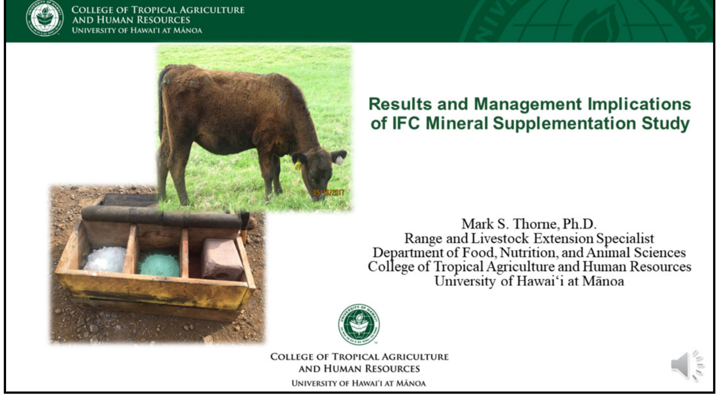
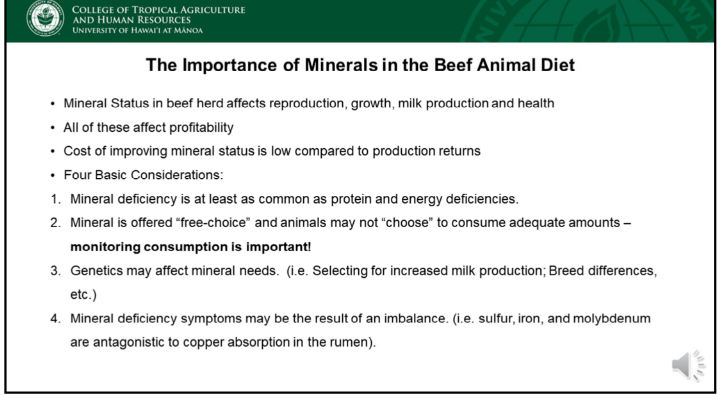



Hello and welcome. Thank you for tuning into this presentation. I hope you will find the information useful as you consider your mineral supplementation program.

In this presentation we will briefly review the macro- and micro-minerals required for good animal health, factors that affect the availability, intake, and absorption of minerals in the diet, and why mineral supplementation is important. Now, if you recently reviewed the "**Introduction to Mineral Supplementation for Beef Cattle"** presentation in our first webinar program you may recognize some of this information, but it bears repeating because it is critical to good supplementation and provides an important foundation to the rest of the presentation.

After laying the ground work on the different minerals and why they are important, we will briefly discuss what alternatives producers have to choose from when developing a mineral supplementation program. We will discuss the distinction between commercial mineral mixes, custom mixes, and Individual free-choice minerals along with some important considerations to keep in mind as you make your decisions.

We will then introduce the Hawaii Individual Free-Choice Mineral model that was developed and tested in a three-year study funded by the Western Sustainable Agriculture Research and Education program. The remainder of this presentation will then focus the key findings of one of our trials within the larger study.




You may recall from our first webinar program that the mineral status of each animal in the herd affects their ability to reproduce, grow, produce milk, and their general health.

Consequently, 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.

However, providing minerals to the herd is 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 supplements can have a large return 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.

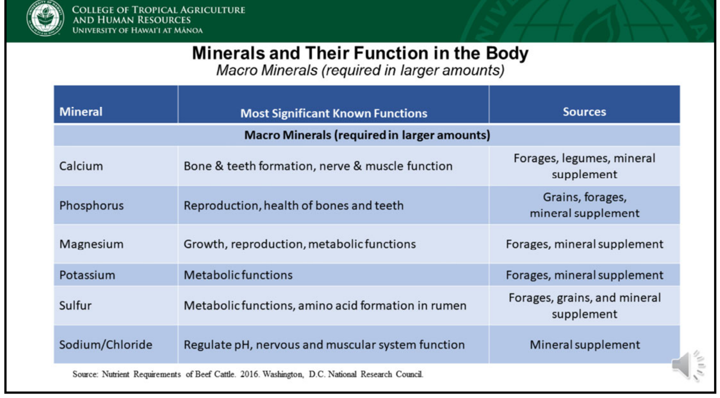
Poor forage that is low in protein and/or energy will also be poor in mineral content. However, even good quality forage in terms of protein and energy, can be deficient in one or more minerals. This can occur for various reasons which we will discuss a little later.

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 review the macro and micro-minerals, thier function in the body, and major sources. For a more complete discussion of the Macro and micro-minerals please review the "Introduction to Mineral Supplementation for Beef Cattle" presentation in our first webinar.

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. Depending on the mineral, other sources for these minerals include legumes and or grains. But these sources may be insufficient in providing all that an animal requires, so mineral supplementation is an important source as well.

Note the various functions of these minerals in the body. They range from bone and teeth formation, nerve and muscle function, to regulating growth, reproduction, and metabolic function. Obviously, deficiencies in these minerals can have significant consequences for animal production.

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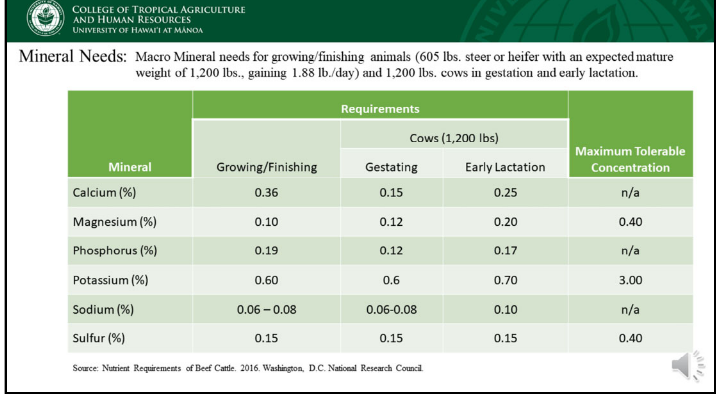
## Minerals and Their Function in the Body

*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 |

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.

