b: Amount of manganese a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

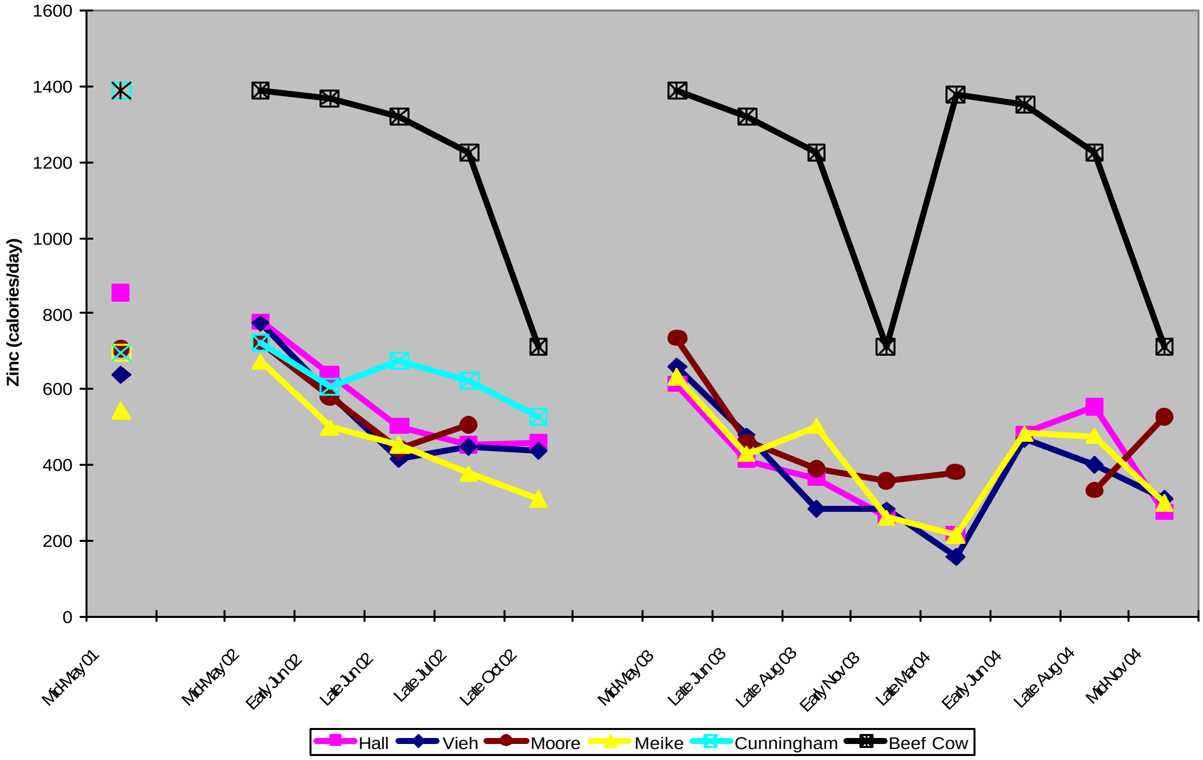

Figure 8a: Amount of zinc a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

