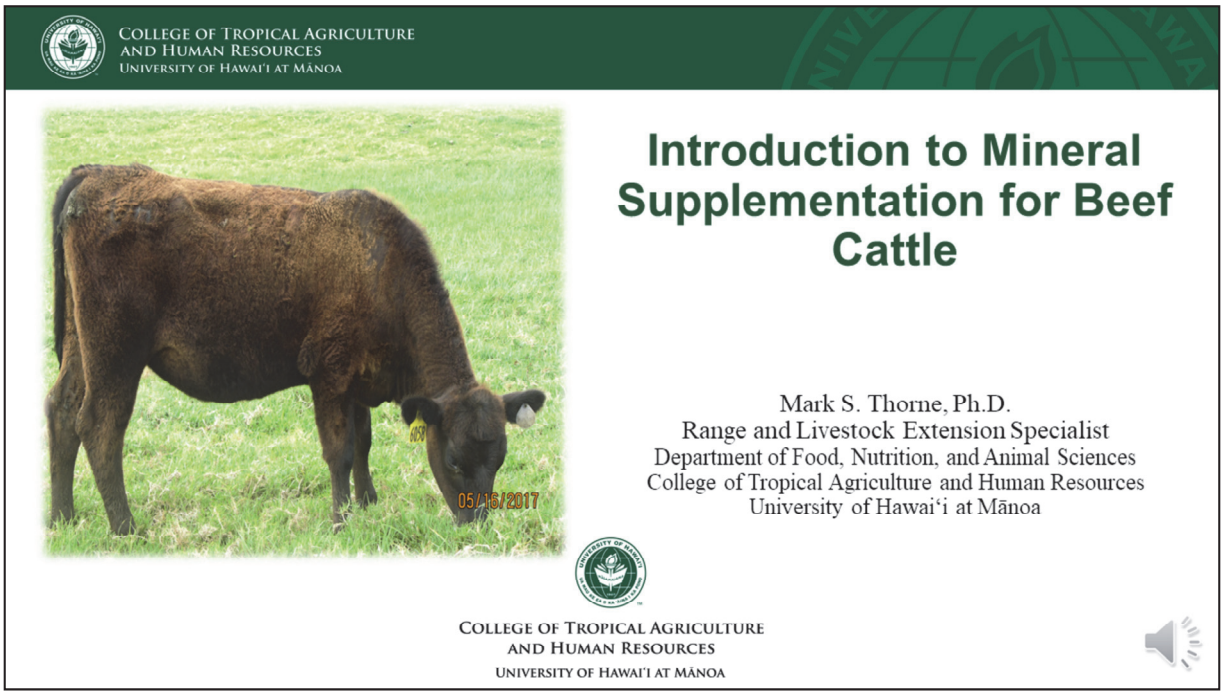
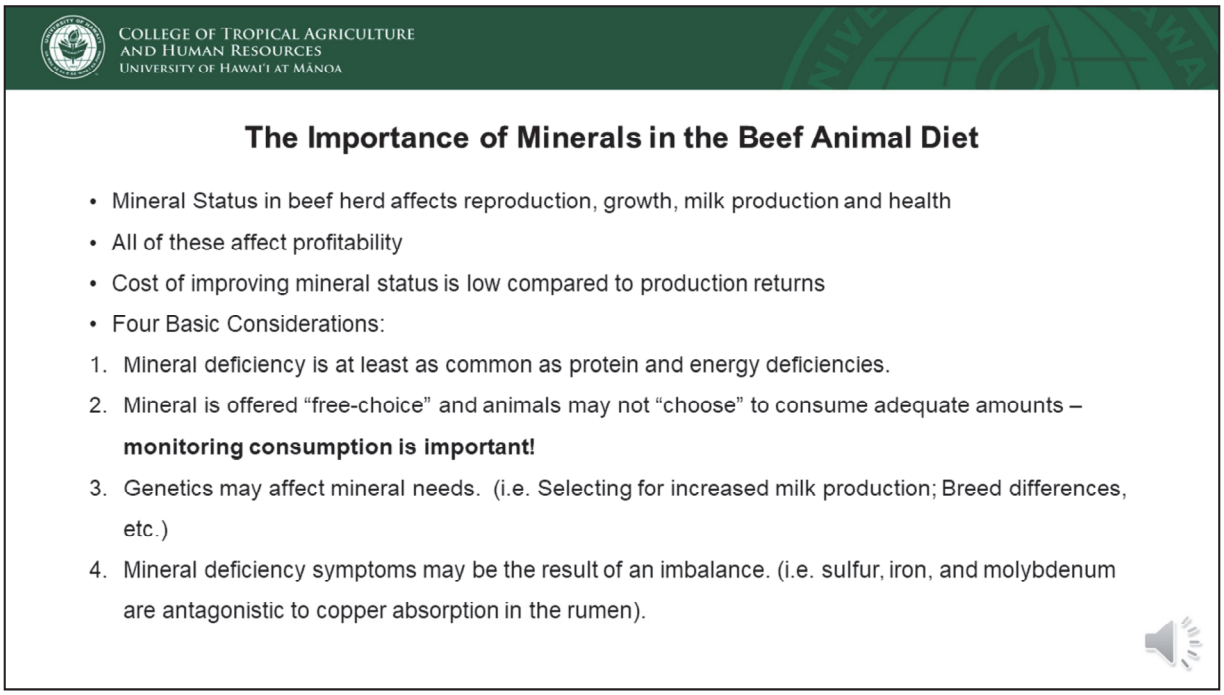


In this presentation we will discuss why mineral supplementation is important, introduce the different macro- and micro-minerals and how they function in the body.

We will discuss the mineral nutritional needs of various classes of beef cattle and common deficiencies and how they affect your cattle.

Finally, we will discuss how to assess your existing mineral program and your herd mineral needs, and we will provide examples of different mineral supplementation programs with cost comparisons.



You might be wondering why mineral supplementation is important for your beef herd. The first thing to know is that the mineral status of each animal in the herd affects their ability to reproduce, grow, produce milk and their general health.

Poor mineral status of the beef herd affects ranch profitability through lower calving percentages, lower milk production and calf growth rates, and generally poorer health of the herd. Minerals are relatively inexpensive when compared to the cost of reduced profits as a result of poor mineral status in the herd.

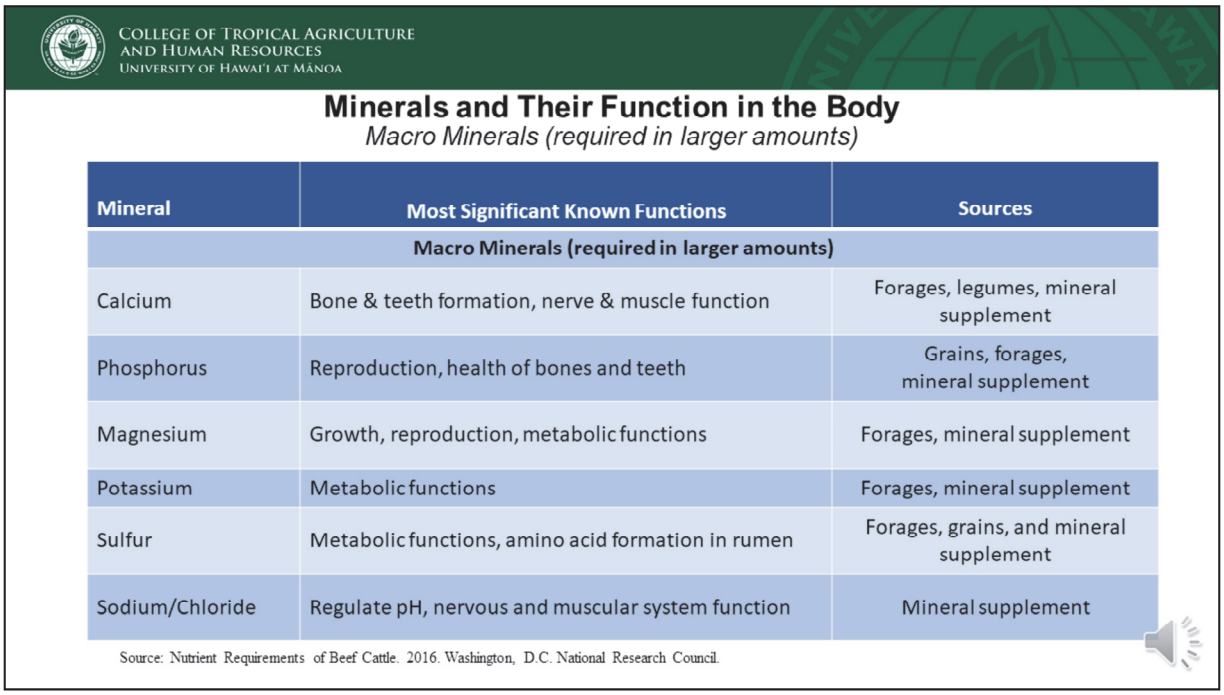
In other words, a small investment in mineral can have large returns on herd production and ranch profits. There are for basic considerations to keep in mind when thinking about a mineral program: Mineral deficiency is a least as common as protein and energy deficiencies.