As you can see from the table forages and legumes are important sources of micro-minerals in the grazing animal's diet and deficiencies have to be made up with mineral supplements. Like the macro-minerals, the micro-minerals support a wide array of bodily functions ranging from supporting immune response, hemoglobin formation to regulating enzyme activity. Again, deficiencies in the micro-minerals have severe consequences for animal production.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Mineral Needs: Macro Mineral needs for growing/finishing animals (605 lbs. steer or heifer with an expected mature weight of 1,200 lbs., gaining 1.88 lb./day) and 1,200 lbs. cows in gestation and early lactation.

| Mineral | Requirements | | | Maximum Tolerable Concentration |
|---|---|---|---|---|
| | Growing/Finishing | Cows (1,200 lbs) Gestating | Cows (1,200 lbs) Early Lactation | |
| Calcium (%) | 0.36 | 0.15 | 0.25 | n/a |
| Magnesium (%) | 0.10 | 0.12 | 0.20 | 0.40 |
| Phosphorus (%) | 0.19 | 0.12 | 0.17 | n/a |
| Potassium (%) | 0.60 | 0.6 | 0.70 | 3.00 |
| Sodium (%) | 0.06 – 0.08 | 0.06-0.08 | 0.10 | n/a |
| Sulfur (%) | 0.15 | 0.15 | 0.15 | 0.40 |

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

So, just how much of the Macro- and Micro-mineral do beef cattle need?

Well 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 the 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.

The Macro-minerals are typically reported on a percent basis which is equivalent to grams/kilogram of DM feed. 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. A feed analysis that showed values for one or more of these macro-minerals less than what is shown in the table would be considered deficient for these animals.

In the right column you will see the maximum tolerable concentration recommended by the National Research Council. Mineral concentrations beyond these recommended levels should be regarded as 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%.

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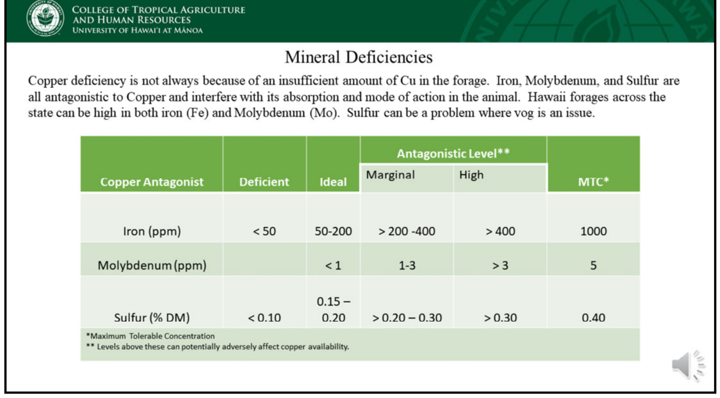
Mineral Needs: Micro Mineral needs for growing/finishing animals (605 lbs. steer or heifer with an expected mature weight of 1,200 lbs., gaining 1.88 lb./day) and 1,200 lbs. cows in gestation and early lactation.

| 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 | 40.00 |
| 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 |

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

When we consider the micro-minerals, we see first that they are required at a much smaller amount and reported as parts per million which is equivalent to mg/kg of DM feed. The Micro-mineral needs of growing cattle are not that much different than in mature cattle with the exception of 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. As with the Macro-minerals, forage or feed analyses that report values for the micro-minerals less than those shown in the table would be considered deficient.

The micro-minerals also have maximum tolerable concentration values. Again, concentrations beyond these levels should be regarded as toxic.




### Mineral Deficiencies

Copper deficiency is not always because 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 (Fe) and Molybdenum (Mo). Sulfur can be a problem where vog is an issue.

| Copper Antagonist | Deficient | Ideal | Antagonistic Level** | | MTC* |
|---|---|---|---|---|---|
| | | | Marginal | High | |
| Iron (ppm) | < 50 | 50-200 | > 200 -400 | > 400 | 1000 |
| Molybdenum (ppm) | | < 1 | 1-3 | > 3 | 5 |
| Sulfur (% DM) | < 0.10 | 0.15 – 0.20 | > 0.20 – 0.30 | > 0.30 | 0.40 |

*Maximum Tolerable Concentration
** Levels above these can potentially adversely affect copper availability.

In the previous slide we discussed the Macro and Micro-mineral needs of beef cattle based on their size and status. Deficiencies, we noted arise when the forages grazed by the animals do not contain adequate concentrations of the minerals to meet their daily needs. This type of deficiency is referred to as a primary deficiency. Secondary deficiencies, on the other hand, arise when there are imbalances in the mineral composition of the forages. For example, Ca deficiencies can occur when the amount of P is greater than Ca in the forage. Another example of a secondary mineral deficiency occurs when one or more minerals inhibit the absorption of another in the rumen of the animal. This is the case with Copper, which is probably the most prevalent mineral deficiency issue we have in the state and is common globally.

The availability of the copper in the forage depends very much on the amount of Iron, Molybdenum, and sulfur that is found in the forage as well. These three minerals bind with copper and prevent its absorption from the rumen into the bloodstream. At certain levels, shown here in the table these three minerals are considered antagonistic to copper uptake. For Iron this is anything over 200 ppm. Keep this in mind as Hawaii soils are high in Fe and as will be shown later, our forages can be very high in this mineral at different times of the year. Moybdenum is considered to be antagonistic at values over 1 ppm and sulfur becomes antagonistic at levels greater than 0.2 percent.