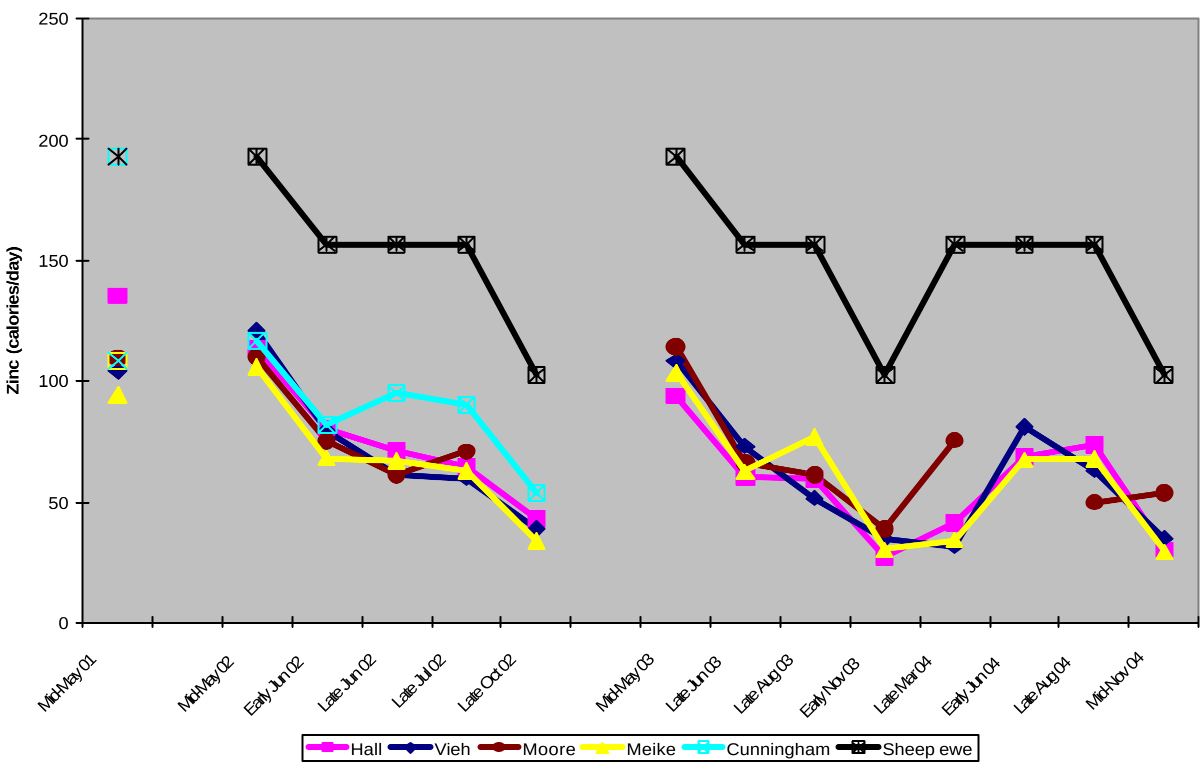

Figure 8b: Amount of zinc a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

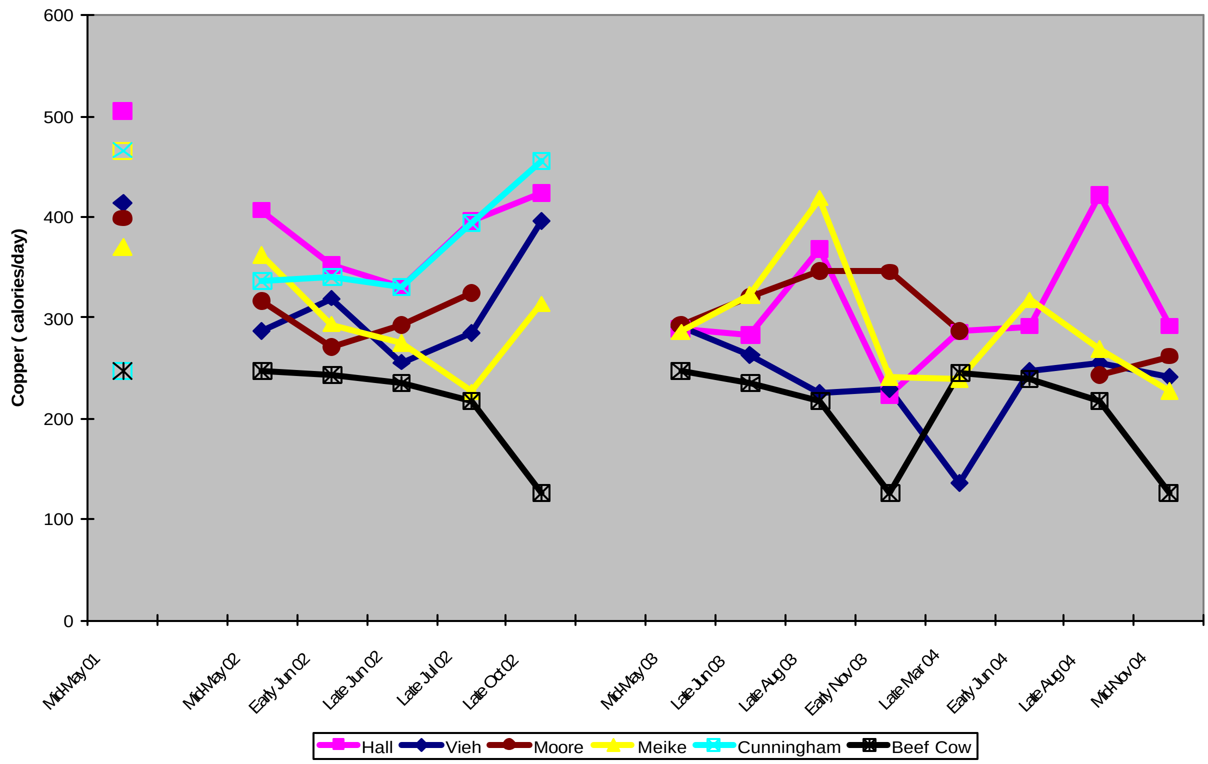