Poor forage that is low in protein and/or energy will also be poor in mineral content. However, even good quality forage in terms of protein and energy, can be deficient in one or more minerals. This can occur for various reasons which we will discuss a little later.

Mineral is typically offered "free-choice" but animals my not "choose" to consume adequate amounts of the mineral. Thus, monitoring consumption is important. Most commercial mineral mixes provide a recommended rate of consumption per head per day. This makes it easy to monitor the actual rate of consumption in comparison to the recommended rate and make decisions about necessary adjustments.

Genetics may affect mineral needs. For example, selectively breeding for higher milk production will increase the mineral needs of the herd over time. Additionally, some breeds may have higher mineral demands than others.

Finally, mineral deficiency symptoms may be the result of an imbalance among the minerals in the forage. For example, sulfur, iron, and molybdenum are antagonistic to copper absorption in the rumen. Consequently, your forage may be adequate in copper, but if it is high in one or more of these three antagonists, your animals could display symptoms of copper deficiency.



In the next two slides we will look at the macro and micro-minerals, how they function in the body, and their major sources.

The Macro-minerals are considered to be Calcium, Phosphorus, Magnesium, Potassium, Sulfur, and Sodium (which typically occurs with Chloride). These are minerals that are required in larger amounts than other minerals.

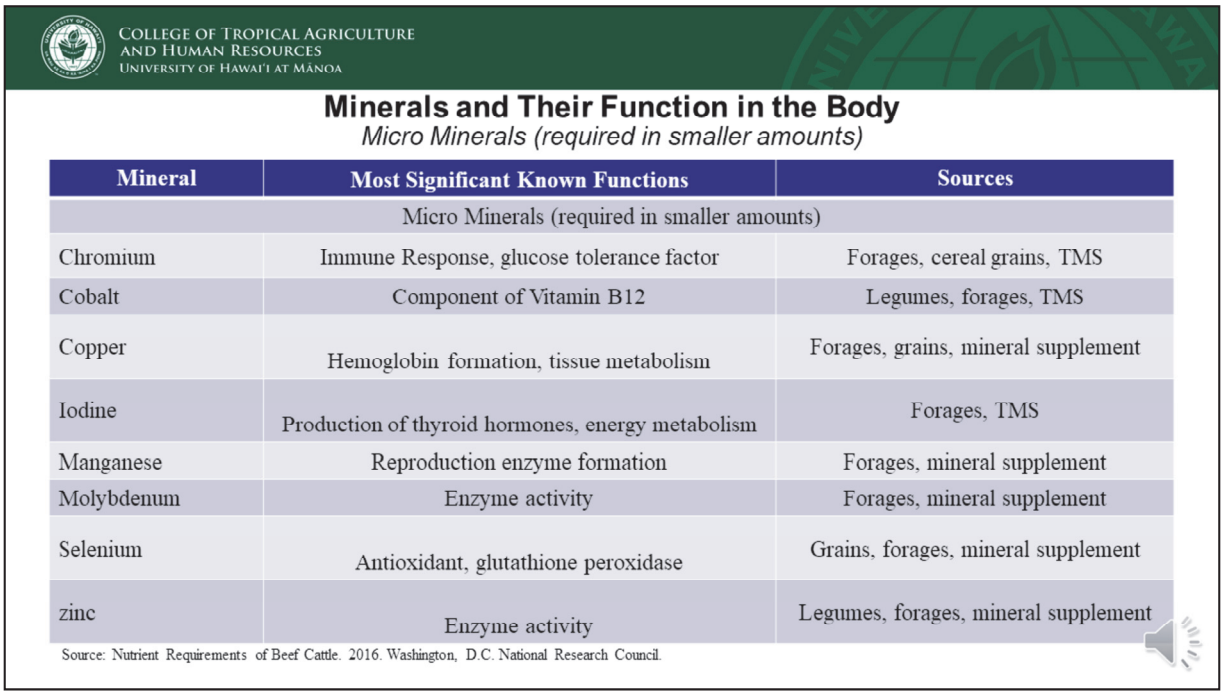
In the table you see that forages provide all of the macro-minerals except sodium chloride.

Calcium is important for the development of bone and teeth in young animals. It is also important in nerve and muscle function in all types of livestock. Pasture forages, including grasses and legumes, contain calcium. The only other source of calcium is through mineral supplementation.

Phosphorus is important for reproductive health of breeding animals and is also important for heathy teeth and bones. Important sources of P include pasture forages, grains, and mineral supplementation.

Magnesium, potassium, and sulfur are all essential in maintaining metabolic function in the body. Additionally, magnesium supports reproductive health and growth in young animals. Sulfur is required for amino acid formation in the rumen. Forages and mineral supplementation are the main sources of these minerals for beef cattle.

Sodium chloride is required to regulate body pH, and to maintain nervous and muscular system function. The only place animals can get adequate sodium is through supplementation. It is important to note that Salt-spray from the ocean, for those who have pasture near the coast, is not sufficient in sodium or any other mineral to meet the needs of beef cattle.



Minerals and Their Function in the Body

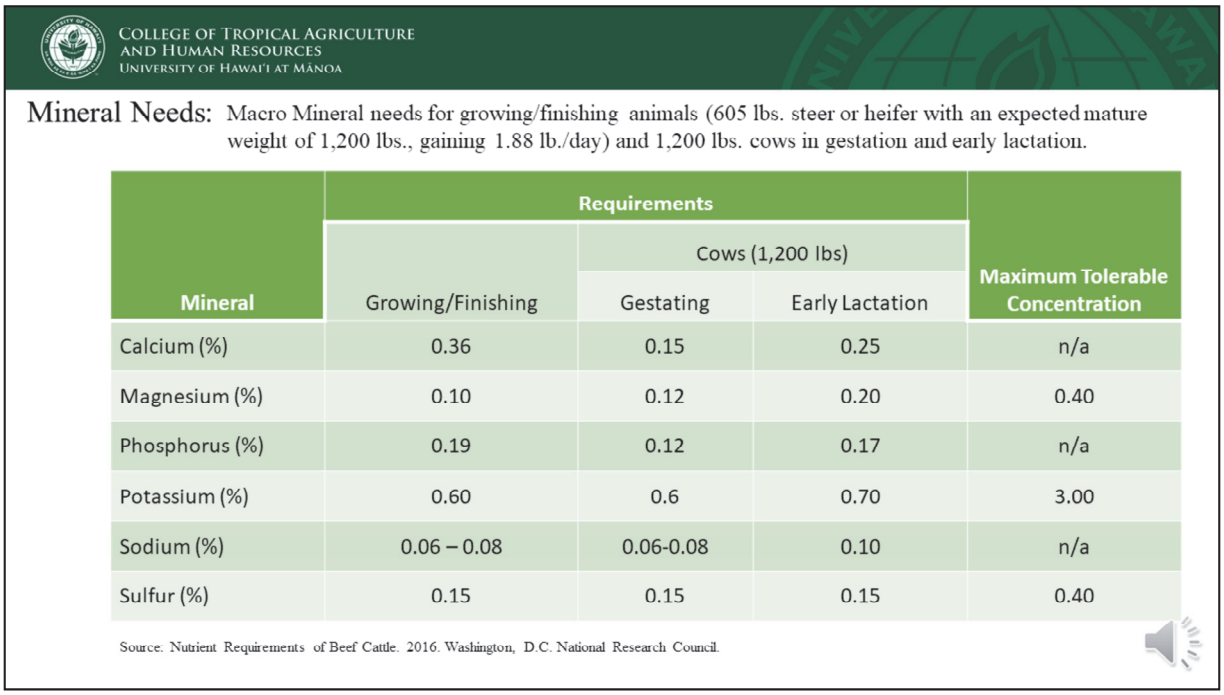
Micro Minerals (required in smaller amounts)

Mineral	Most Significant Known Functions	Sources
Micro Minerals (required in smaller amounts)		
Chromium	Immune Response, glucose tolerance factor	Forages, cereal grains, TMS
Cobalt	Component of Vitamin B12	Legumes, forages, TMS
Copper	Hemoglobin formation, tissue metabolism	Forages, grains, mineral supplement
Iodine	Production of thyroid hormones, energy metabolism	Forages, TMS
Manganese	Reproduction enzyme formation	Forages, mineral supplement
Molybdenum	Enzyme activity	Forages, mineral supplement
Selenium	Antioxidant, glutathione peroxidase	Grains, forages, mineral supplement
zinc	Enzyme activity	Legumes, forages, mineral supplement

Source: Nutrient Requirements of Beef Cattle. 2016. Washington, D.C. National Research Council.

The micro-minerals include chromium, cobalt, copper, iodine, manganese, molybdenum, selenium, and zinc. These are needed in smaller amounts than the macro-minerals. The main sources of these minerals include forages, legumes, and mineral supplementation.