It is important to know what these values are in your forages and how they change seasonally to fully understand your beef herd mineral requirements.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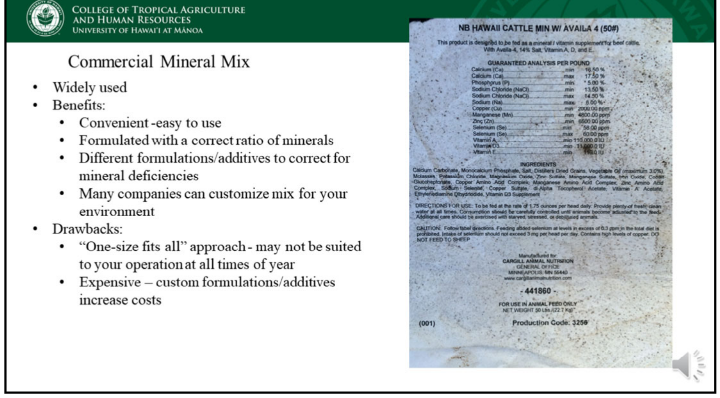
| | Season | Sample Size | % DM | % CP | % Ca | % P | % Mg | % K | % Na | Fe ppm | Zn ppm | Cu ppm | Mn ppm | Mo ppm | % S | Ca:P (1.5 min) | Cu:Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. & Nov. 2011 | Fall | n=9 | 23.0 | 15.3 | **0.3** | **0.4** | 0.3 | **3.0** | 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 |

The table in this slide presents the CP and macro and micro mineral data from the analyses of forages collected from pastures at the University of Hawaii Mealani Experiment station. The data are grouped by season starting in the fall of 2011 to the summer of 2012. The CP levels are provided as a reference for overall forage quality and as you can see the levels are more than sufficient for all classes of cattle across all seasons during that year. Looking closely at the mineral components we can check for any Primary deficiencies. Without bouncing back to our slide on the Maco-mineral requirements for a growing animal or a mature cow in gestion or lactation, let me point out that Ca, P, Mg, K, Na, and S are all, by themselves, sufficient to meet the needs of these animals. However, when we start to look at the relationship between these minerals we begin to see a different story. Ca and P need to be in the right balance to prevent certain deficiency issues. At a minimum there should be 1.5 parts Ca to 1-part P; ideally that ratio would be 2:1 for beef cattle. Looking at the yellow column on the right we note that the Ca:P ratio is less than 1.5:1indicating that the cattle at Mealani are at risk for Ca deficiency and without supplementation they would express those complications.

As we view the micro-minerals, Fe, Zn, Cu, Mn, and Mo, note the seasonal variation in their values. Zn and Mn vary across the seasons but remain sufficient for our model animals. Note the variation in Fe that ranges from a very high level of 810 ppm in the spring of 2012 to a low of 180 ppm in the summer of that year. Cu on the other hand is deficient in the fall of 2011 while it is, by itself, sufficient in all other season. However, when we consider the relationship between Cu, Fe, Mo, and S we see first that the Fe levels in the first three quarters of the year exceed 200 ppm and is therefore antagonistic to Cu absorption. Thus, even in the winter and spring periods when Cu was adequate in the forage the cattle at Mealani would have been deficient in Cu without mineral supplementation. Likewise, S is sufficiently high to also cause a reduction in Cu uptake in the animals.

These results illustrate that a seasonal analysis of your forages is important as you plan or evaluate your mineral supplementation program. Without this kind of information, you can’t determine the effectiveness of the mineral supplements that are provided.




When we think about mineral supplements offered free choice in the pasture there are really two ways they can be provided. The most common method is through commercially formulated mixes. The other, is to provide those minerals individually sometimes referred to as a cafeteria-style program.

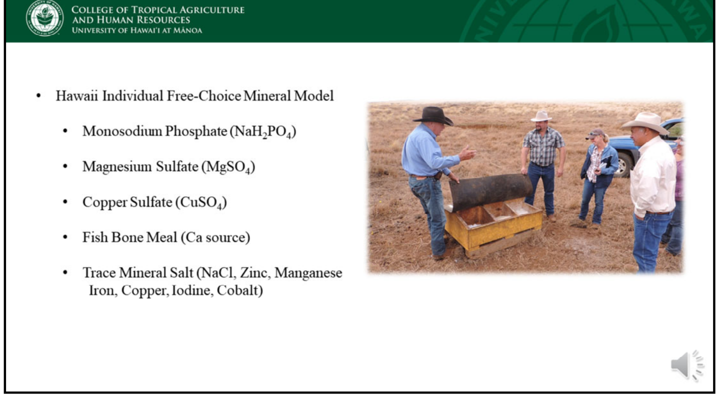
Commercial mineral mixes are widely used. Their benefits include convenience; they are easy to use. Everything is in one bag, formulated with the correct ratio of minerals delivered at a specific feeding rate; usually 2 to 3 oz per animal per day. Many companies have developed special formulations and/or additives that correct for mineral deficiencies. Moreover, those same companies can work with you to develop a custom mix based on the analysis of your forages.

Some drawbacks to the common commercial mixes are that a "one-size fits all" approach may not be suited to your operation at all times of the year. We saw previously the Macro and micro mineral concentrations in forages can vary across different times of the year. Consequently, when consuming the commercial mineral mix at the recommended rate, there may be times of the year when the animals are taking in more of one mineral than they need, while not getting enough of another. Simply put, the commercial mixes can't be adjusted to fit the changing mineral profiles of the forages that naturally occur.