Figure 9a: Amount of copper a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

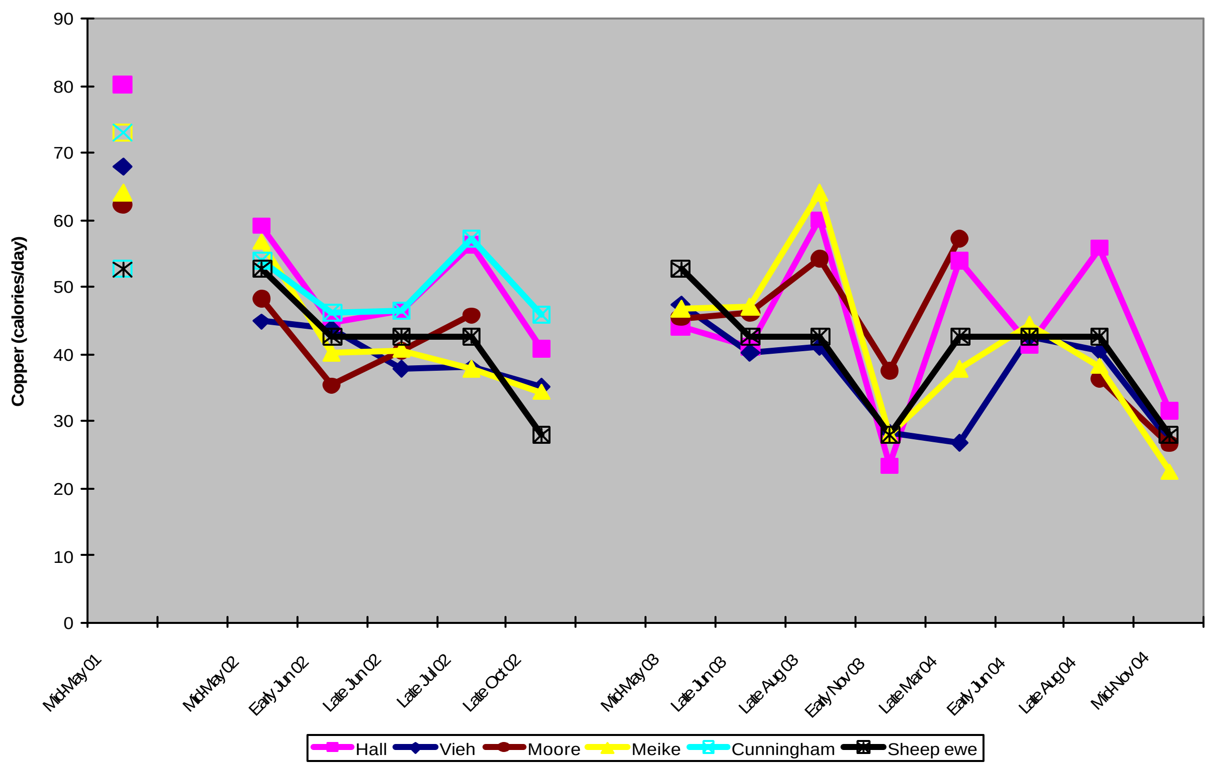

Figure 9b: Amount of copper a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