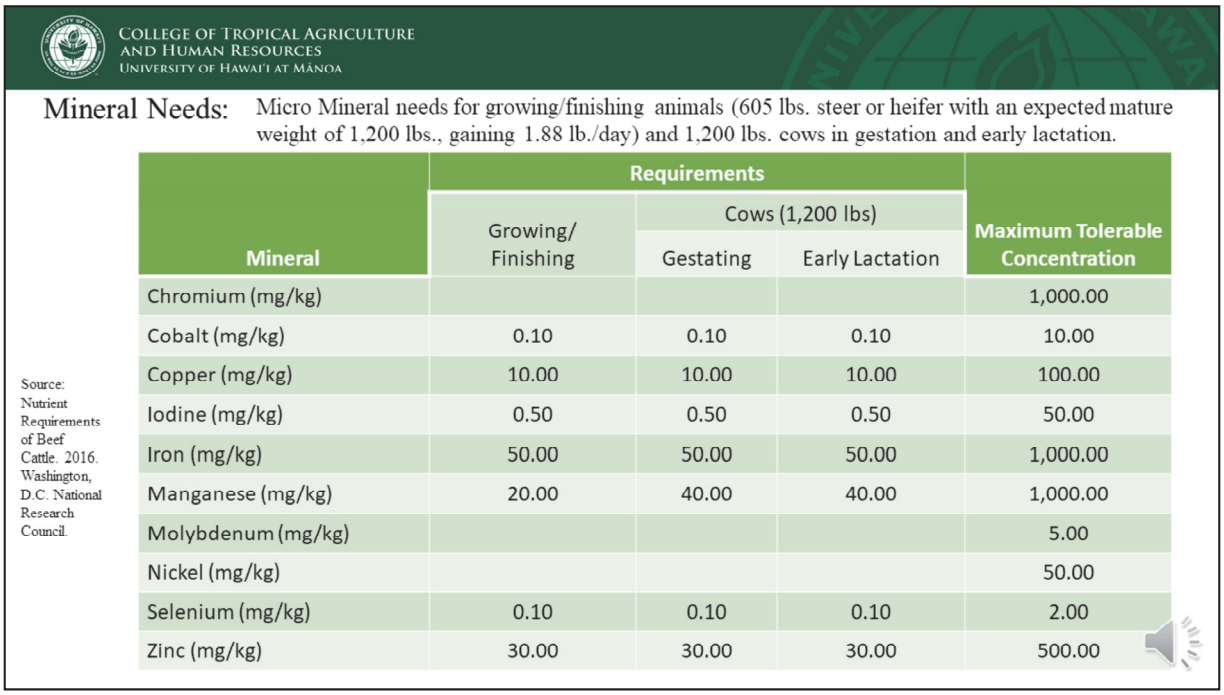
Chromium is important for immune response while cobalt is a component of vitamin B12. Copper is essential for hemoglobin formation and tissue metabolism. Iodine is critical in the production of thyroid hormones and energy metabolism. Manganese and molybdenum are important for enzyme formation and activity. Selenium is an important antioxidant, and in the formation of glutathione peroxidase contributing to healthy thyroid function. Finally, zinc contributes to healthy enzyme activity.



In the next two slides we will examine the macro and micro mineral needs of growing and breeding beef cattle. The mineral needs of a beef animal depends on their size, kind and class. For example, a growing steer has different mineral needs than a dry cow. The status of animal also plays a roll, for example a dry cow has different mineral needs than a cow in lactation. For this exercise I have selected a 605 lbs. growing animal with an expected mature weight of 1,200 lbs., gaining at 1.88 lbs./day, and a 1,200 lbs. breeding cow in gestation and early lactation, for comparison of their mineral needs. The values presented here come from the National Research Council 2016 publication on Nutrient Requirements of Beef Cattle.

Note that growing/finishing cattle require considerably more calcium and phosphorus than mature cattle, while magnesium, potassium, sodium, and sulfur remain nearly constant as the animals mature. In a breeding cow the requirement for calcium, magnesium, phosphorus, and potassium increase considerably between gestation and early lactation in support of milk production. On the other hand, while the sodium requirement increases slightly, sulfur remains unchanged.

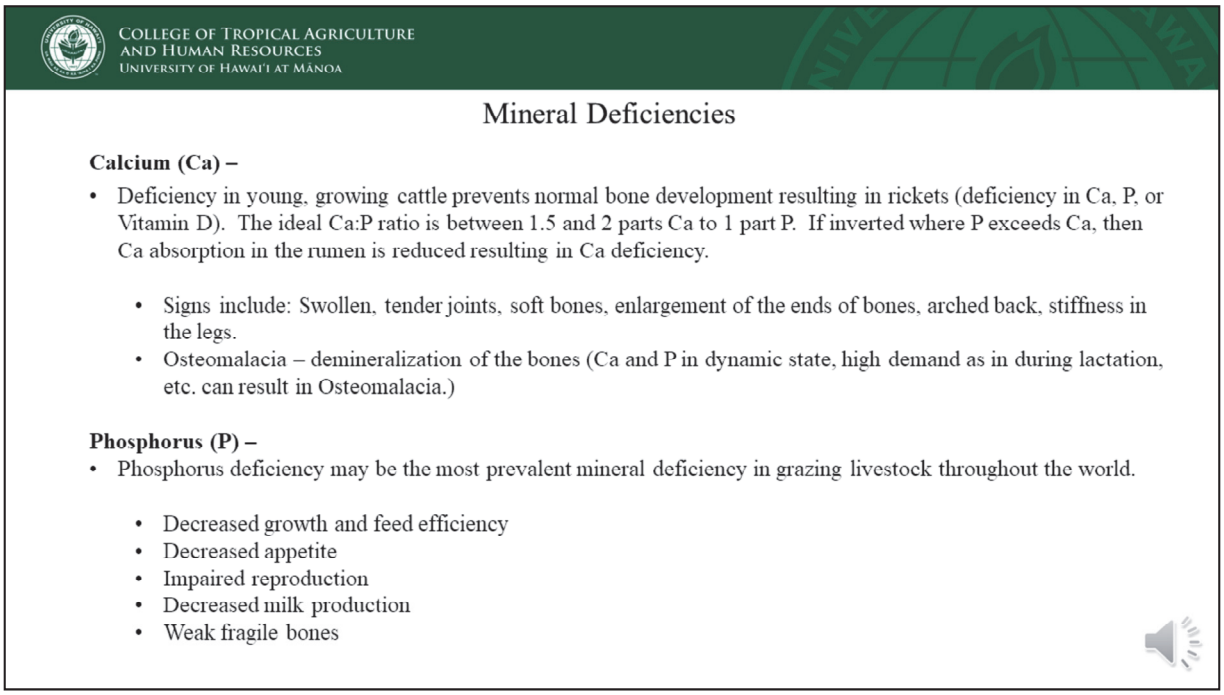
In the right column you will see the maximum tolerable concentration recommended by the National Research Council. Mineral concentrations beyond these recommended levels are considered toxic. While Calcium, phosphorus, and sodium have no values assigned, the maximum tolerable concentration for Magnesium and sulfur are set at 0.4%. Potassium is set at 3%.



Mineral	Requirements			Maximum Tolerable Concentration
	Growing/ Finishing	Cows (1,200 lbs)		
		Gestating	Early Lactation	
Chromium (mg/kg)				1,000.00
Cobalt (mg/kg)	0.10	0.10	0.10	10.00
Copper (mg/kg)	10.00	10.00	10.00	100.00
Iodine (mg/kg)	0.50	0.50	0.50	50.00
Iron (mg/kg)	50.00	50.00	50.00	1,000.00
Manganese (mg/kg)	20.00	40.00	40.00	1,000.00
Molybdenum (mg/kg)				5.00
Nickel (mg/kg)				50.00
Selenium (mg/kg)	0.10	0.10	0.10	2.00
Zinc (mg/kg)	30.00	30.00	30.00	500.00

The micro-mineral needs of growing cattle are not that much different than in mature cattle except for Manganese. Growing cattle need about half the amount of this mineral as do mature cattle. Likewise, there is no real additional requirement in micro-minerals between gestation and lactation.

However, all the micro-minerals have a maximum tolerable concentration. Again, concentrations beyond these levels are considered toxic.