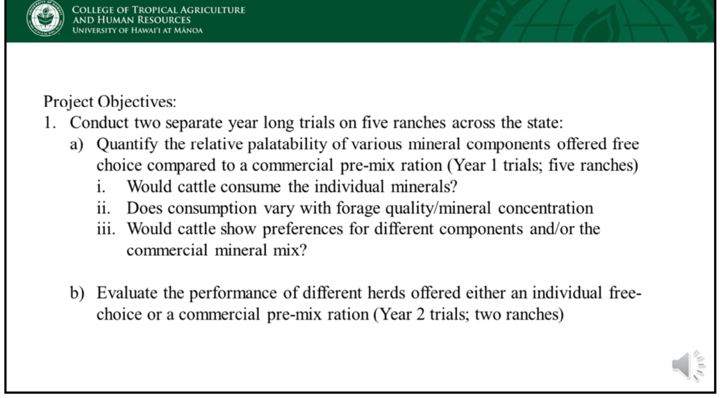
Providing mineral is an investment, like purchasing an insurance policy, against the health of your herd. The cost of a commercial mineral mix is well worth the value derived in the improved productivity of the herd. If you are not providing any mineral at this time a commercial mineral mix is a good start to evaluate your herds response to the supply of mineral. If you are considering a custom mineral mix or one that has additives, know that they come, naturally, with additional costs. If costs are an issue preventing you from providing minerals to your herd, you may want to consider and individual, or cafeteria mineral program.


The idea of providing salt other minerals individually has been around the 1950's and actually it is how mineral supplementation was done before commercial mixes were formulated. While they are not widely used today, practitioners suggest that the benefits of offering individual minerals free-choice include decreased cost of supplementation, increased animal performance and increased efficiency. Since animals are allowed to select according to their needs, waste is reduced, while animal performance is improved.

There are however, important drawbacks to this mineral supplementation system. The maintenance of several individual mineral components requires more labor, storage space, and feed bunk/box space to deliver the minerals to the herd. These all add additional costs to the operation that must be considered when decisions are being made.




Working with several Hawaii Beef Cattle producers we developed a five-component individual mineral supplementation program. The components of this program include Monosodium phosphate as a source of Phosphorous, Magnesium sulfate as a source of Magnesium, Copper sulfate as a source of copper, either fish bone meal or dolomite as a source of Ca and trace mineral salt in either block or loose form to provide NaCl, Zinc, Manganese, iodine, cobalt, and selenium.

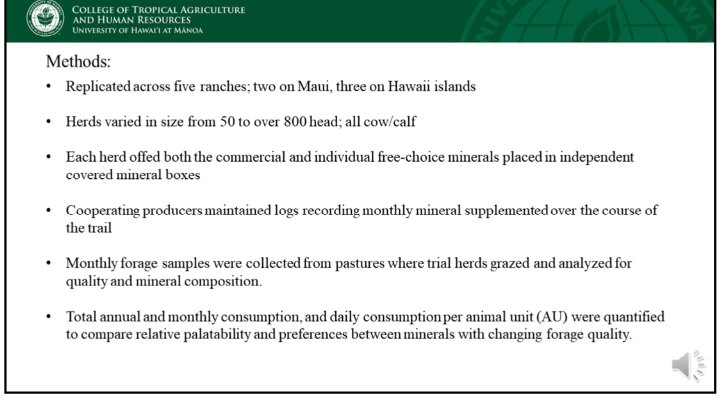



We initiated two trials to test the effectiveness of the Hawaii Individual Mineral Model against a widely available commercial mineral mix.

In the first trial we wanted to test the relative palatability of the various mineral components compared to the commercial mineral mix. Basically, we wanted to know: 1) would the cattle consume the individual minerals; 2) does consumption vary with forage quality/mineral concentration; and 3) would cattle show preferences for different components and/or the commercial mineral mix?

The goal of our second trial was to evaluate the performance of different herds offered either the individual free-choice minerals or the commercial mix.

The remainder of this presentation will focus on the results of the first trail. The results of the second trial will be presented in a later webinar.




The first trial was replicated across five ranches; two on Maui and three on Hawaii island. The herds varied in size from 50 to over 800 head of breeding cows. Each herd was offered both the commercial mineral mix and the individual free-choice minerals placed in independent covered mineral boxes. Each cooperating ranch maintained mineral logs recording the date and weight of mineral loaded into each box. The mineral boxes were checked on regular schedules so that mineral could be added as soon as it was fully consumed. In this way we could track consumption per animal. Monthly forage samples were collected from pastures where the trial herds we grazing and analyzed for quality and mineral composition. Total annual and monthly consumption, and daily consumption per animal unit were quantified to compare the relative palatability and preferences between minerals with changing forage quality.

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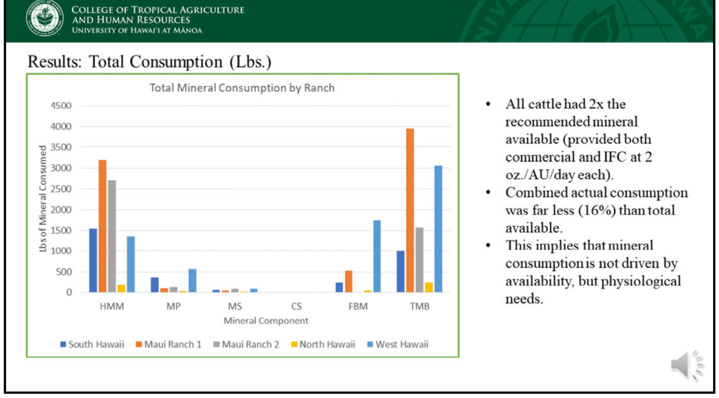
Commercial and individual supplementation components, feed rates, and associated annual per cow costs for the project.