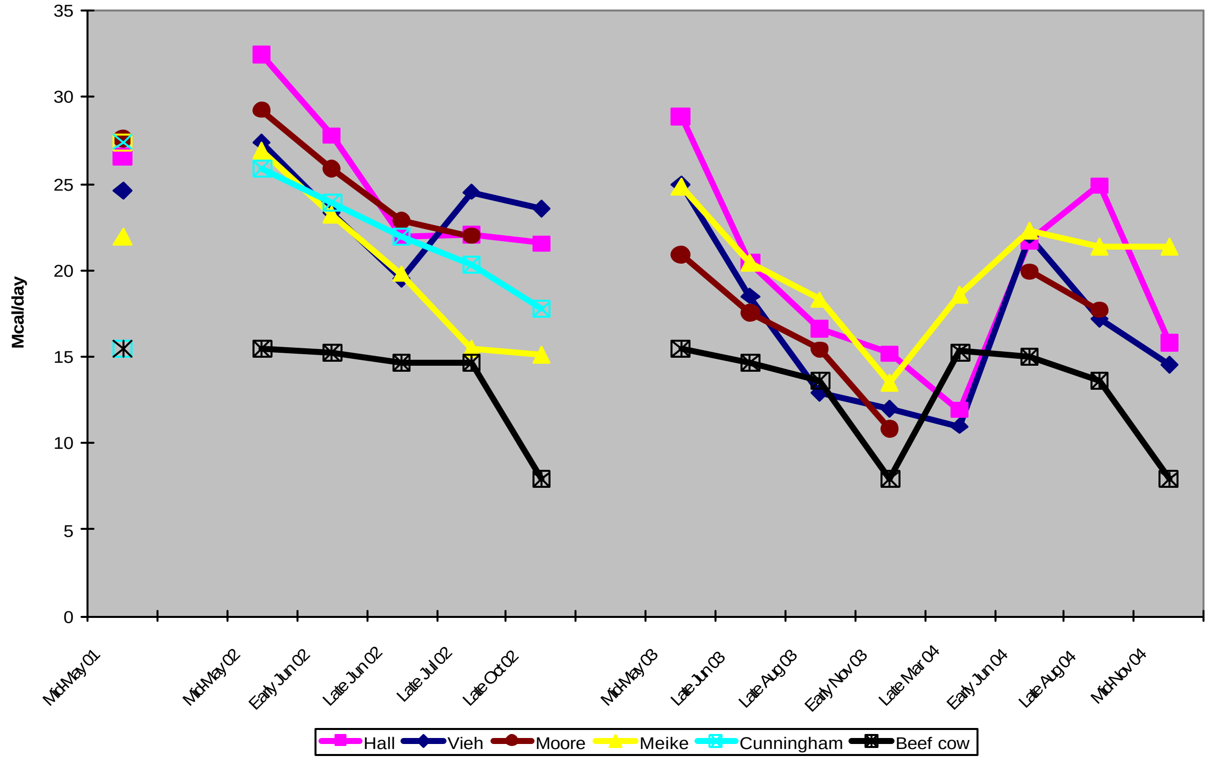

Figure 10a: Amount of NEm a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

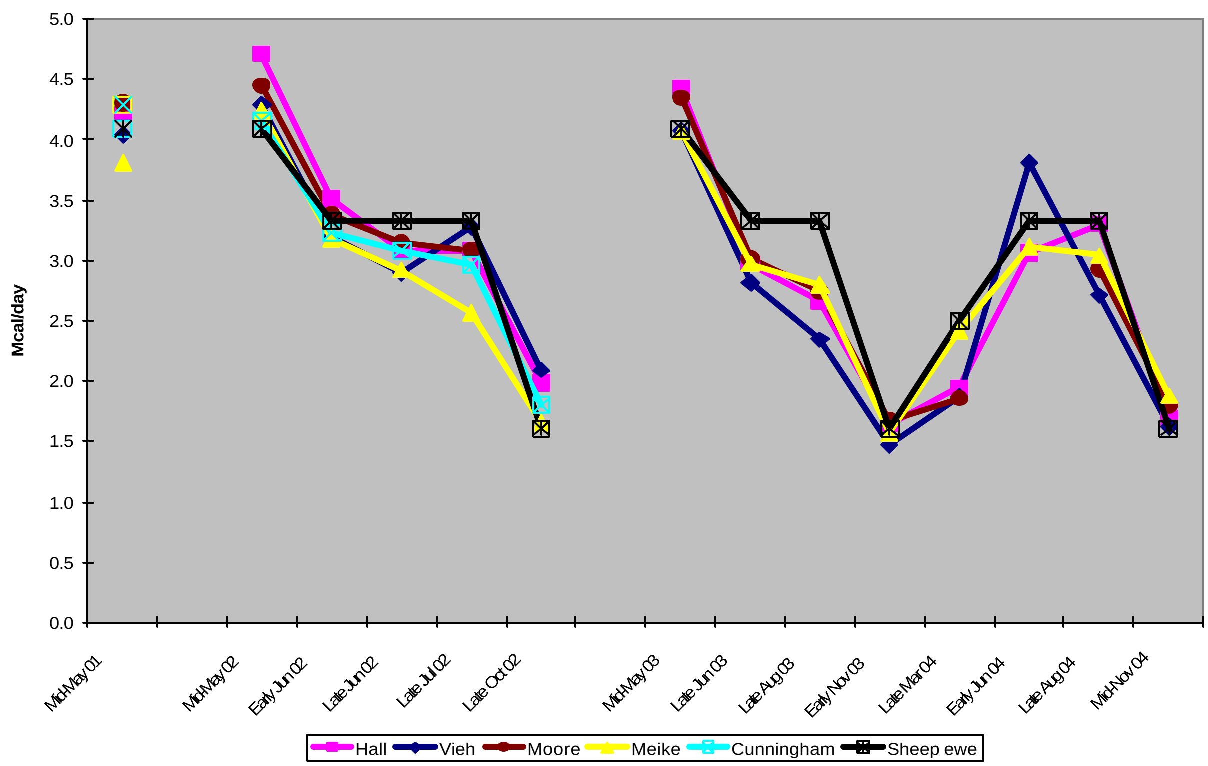

Figure 10b: Amount of NEm a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires in her diet.