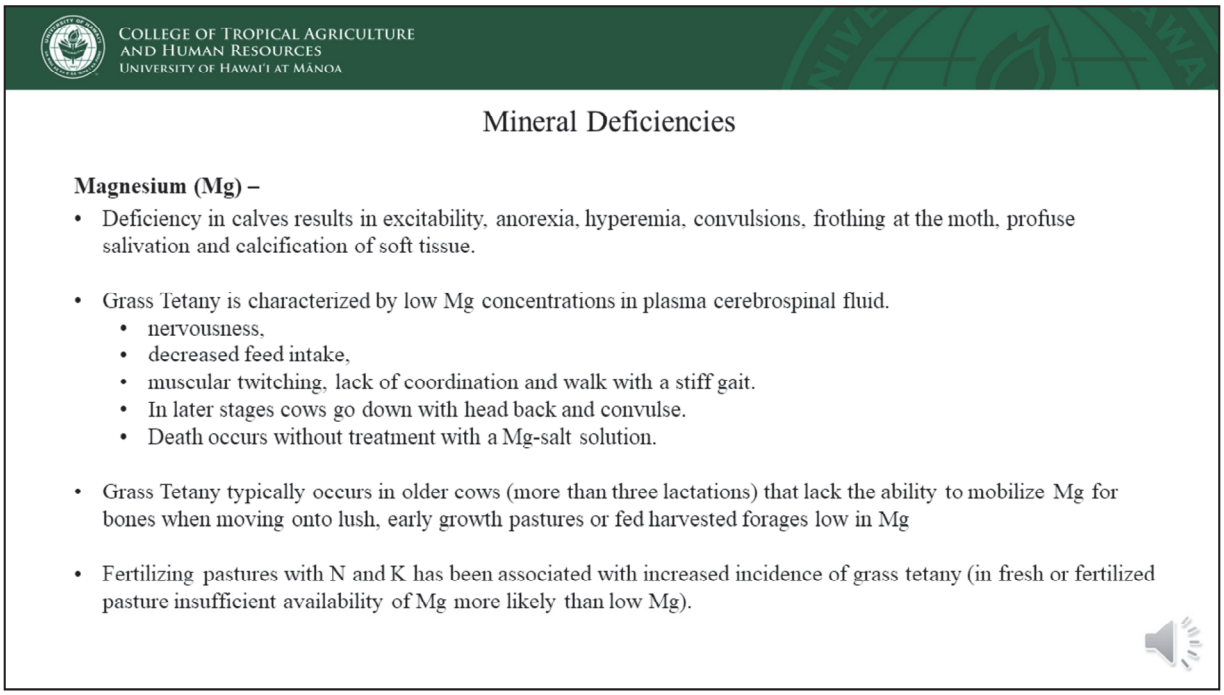


In the next five slides we will discuss the most common mineral deficiencies and how they affect beef animals and your operation. The first two we will discuss will be Calcium and Phosphorus.

Calcium deficiency most commonly occurs in young growing animals and results in poor bone development often referred to as “rickets”. It develops when there is an imbalance between C, P, and Vitamin D. The ideal ratio of C to P is between 1.5 and 2 parts C to 1-part P. If this in inverted and P exceeds C then calcium absorption in the rumen is reduced resulting in C deficiency. Signs of C deficiency in growing cattle include swollen tender joints, soft bones, enlarged ends of bones, arched back, and stiffness in the legs.

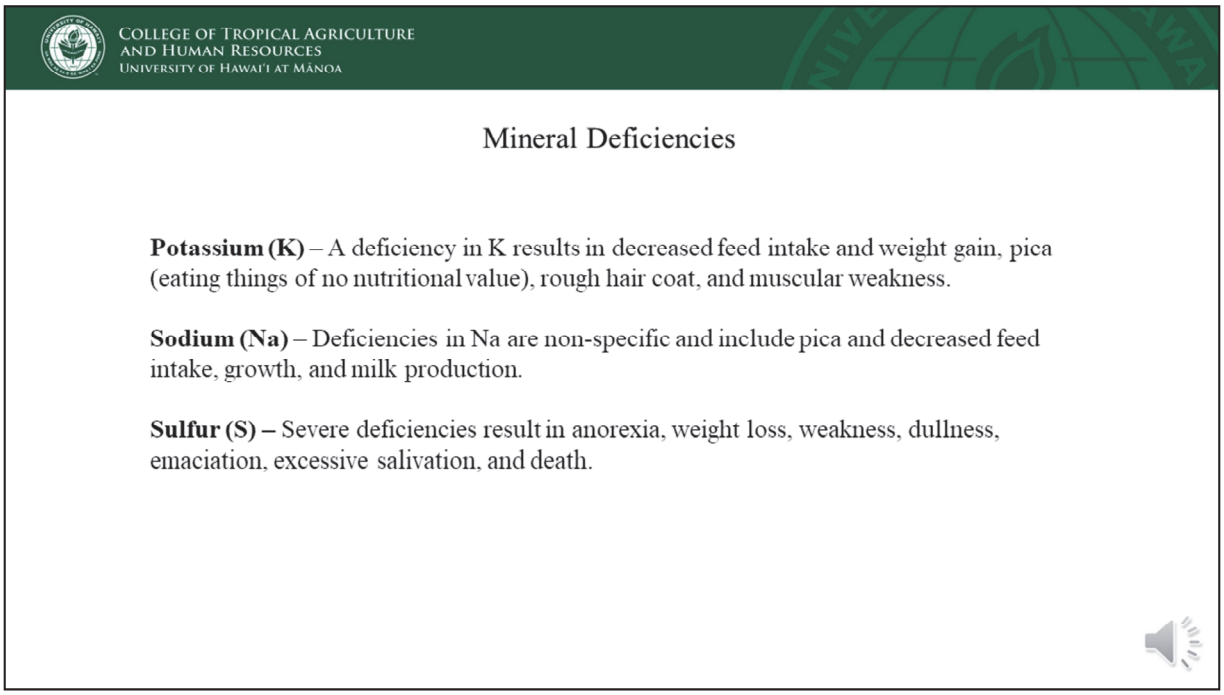
Osteomalacia or the demineralization of the bones can occur in lactating cows when forage quality is poor and the C:P ratio is below 1.5:1 causing C and P to be in a dynamic state internally.

Phosphorus deficiency may be the most prevalent mineral imbalance in grazing livestock worldwide. Symptoms of P deficiency include decreased growth and feed efficiency, decreased appetite, impaired reproduction, decreased milk production, and weak, fragile bones.



Magnesium deficiency in young cattle results in excitability, anorexia, hyperemia, convulsions, frothing at the mouth, profuse salivation, and calcification of soft tissue.

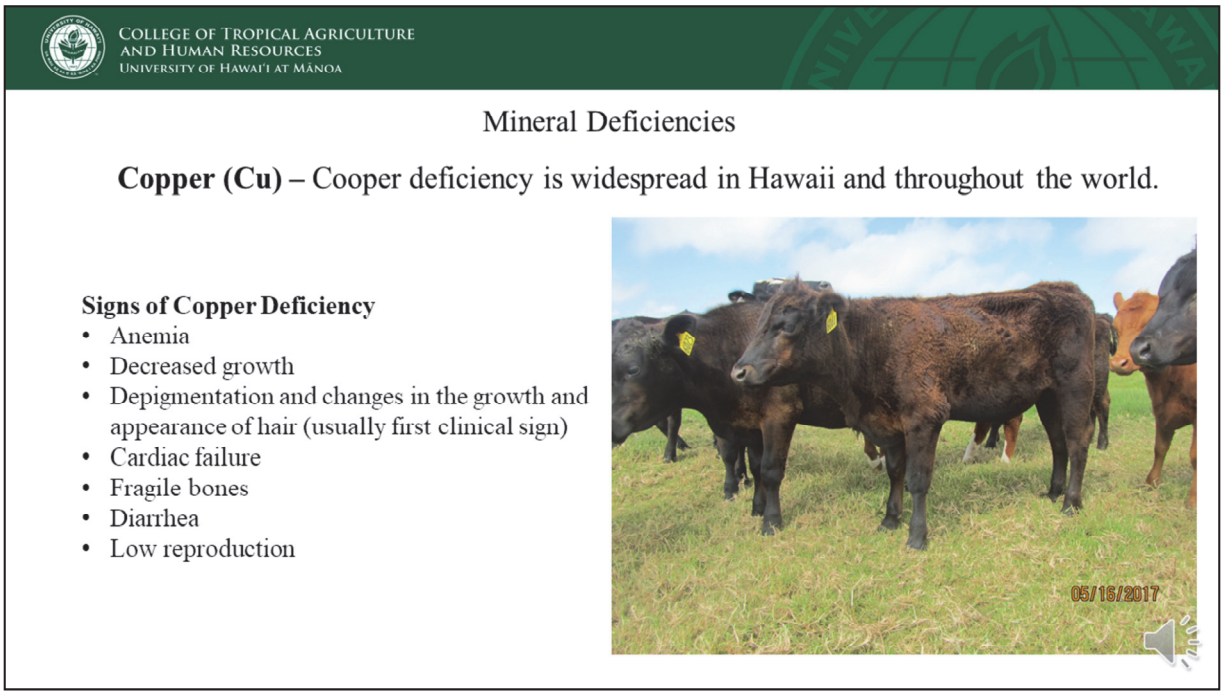
A condition referred to as Grass Tetany is characterized by low Mg concentrations in plasma cerebrospinal fluid. It typically occurs in older cows, having had more than three lactations, that lack the ability to mobilize Mg for bones when moving onto lush, early growth pastures or fed harvested forages low in Mg. Fertilizing pastures with N and K has been associated with increased incidence of grass tetany as a result of insufficient availability of Mg as opposed to low Mg concentrations. Symptoms of Grass Tetany include nervousness, decreased feed intake, muscular twitching, lack of coordination and walking with a stiff gate. In later stages cows will go down with head back and convulse. Death occurs shortly thereafter without treatment with a Mg-salt solution.