| Product | Key Mineral Supplement | Percent of Hawaii Mineral Mix | Amount per animal/day (oz.)[1] | Annual Requirement per Cow (lbs.) | Price per unit (50 lbs.)[2] | Price per lbs. | Price per Cow/year[3] |
|---|---|---|---|---|---|---|---|
| Commercial Mineral Mix | All | 100 | 2 | 45.6 | $37.93 | $0.76 | $34.66 |
| $NaH_2PO_4$ | P | 0.05 | 0.1 | 2.28 | $116.00 | $2.32 | $5.29 |
| $MgSO_4$ | Mg | 0.02 | 0.04 | 0.91 | $24.50 | $0.49 | $0.46 |
| $CuSO_4$ | Cu | 0.003 | 0.006 | 0.137 | $152.00 | $3.04 | $0.42 |
| Fish Bone Meal | Ca | 0.155 | 0.31 | 7.07 | $40.50 | $0.81 | $5.73 |
| Trace Mineral Salt | All Trace | | 1 | 22.81 | $10.60 | $0.21 | $4.79 |
| Total annual cost of individual mineral supplement program per cow[4] | | | | | | | $16.69 |

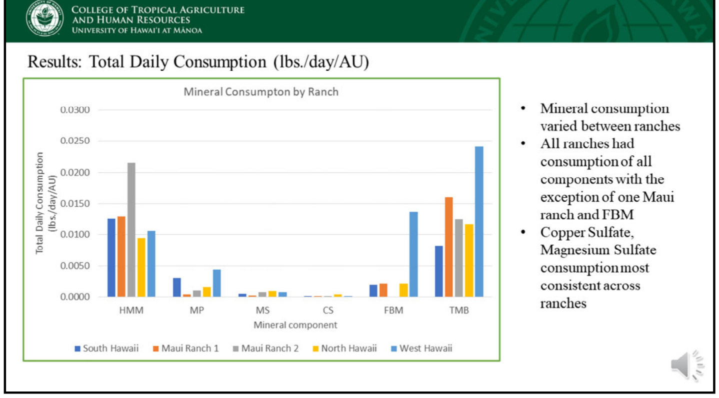
[1]Recomended daily intake of commercial pre-mix mineral supplement is 2 oz. cow; estimated daily intake rate of individual supplements as a percent of supplement in the commercial Mineral Mix. Individual free-choice mineral shown totals 1.46 oz. per head per day, remaining consumption, 0.54 oz head 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]Estimated annual cost per cow for each mineral component
[4]Total annual cost of individual mineral supplementation program is the sum of the per cow costs of ($NaH_2PO_4$, $MgSO_4$, $CuSO_4$, Fish Bone Meal, and Trace Mineral Salt).

The chart in this slide provides a comparison between the commercial mineral mix and the individual mineral components in annual requirement and cost per cow. The percent each of the target independent minerals comprised of the commercial mix was used to determine the required daily consumption rate for that mineral. This was then used to calculate the annual per cow requirement and cost per cow. We used a consumption rate of 2 oz. day /cow for the commercial mix. Combined the individual minerals amount to 1.46 oz. day/cow excluding the NaCl in the trace mineral block, which accounts for the remaining 0.54 oz/head/day. Looking at the commercial mix the annual per cow requirement for the commercial mix is about 45.6 lbs. and based on unit prices at the time of the trial the annual per cow cost was $34.66. Comparatively, when we add up the associated annual per cow costs for the individual minerals this equates to about $16.69 per cow; a little less than half the cost of the commercial mix.

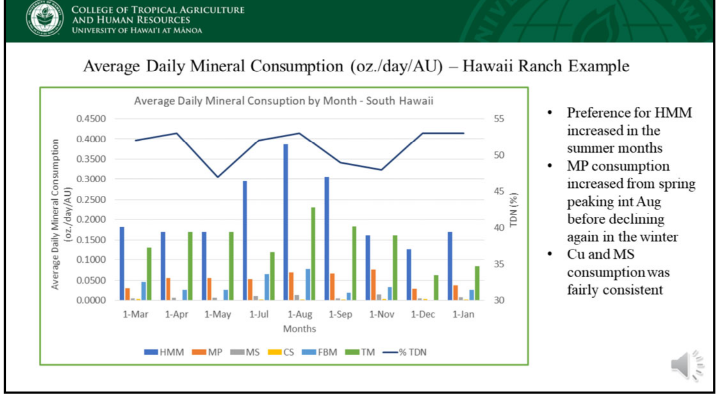
Clearly the individual mineral components are less expensive, but what matters is whether the cattle will consume it and do as well or better on it.




We found that indeed the cattle will consume all components of the individual mineral offered, even in the presence of the commercial mineral offered alongside. All cattle had 2X the recommended amount of mineral available. Consumption of the commercial mineral mix and the individual mineral components was highly variable across the ranches, but this had more to do with herd size than anything else. The commercial mineral mix and the Trace Mineral block were consumed more than the individual mineral components. The monosodium phosphate was consumed more than the MS and Cu. Fish bone meal was consumed at variable rates down to not at all on one ranch. While the amount of mineral on offer was 2x what was needed the cattle, on average only consumed about 16% of the total available. This would suggest for the cattle on trial consumption was driven by their physiological need and not by availability.

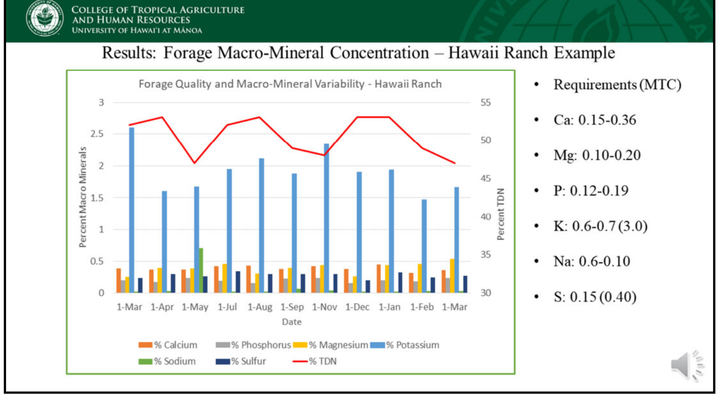



To compare consumption across ranches total consumption was converted to a per AU day basis, or total daily consumption rate. The commercial mix was consumed consistently across four of the five ranches at about 0.01 lbs. AU day. Consumption of the commercial mix for the fifth ranch, noted as Maui 2, was double this rate at 0.022 lbs AU day. The ranches all varied in the consumption rate of MP and FBM, but MS and CS consumption was fairly consistent across the ranches. MP, MS, and CS are required in very small amounts on a daily basis and we would expect daily consumption rates to be low and this is reflected in the chart here. Fish Bone Meal was not consumed at al for the Maui 2 ranch.