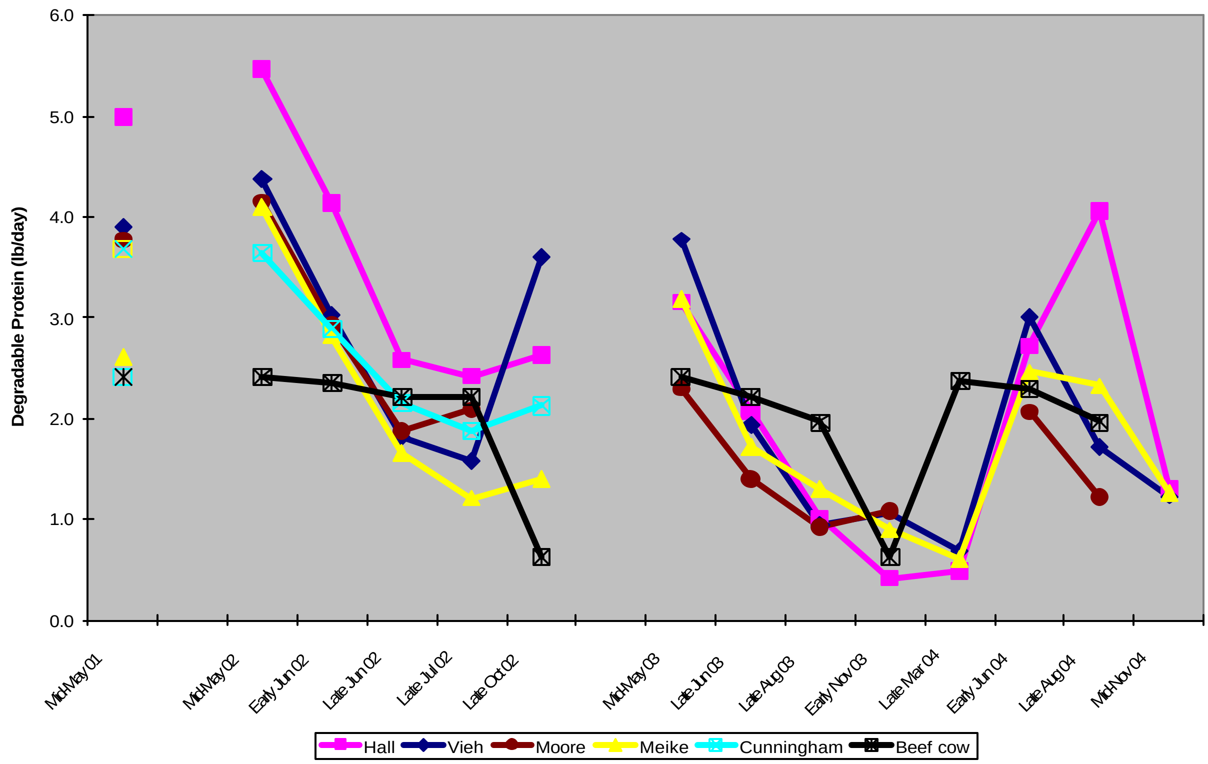

Figure 11a: Amount of degradable protein a 1250 pound beef cow that calves March 1 and calf weaned October 15 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires.

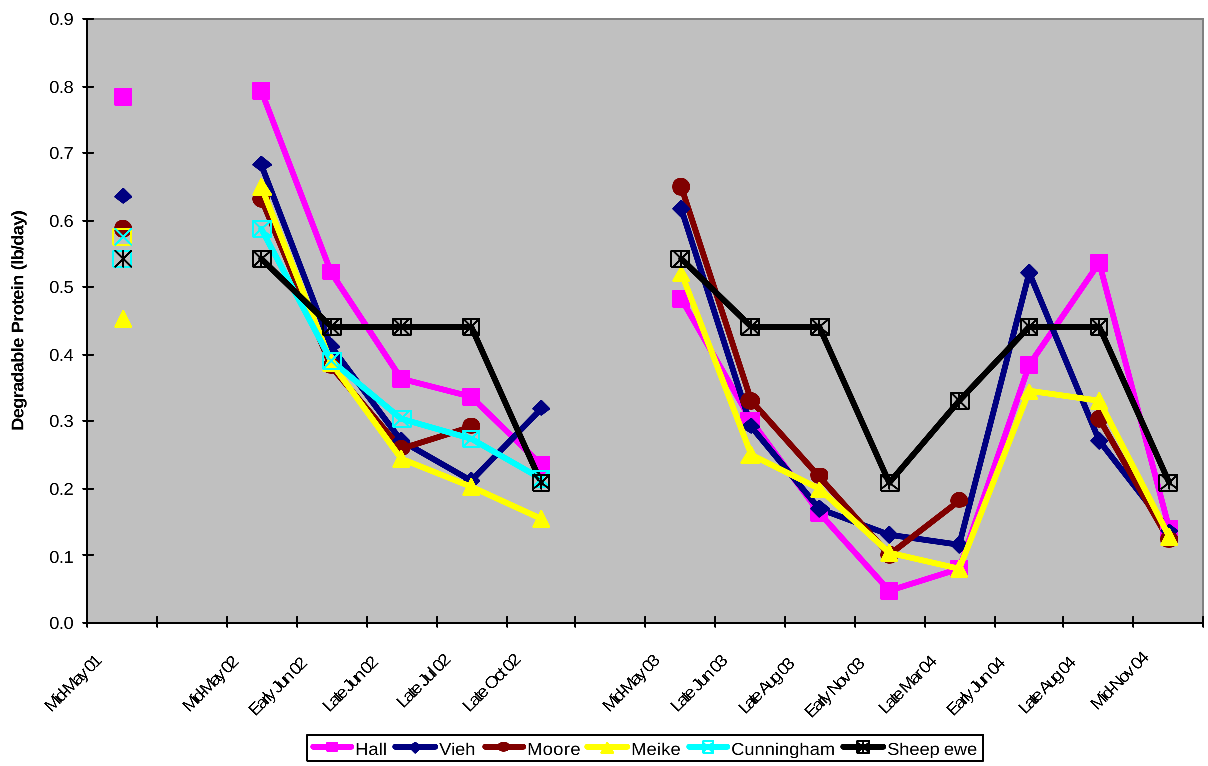

Figure 11b: Amount of degradable protein a 154 pound sheep ewe that lambs April 1 and lamb(s) weaned September 1 would consume from native range pastures from five Johnson County Wyoming ranches and the minimum amount she requires.