Potassium concentration in forages is highest in young photosynthetically active leaf material. As the leaf material ages, or the plant dries up or goes dormant potassium is lost from the plant tissues. Consequently, Potassium deficiencies are most common on old dry forages or poorly cured hay. A deficiency in K results in decreased feed intake and weight gain, pica, rough hair coat, and muscular weakness.

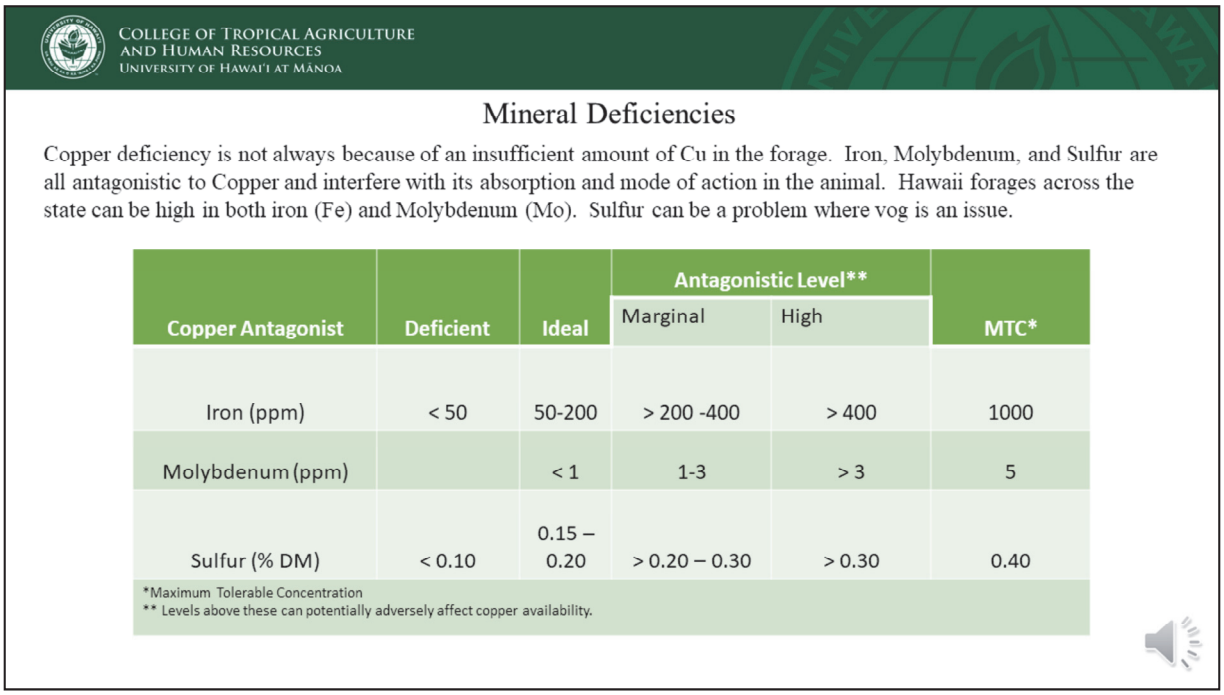
Deficiencies in Na are non-specific and include pica and decreased feed intake, growth, and milk production. Sodium deficiency is common in Hawaii where mineral supplementation is not provided. Sea-spray is not a sufficient source of Na for cattle.

Deficiencies in sulfur result in anorexia, weight loss, weakness, dullness, emaciation, excessive salivation, and death.



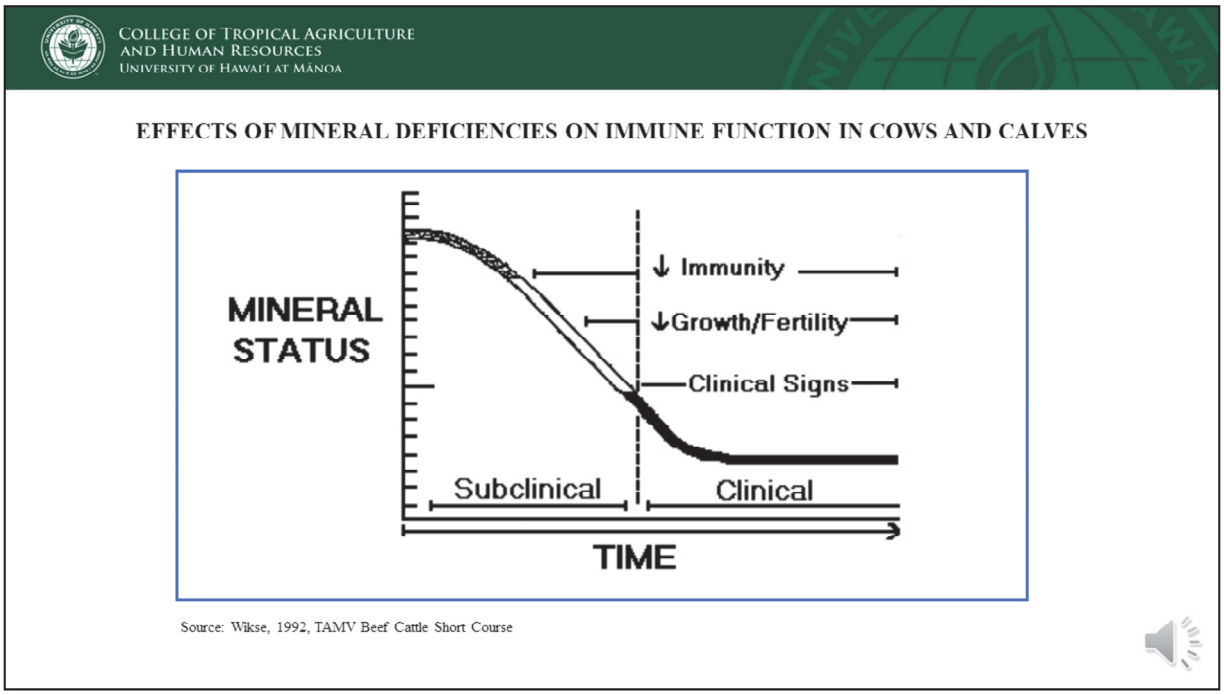
Copper deficiency is widespread in Hawaii and throughout the world. The heifer in the center of the picture on this slide is expressing clinical signs of copper deficiency.

These symptoms include anemia, decreased growth rate, and depigmentation and changes in the growth and appearance of hair. This is usually the first clinical sign observed. Other symptoms include cardiac failure, fragile bones, diarrhea, and low reproduction rates.

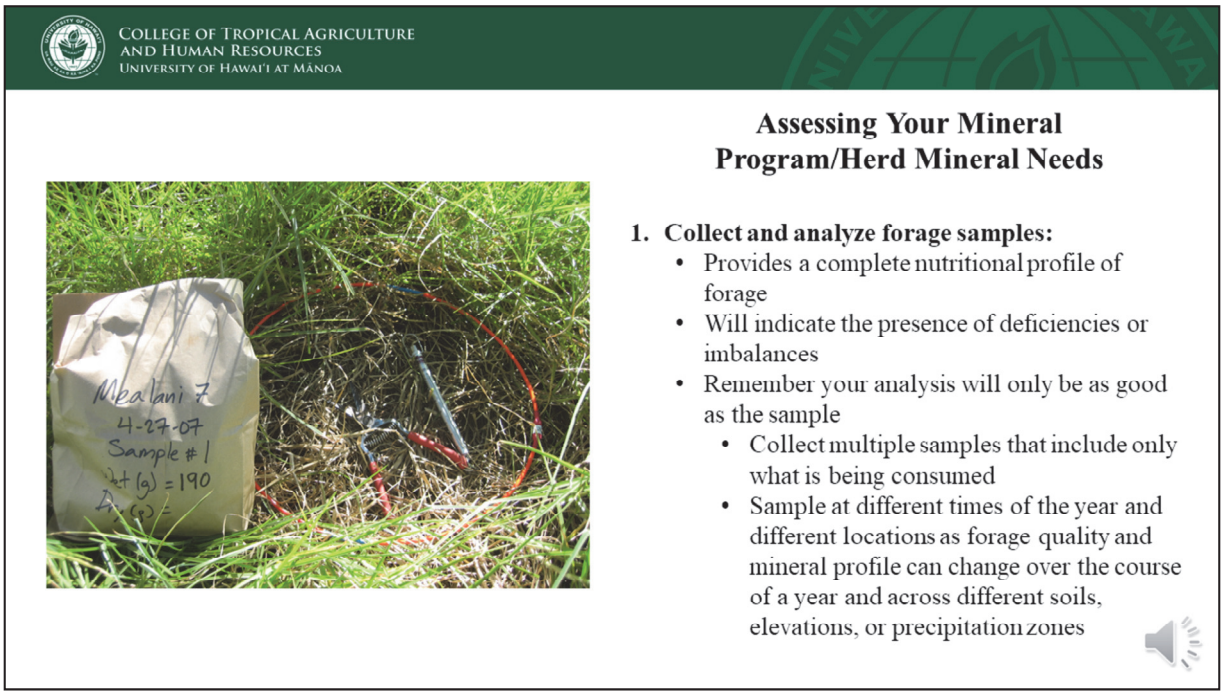


Copper deficiency is not always the result of an insufficient amount of Cu in the forage. Iron, Molybdenum, and sulfur are all antagonistic to copper and interfere with its absorption and mode of action in the animal.