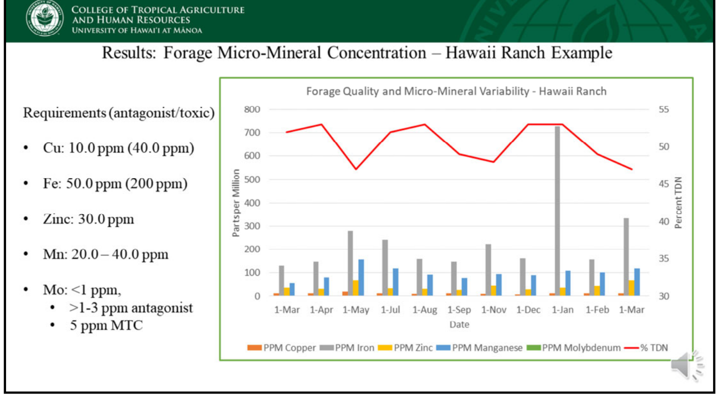



In the next series of slides, I will be using the results from two of the five ranches as examples; these will be the south Hawaii and Maui 1 ranches.

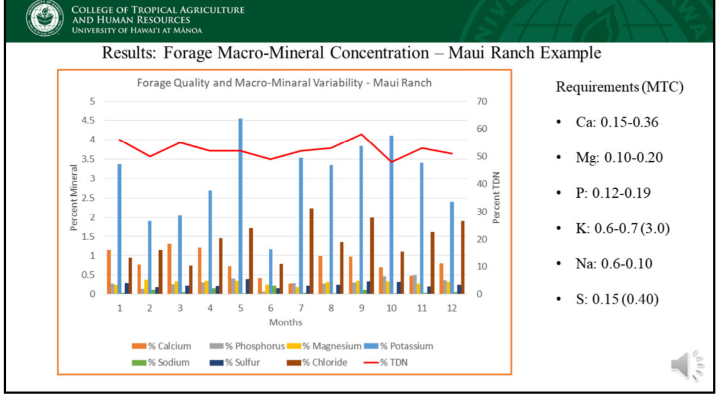
In the chart on this slide we have the average daily mineral consumption, in oz/day/AU on the left vertical axis and percent TDN on the right vertical axis. TDN is provided as a reference to forage quality as we look at the mineral consumption values by month over the year of this trial. You can see that TDN varied over the year as would be expected, between a low of 47% in May to 53% in April, December and January. Across the horizontal axis we have the various consumption rates by month for the commercial mix noted as HMM, and for MP, MS, CS, FBM, and TM. For this ranch preference for the commercial mix increased in the summer months, likewise MP consumption increased in the spring and peaked in August through November. Consumption of MS and CS was more consistent throughout the year. FBM and TM consumption varied throughout the year.



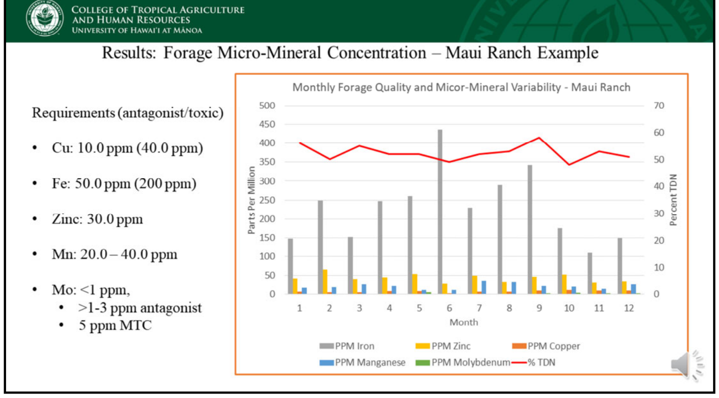

The chart presented here provides the macro-mineral concentrations in the forage samples collected from the pastures grazed by the trial herd on the south Hawaii ranch. Note these samples come from different pastures following the rotation of the herd, so it shows the variation in the different macro-minerals the herd was exposed over the year. At the right of the chart, for reference I have provided the range of requirements for each macro-mineral with the MTC in parentheses. Again, I have provided the TDN of the forage as a reference of overall forage quality. By far the most abundant macro-mineral the forages on this ranch was K and it was always available in the forage at levels exceeding what was required. Ca ranged between 0.45 and 0.32% while P ranged between 0.24 and 0.16% showing some potential to be deficient in certain locations. Sodium was deficient in every month except May. Mg was never deficient ranging between 0.54 and 0.26%. Sulfur was consistently greater than 0.2%, the threshold for causing low copper absorption.



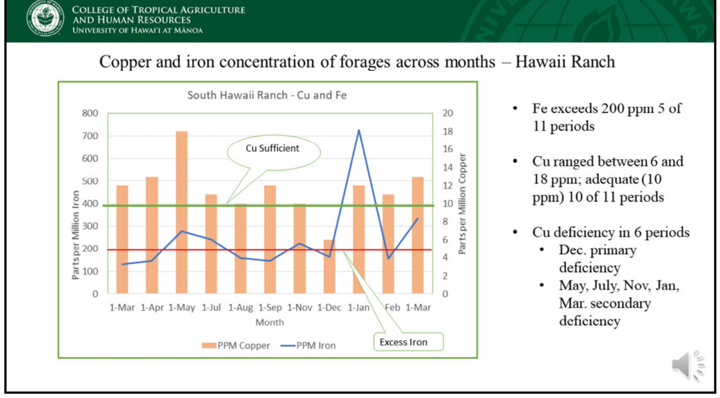

This is a similar slide for the micro-mineral concentration of the forages from the Hawaii ranch. The micro mineral requirements are provided on the left of the slide. Iron is abundant and high in the forages; at times exceeding the 200 ppm threshold for copper antagonism. Manganese concentrations were highly variable but well over the need amounts, ranging between 156 and 57 ppm. Zinc ranged between a high of 69 ppm and low of 26 ppm with deficiency showing up in several of the months. Copper concentrations ranged between 18 and 6 ppm. Showing a primary deficiency in December. However, with the high Iron and Sulfur content of the forages secondary deficiencies in Copper would have been possible without supplementation.



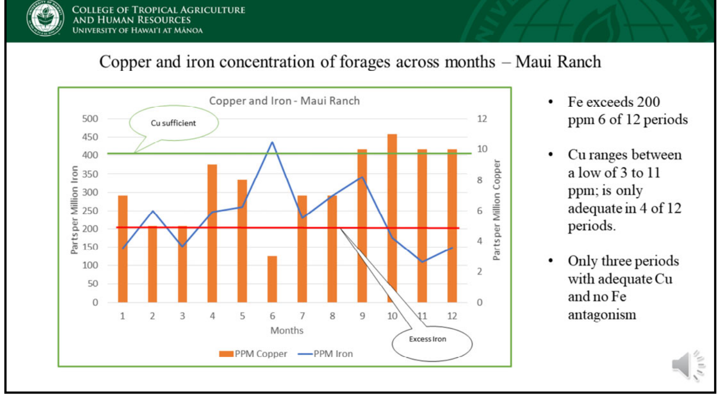

This chart provides the macro mineral concentrations for the Maui ranch along with the forage TDN values for the 12 month period of the trial. Over all there was considerable variation in the forage concentration of the various macro minerals for this Maui Ranch. Range of pastures types these cattle were rotated through is reflected in this variation, but highlights the fact that cattle are rarely ingesting a consistent amount of any mineral. As with the Hawaii ranch K is the most abundant macro-mineral in the forage on this Maui ranch. In the case of this ranch however, K exceeds the 3% threshold for the maximum tolerable concentration in 7 of 12 periods. This could produce complications for older cattle, particularly grass tetany depending on the Ca and Mg concentrations of the forages. Another mineral of concern is sulfur which exceeded the 0.2% threshold for copper antagonism in most periods.



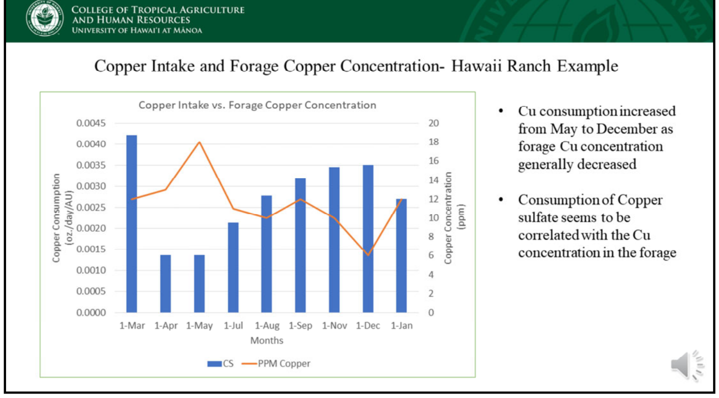

On the Maui ranch the micro mineral concentration of the forages varied widely also. Iron was high, as expected and exceeded the 200 ppm threshold for copper antagonism 7 of 12 periods. Zinc ranged between 69 and 29 ppm, while Mn was deficient in all months for mature cattle. Copper was relatively low ranging between 11 and 3 ppm with primary deficiency evident in at least 8 of the twelve periods.



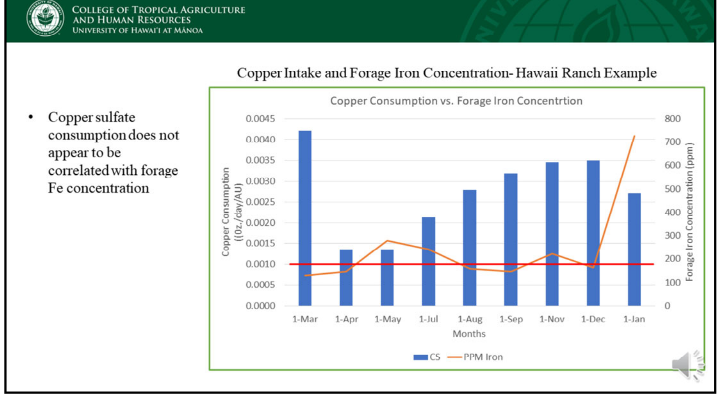

One of the more significant findings of this study is the potential for copper deficiency issues to arise through interactions with iron and sulfur. The chart in this slide looks specifically at the forage copper and iron concentrations of the forages for the Hawaii ranch across the different months. The blue line is iron on the left vertical axis, while copper represented by orange bars is on the right vertical axis. The threshold iron becomes antagonistic to Copper uptake is represented by a red line at 200 ppm Iron, while the 10 ppm minimum copper needed in the diet of cattle is provided by the green line. At this south Hawaii ranch Iron exceeds the 200 ppm threshold 5 out of 11 periods. While a primary deficiency in copper only occurred one time in December, secondary deficiencies were likely to occur in May, July, Nov, Jan, and March due to interactions with high iron levels.