Hawaii forages across the state can be high in both iron and molybdenum. Sulfur can be a problem where vog is an issue. The table below provides the range of values, from deficient to the Maximum Tolerable Concentration for Iron, Molybdenum, and sulfur. In between these two extremes are the ideal range and the range at which the mineral becomes antagonistic to copper. For example, Iron is marginally antagonistic to copper between 200-400 ppm and highly antagonistic above 400 ppm. It is common for Hawaii forages to have iron concentrations in the range of 150 – 450 ppm; and at certain times of the year and locations iron concentration can exceed 1,000 ppm. Molybdenum and sulfur concentrations in Hawaii forages can also be marginal to highly antagonistic.



This diagram illustrates the consequences of chronic mineral deficiency in beef cattle. Mineral status is displayed on the vertical axis and time on the horizontal axis. Thus, initially when mineral status is high the animal is healthy and able to grow, reproduce, or produce milk depending on the animal. Over time though, if a mineral deficiency is not addressed bodily functions begin to be compromised. For a time, the animal may not express any clinical signs; this is the subclinical period in the diagram. However, note that in this region immunity is first depressed followed by a reduction in growth and fertility, before clinical signs appear. Thus, by the time you observe the clinical signs of a mineral deficiency in the herd, you have already lost money through depressed immunity, and lower growth and fertility rates. It is important therefore, to continually assess and monitor your mineral program and herd mineral needs.



When assessing your existing mineral program and your herd mineral needs there are six key factors that will provide important information as you make decisions.

The first is an analysis of mineral quality of the forages in your pastures. This is an important first step and is the most economical means to determine what minerals are sufficient, lacking, or causing antagonistic issues in the mineral health of your herd. Forage samples should include only what is being consumed. Do not include plants or plant parts that the animals do not eat as this will affect the nutrient profile and could lead to incorrect decisions. Sample at different times of the year and across different locations as forage quality and mineral profiles can change over the course of a year and across different soils, elevations, and precipitation zones.

	Season	Sample Size	% DM	% CP	% Ca	% P	% Mg	% K	% Na	Fe ppm	Zn ppm	Cu ppm	Mn ppm	Mo ppm	% S	Ca:P	Cu:Mo
Oct. & Nov. 2011	Fall	n=9	23.0	15.3	0.3	0.4	0.3	3.0	0.1	458.0	48.3	8.9	144.7	0.3	0.2	0.9	69.6
			2.1	2.3	0.0	0.1	0.0	0.6	0.0	327.3	7.4	0.8	43.0	0.1	0.0	0.2	33.7
Dec. 2011 - Feb. 2012	Winter	n=9	24.1	20.4	0.4	0.4	0.3	2.3	0.1	492.7	38.4	11.2	127.6	0.9	0.2	1.1	13.4
			6.7	2.6	0.0	0.0	0.0	0.1	0.1	298.0	8.9	1.4	46.7	0.3	0.1	0.1	3.1
Mar. 2012 - May 2012	Spring	n=6	28.8	20.1	0.4	0.3	0.3	2.3	0.1	810.8	36.7	10.5	130.5	0.5	0.3	1.2	29.0
			1.7	1.7	0.0	0.0	0.0	0.5	0.0	855.3	11.5	1.9	83.9	0.3	0.0	0.1	20.6
Jun. 2012 - Aug. 2012	Summer	n=9	23.8	18.9	0.3	0.3	0.3	2.7	0.1	180.8	38.1	11.3	225.1	0.1	0.2	1.0	100.0
			5.2	1.1	0.0	0.0	0.0	0.4	0.1	49.3	5.9	1.3	63.0		0.0	0.2	39.4

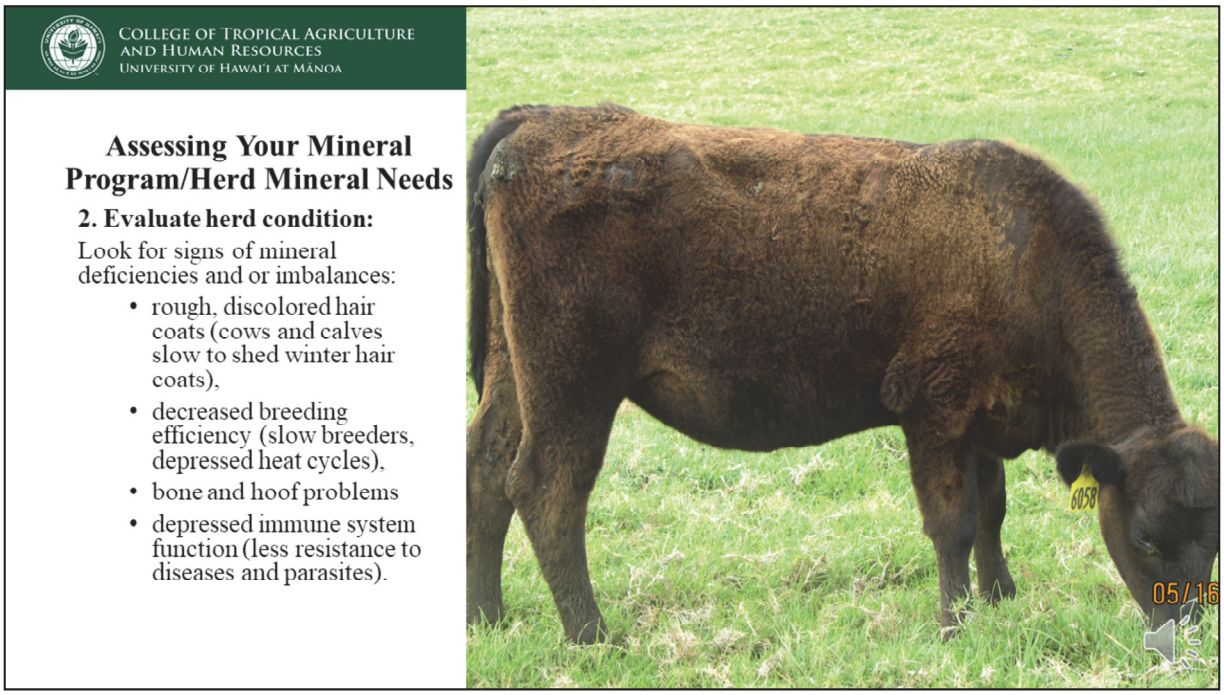
This slide presents selected forage analysis data from the University of Hawaii Mealani Experiment station over a one-year period between fall of 2011 and the end of summer 2012. These data illustrate several points we have been discussing so far.

The first thing to note is how the concentration of the highlighted minerals change over the course of the year. All fluctuate to one degree or another across seasons. Consequently, a sample taken in the fall of the year will not accurately reflect the mineral needs of the herd in the spring of the year.

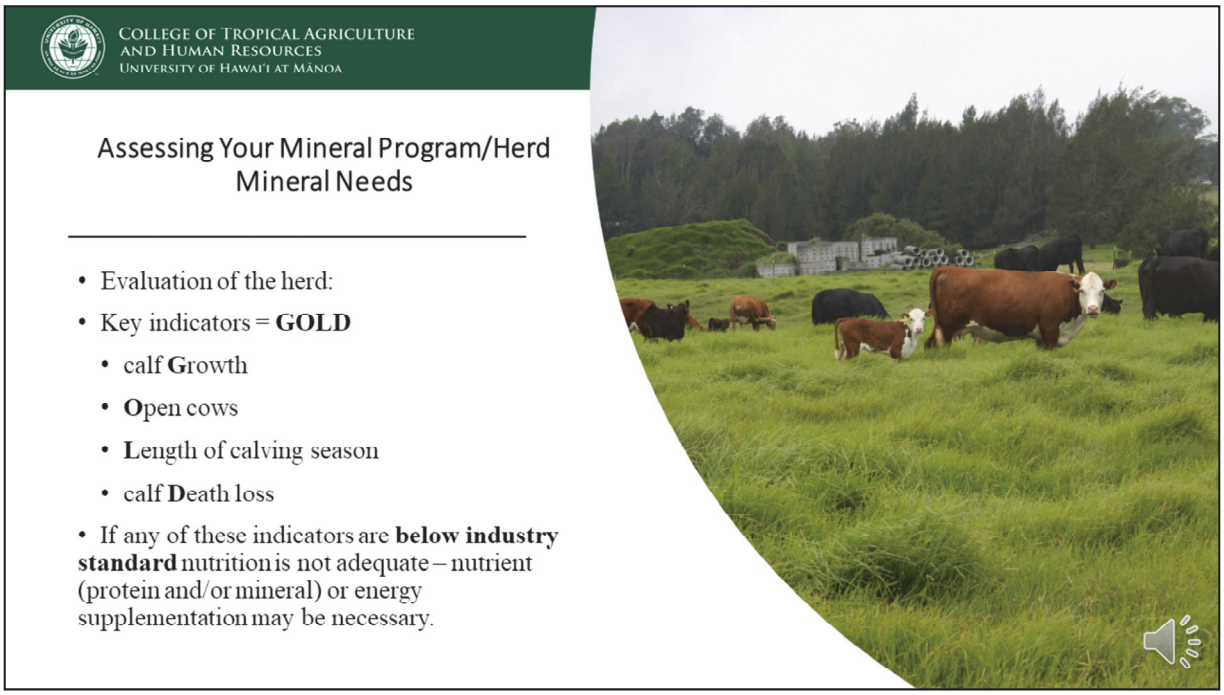
Note that in the blue column potassium is relatively high, being between 2.3 and 3 % on a dry matter basis across the year. Recall that cattle only need about 0.6% and that 3% is considered to be the Maximum Tolerable Concentration. In this case a mineral supplementation formulation would not need to include potassium.

Next, observe the Ca, P, and Ca:P ratio columns in yellow. Recall that the Ca needs of cattle range between 0.36% for growing animals on the high end and 0.15% for mature cows in gestation on the low end. P ranges between 0.19% and 0.12% for these animals. Both Ca and P, therefore are sufficient for both growing cattle and lactating cows. However, note the far right yellow column for ratio of Ca:P which ranges between 0.9 and 1.2, but the ideal Ca:P range is between 1.5 and 2 parts Ca to 1 part P. In this case additional Ca is necessary to offset the high P concentration in the forages.

Finally note the green column for Copper and the orange columns for iron (Fe), Mo, and S. Except in the fall of 2011, copper is sufficient for all classes of cattle which require a concentration in the forage of 10 ppm. However, in the fall, winter and spring iron and sulfur are marginally antagonistic to copper absorption in cattle. Note in particular the very high concentration of iron at 810 ppm in the spring, approaching the Maximum Tolerable Concentration for this element. In this case, additional copper is necessary to overcome the antagonism of iron and sulfur in the forages.



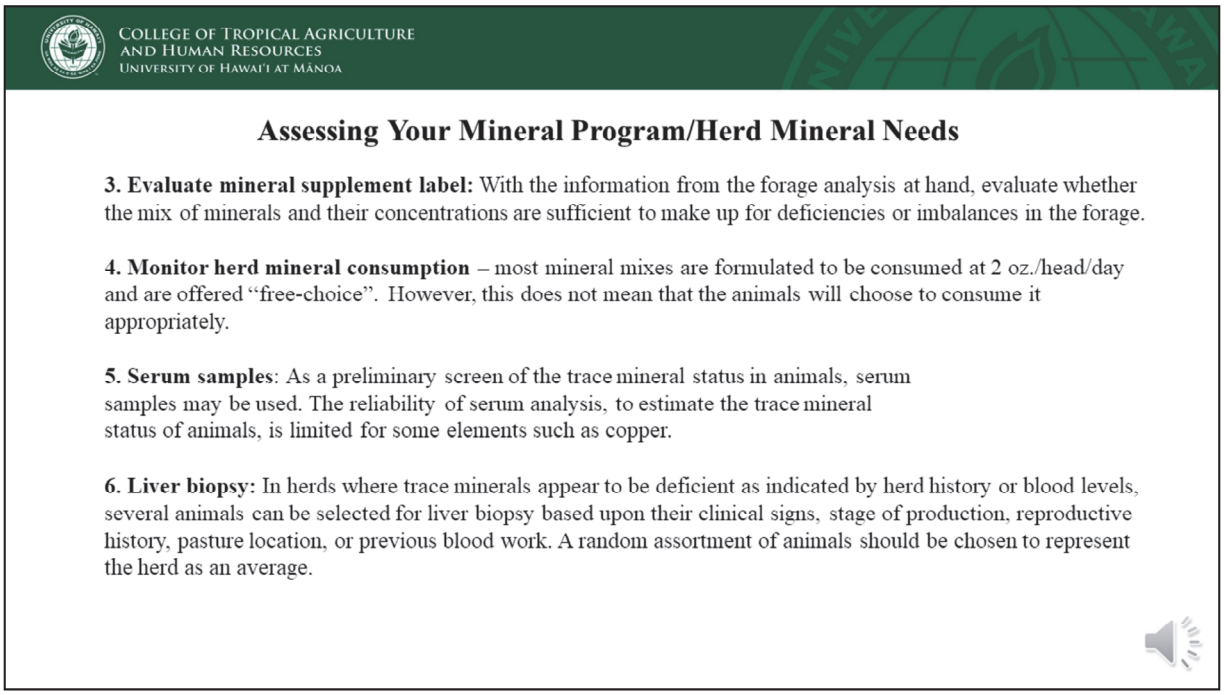
The second step is to closely assess and monitor the condition of the herd with a specific focus on observing any clinical signs of mineral deficiency. Evaluate animals that display rough, discolored hair, or cows and calves that are slow to shed winter hair. Animals that have bone or hoof problems, or animals that display less resistance to diseases and parasites may be indications of mineral imbalances or deficiencies. Finally, a decreased breeding efficiency may have its root in a mineral imbalance or deficiency.



A good acronym to keep in mind in the evaluation of your herd is GOLD

The Key indicators of herd condition are:

Calf Growth, Open cows, Length of calving Season, and calf Death loss. If any of these indicators are below industry standards, nutrition is not adequate, and supplementation may be necessary. Supplementation may include minerals, protein, and/or energy. Taking steps to properly assess your forage quality will help determine which of these are necessary to turn your herd around.



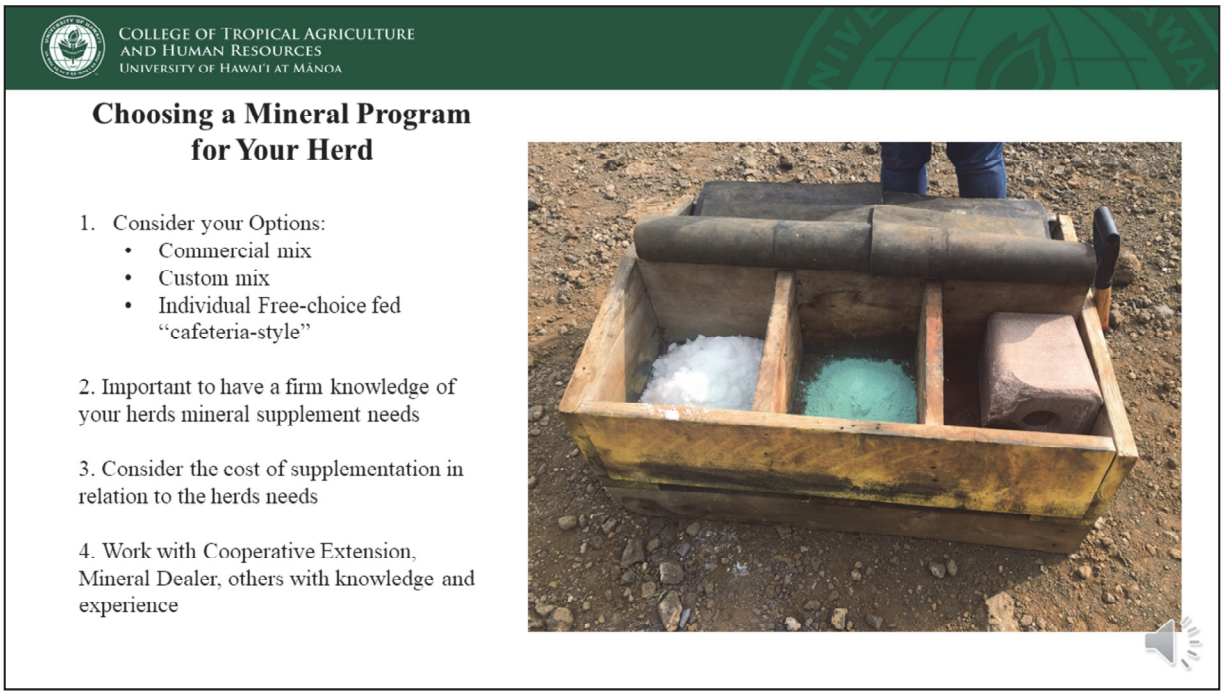
The third step is to evaluate your current mineral supplement using the product label. With the information from the forage analysis at hand, evaluate whether the mix of minerals and their concentrations are sufficient to make up for deficiencies or imbalances in the forage. Any lingering deficiencies or imbalances should be taken into consideration and fixed by either adding or subtracting minerals from the program.