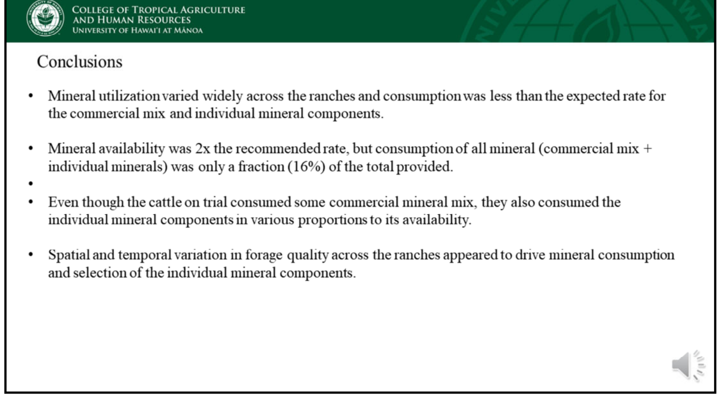

A similar story can be told for the Maui ranch as well. Iron exceeded the 200 ppm threshold 6 of 12 periods. Copper ranging between 3 and 11 ppm was only adequate in 4 of 12 periods. Consequently, Copper deficiency issues were likely in nine of the 12 periods.




This chart compares the copper concentration of the forages over time with the consumption of copper sulfate for the south Hawaii ranch. Consumption of copper sulfate in the blue bars increased from May to December as copper concentration in the forages, represented in the orange line, generally decreased. This is a significant relationship and strongly suggests that copper sulfate consumption was driven by the copper concentration of the forages. It is reasonable to conclude that the increase in copper intake exhibited here was in response to an increasing deficiency brought about by the interaction of iron in the forages.



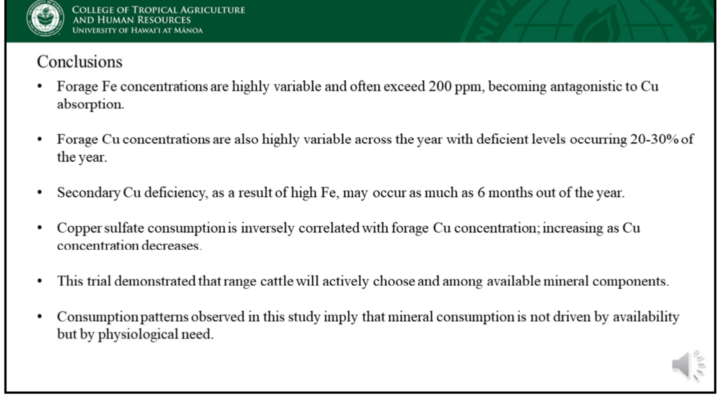

However, when we look at the relationship between copper intake and forage iron concentration there is no correlation between the two. Recall though that while iron values move around the 200 ppm threshold forage Cu concentration was declining. Consequently, while copper intake is not directly related to forage iron levels, indirectly the high iron levels in the forage likely contributed to the increased copper intake by reducing the bioavailability of the copper in the forage.




The results of this trial showed that cattle will consume the individual mineral components. While mineral utilization varied widely across the ranches, consumption rate of the Individual minerals and the commercial mix was less than the expected rates for both.

Combined mineral availability was 2 x the recommended rate, but consumption of all minerals was only a fraction, about 16% of the total provided.

Importantly, the spatial and temporal variation in forage quality across the ranches appeared to drive mineral consumption and selection of the individual mineral components.




We found that Fe concentrations in the forages were highly variable and often exceed the 200 ppm threshold Cu antagonism.

Concurrently, we found that forage Cu concentrations also varied across the year with deficient levels occurring 20-30% of the year. Secondary Cu deficiency, as a result of high Fe and S, may occur in as much as 6 months out of the year.

We found the consumption of Copper sulfate was inversely correlated with forage Cu concentration; increasing as Cu concentration decreased.

This trial demonstrated that range cattle will actively choose among available mineral components and the consumption patterns observed in this study imply that mineral utilization is not driven by availability but by physiologic needs.

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## Conclusions

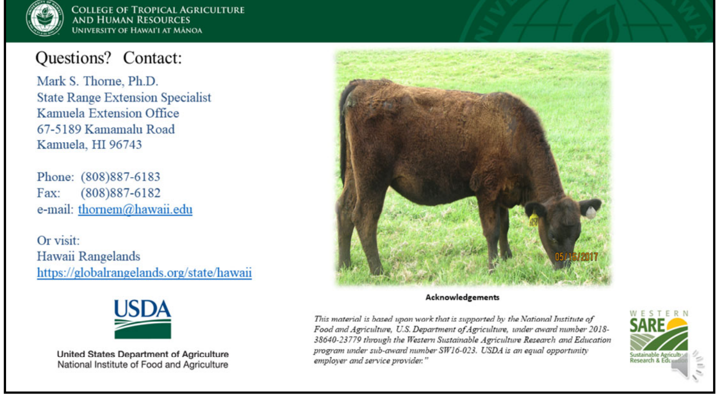
With a greatly reduced cost, IFC mineral supplementation may be a viable option for producers

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.

Recall that the annual cost of the commercial mix at about $35 per head was twice the cost of the individual mineral components combined at about $17 per cow. Thus, the Individual Free-choice mineral program studied here may be a viable option for Hawaii beef cow operations.




I want to thank you for taking the time to view this presentation. I hope you found it informative. If you have any questions you can contact me by email or phone as provided on the slide or you can visit the Hawaii Rangelands website by following the link provided.

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