If between the forage quality and the mineral supplement all mineral needs are balanced and met, the next step is to monitor the mineral consumption of the herd. Most mineral mixes are formulated for a specific consumption rate per head; typically, 2 oz./head/day and are offered "free-choice". However, the cattle may not actually be consuming the mineral at the recommended rate. While overconsumption is rare, under consumption is common and occurs when forage quality is high. Keep in mind that even when forage quality is high, deficiencies and imbalances are common. Under consumption of mineral supplements can exacerbate deficiencies and imbalances. Measuring the herd consumption rate of mineral will help you understand your herds mineral needs and why mineral deficiencies and imbalances occur.

Additional steps that can be taken to get a clearer picture of your herds mineral status is to collect blood serum samples and/or liver biopsies. Due to their cost and need for handling animals they should be used only when all previous steps have been completed and it is determined that additional information is necessary to fully understand a specific mineral deficiency condition.

Blood serum samples can be used to screen for trace mineral status in animals, however the reliability of the analysis is limited for some elements, such as copper. When considering blood serum analyses you should work closely with your veterinarian to make sure it will give you the information you need to make decisions.

Liver biopsies can be used to verify trace mineral deficiencies where herd history or blood serum levels indicate issues. Several animals can be selected for biopsy based on their clinical signs, stage of production, reproductive history, pasture location, or previous blood work. A random assortment of animals should be chosen to represent the herd average. The results should be discussed with your veterinarian as to what they mean in relation to the overall status of the herd.



When choosing a mineral program for your herd there are several options to consider. Commercial mineral mixes are common and marketed broadly across the U.S. Consequently, these "one-size-fits-all" mixes don't always meet the mineral needs of herds across different geographical regions. Another option is to purchase a custom mineral mix that is specific to your herd needs. This is usually an expensive option. Another option is to use an "individual free-choice mineral program, often referred to as a "cafeteria-style". This program uses an array of different minerals offered individually, free-choice. They can be complicated using as many as 9-10 different mineral compounds or simple, using as few as five different mineral sources.

To choose the mineral option best for your operation it is important to have a firm knowledge of your herds mineral supplement needs; and as we discussed previously this involves knowing your forages mineral quality at different times of the year and in different pastures; and knowing your herds GOLD indicators.

Additionally, you should closely consider the cost of each option in relation to your herds needs. Why pay more for something when a less expensive option meets your herds needs?

Finally, work with the cooperative extension, your veterinarian, mineral dealers and others with knowledge and experience when making your decisions. These individuals will provide support and important feedback to help you make a sound decision.

COLLEGE OF TROPICAL AGRICULTURE
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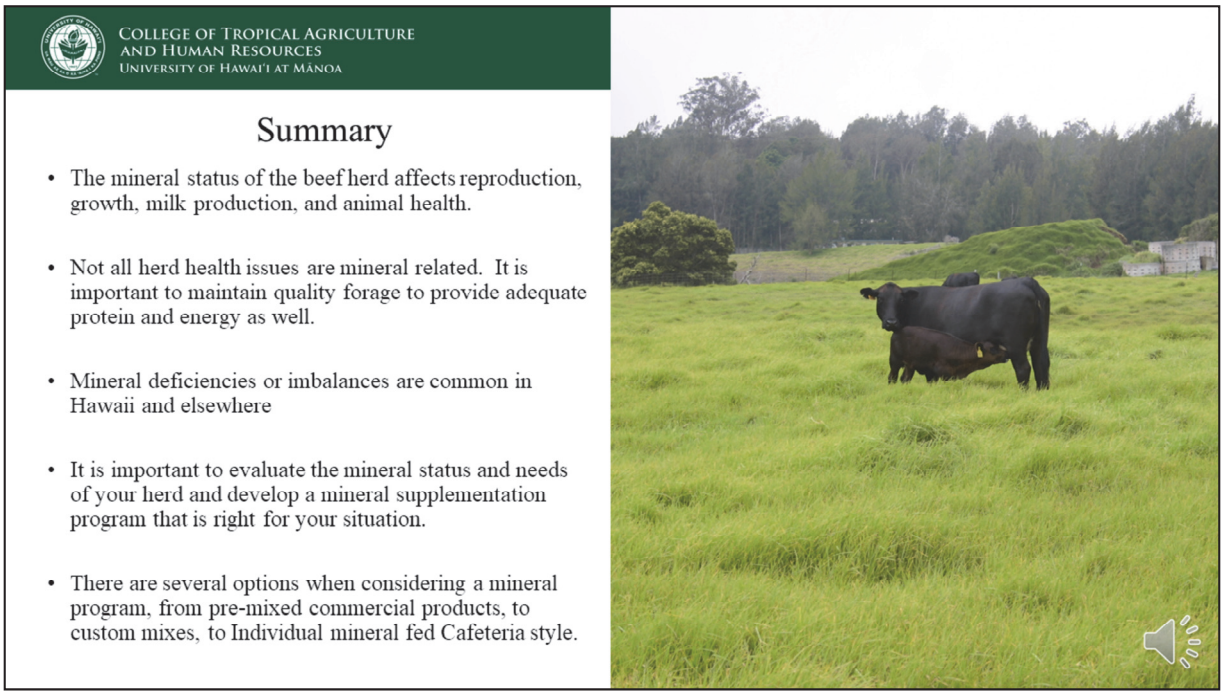
UNIVERSITY OF HAWAI'I AT MĀNOA

Table 1. Mineral supplementation components, feed rates, and associated costs for XIT Ranch with 450 head of breeding cows. Note the cost per cow differential between the Commercial Mineral Mix ($34.66) vs. the sum of the individual free-choice minerals ($16.69).

Product	Key Mineral Supp.	Percent of comm. Mineral Mix	Amount per animal/day (oz.)[1]	Annual per Cow (lbs)	Price per unit (50 lbs)[2]	Price per lbs.	Price per Cow/yr ($)	Total Ranch need (lbs)[3]	Estimated Annual herd Cost ($)[4]
Commercial Mineral Mix	All	100	2	45.6	37.93	0.76	34.66	20,531	15,597
NaH_2PO_4	P	0.05	0.1	2.28	116.00	2.32	5.29	1,027	2,380
$MgSO_4$	Mg	0.02	0.04	0.91	24.50	0.49	0.46	411	207
$CuSO_4$	Cu	0.003	0.006	0.137	152.00	3.04	0.42	62	189
Dolomite	Ca	0.155	0.31	7.07	40.50	0.81	5.73	3,182	2,578
TM Salt	All Trace		1	22.81	10.60	0.21	4.79	10,266	2,155

[1]Recomended daily intake of commercial pre-mix mineral supplement is 2 oz. cow; estimated daily intake rate of individual supplements as a percent of supplement in the commercial Mineral Mix. Individual free-choice mineral shown totals 1.46 oz. per head per day, remaining consumption, 0.54 oz head per day is comprised of sodium (not shown) from TM salt.
[2]Most recent quoted amounts for locally available commercial mix and individual mineral components. Note that mineral prices regularly fluctuate.
[3]Based on 450 head of breeding cows.
[4]Based on 450 x mineral cost per cow per year.

This slide provides a comparison in mineral costs between a commercial mineral mix locally available and a five-component individual free-choice mineral program currently being research by the University of Hawaii Cooperative Extension. All mineral amounts and costs are based the mineral requirement of a 450 head beef herd. The commercial mix provides all of the needed minerals at an estimated cost per cow of $34.66 annually. The individual free-choice mineral program provides the same minerals in five different components at an annual cost per cow of $16.69. These costs do not account for the labor, transportation, and storage costs differentials between the two mineral program options. With more components, the individual free-choice program may require more time, transportation and storage than a single bag commercial mix. All things that should be considered when choosing a program.



To summarize, the mineral status of your beef herd affects reproduction, growth, milk production and animal health. Maintaining good pasture condition and forage quality will provide adequate protein and energy, however mineral deficiencies and imbalances are common in Hawaii – even in the best of forages. It is important to evaluate the mineral status and needs of your herd and develop a mineral supplementation program that is right for your herd. There are several options when considering a mineral program, from pre-mixed commercial products, to custom mixes, to individual minerals fed cafeteria style, each with different costs and benefits associated with them. Whichever you choose it should meet the nutritional needs of your herd at the most economical price to reap the benefits of the increased herd productivity that a good mineral supplementation program will yield.

Thank you for viewing this webinar presentation. If you have questions regarding its content or a mineral supplementation program for your livestock in Hawaii you can contact me at the information provided on this slide, or you can visit the Hawaii Rangelands website.

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