How this book is put together

Sometimes I learn by reading, sometimes by example, and sometimes I just have to jump in and learn from my own experience. So, I figured it was best to put this book together for all three of those people.

> *There are three kinds of men. The one that learns by reading. The few who learn by observation. The rest of them have to pee on the electric fence for themselves.*
>
> *~ Will Rogers.*

If you're the reader, you might read from beginning to end. If you learn better by example, skip through the chapters, looking for the "Lessons from the Field" that I've included throughout the book. They'll show you what I learned along the way. I've also summarized some key lessons from my projects in the chapter "Lessons from the Pasture." If you learn best from your own experience, jump straight to the chapter on "Building a Training Plan." It's a framework to walk you through writing your own training plan. As you work on it, you can come back and read parts of the book as necessary to get you through anything that doesn't seem to be going quite right. I anticipated that you might not start at the beginning and read to the end, but would jump from place to place, focusing on those parts that are most useful to you at a particular time. So feel free to browse!

A Word About Science

> *If I have seen farther than others, it is because I was standing on the shoulders of giants.*
>
> *- Sir Isaac Newton*

One of my reviewers asked me, "Is this a book about the science of how animals choose what to eat, or is it a "How-To" book?" My answer is that it is "Both" and that surprises me as much as it might surprise friends who have known me for the last fifteen years.

My life with science hasn't always been comfortable. I have often been frustrated by what sometimes seemed to me to be scientists' preoccupation with achieving order and control and with collecting data and then presenting it in the minutest of detail in their scientific papers. I was less interested in basic science, and much more interested in "getting things done." So - imagine my shock to hear the words **"according to research..."** come out of my mouth very frequently over the last five years!

Somewhere along the way, I began to understand the reasons for the precise language scientists use. It prevents doubt about what they mean, and how much they really know. I began to understand science as a method for collecting information, and being sure of its validity so that we can build upon it, or of highlighting remaining doubts, so we can study them further. The endless citations that once distracted me, now give me an avenue for going back in history, and often point me to sources for additional answers.

But that's not what I like most about science. In this case, what I like most is that it provided me with clues that helped me build a map leading to a new place; one where animals could be trained to eat foods they'd

never eaten before, and in the process do us a tremendous service. The decades of work done by so many dedicated individuals showed me how to build a process that anyone, anywhere can use.

Out of deep respect for these scientists' life's work, and because you may find clues that I've missed, I have included citations in each chapter for the work that led me.

Why Eat Weeds?

Let a man profess to have discovered some new patent powder pimperlimplimp, a single pinch of which being thrown into each corner of a field will kill every bug throughout its whole extent, and the people will listen to him with attention and respect. But tell them of any simple common-sense plan, based upon correct scientific principles, to check and keep within reasonable bounds the foes of the farmer, and they will laugh you to scorn.

Benjamin Walsh, 1866

A weed-pulling volunteer at Chileno Valley Ranch decides to taste distaff thistle.

If you can't beat 'em, you might as well eat 'em!

If you're holding this book, you've probably already decided this is a good idea. I included this chapter because we both know that you're going to run into folks who think you're "a little off," to put it mildly. Here are some stories from other ranchers, and a little ammo/information to share with your neighbors if the going gets tough.

Herbicides aren't working for us!

Did you know that U.S. farmers and ranchers spend an average of $5 billion every year to control JUST pasture and rangeland weeds, and that losses to production are equal to that amount? Yet, in spite of all our efforts, weed populations continue to spread at an average rate of 14%, an area the size of Delaware, every year.[1] And now we're beginning to accumulate a list of weeds that are becoming herbicide resistant.

Herbicides can also actually INCREASE weeds. In his 2009 paper "Control effort exacerbates invasive-species problem," Matthew Rinella and his colleagues in Montana described the results of their 16 year study on the use of herbicides on native grasslands.[2] They found that herbicide use reduced, and in some cases, eliminated native forbs, while the invader (leafy spurge) recovered from the spraying. Since their past

research showed that these native forbs provided significant competition to the invader, once they were removed, spurge increased to fill their place. Meanwhile herbicide use resulted in only a temporary increase in grasses.

Steve Wood, Horse Creek Hay and Cattle, Sheridan, MT trained 40 heifers to eat Canada thistle in 2008

"We've been spraying knapweed for 20 years on this place using a variety of chemicals and we still have it coming back in the same places, and the thistle's the same way. You have control for a short while and then they come back. The seed bank is inexhaustible."

We've often assumed that by using herbicides we can decrease invaders so that we can increase desirable forage and therefore improve livestock productivity, so Samuel Fuhlendorf and his colleagues at Oklahoma State University decided to test this assumption.[3] In 2009 they reported on their 5 year study which found that our assumption is false. Grass production increased more with annual precipitation than with herbicide treatment and average daily weight gain for cattle in the study was the same whether they grazed on sprayed or unsprayed pastures. Their conclusion was: "These results indicate that herbicide to control forbs ....cannot be recommended for increasing forage and livestock production especially in light of the potential for negative impacts on biodiversity and ecosystem services."

So, if herbicides aren't working, isn't it time to try something new? My idea for improving farmer and rancher sustainability is to turn weeds into forage for our livestock and to change our goal to creating biodiverse pastures and rangelands that provide forage and habitat for our livestock and wildlife, and that protect soil and water quality.

By thinking of weeds as forage, and training cows to eat them, we are working with nature's underlying processes and patterns. By grazing them, we reduce weeds' competitive advantage and reduce pressure on other, more traditional forages.

Weeds are nutritious!

Since 2004 when I started training cows to eat weeds, I've been gathering nutritional information on my target species. What I've found is that weeds are very high in nutritional value, often running between 8 and 20% protein.[4] In addition, it is possible that their longer taproots bring up minerals beneficial to our grazing stock.

Example of Weeds With 15 - 20% Protein

Canada Thistle	Leafy Spurge
Spotted Knapweed	Russian Thistle
Distaff Thistle	Musk Thistle
Pigweed	Bindweed
Wild licorice	Ragweed

Typical protein values of grasses run between 2 and 11%

High protein weeds can help animals take advantage of other low quality forage that otherwise might not meet their nutritional needs. For example, distaff thistle is green and growing in California when other grasses are dry and brown. Its protein can help ruminants maintain healthy rumen microbes, and those microbes can do a better job of breaking down the cellulose in the dry forage.

- Sample Only. Not all pages from this chapter are included here -

How Animals Choose Foods

God gives all birds their food, but does not drop it into their nests.

Danish Proverb

My friend Mia learning to pick raspberries in Colorado's Rocky Mountains.

Understanding how animals choose foods is the foundation for the steps we use to train them to eat weeds.

This is the longest chapter in the book and you might not immediately find a use for everything you learn here. But trust me, something will happen as you're working with your animals and you'll make new and important connections between this science and what you see happening. When you know what makes something palatable to an animal, and the role that Mom, the herd and the fear of new things play in food choices, you'll be better able to work with your livestock to create new diet habits.

To Build a Perfect Pasture, Ask Your Livestock

As I do talks and workshops, I meet lots of people who are working hard to create the perfect pasture. They ask me about Brix, or what the perfect seed mix might be to meet the nutritional requirements of livestock. Here's what I tell them:

Brix and the perfect seed mix focus on the plants, and often don't include a good understanding of our livestock - how they're put together, and how they go about their jobs of getting bigger and fatter. Once we

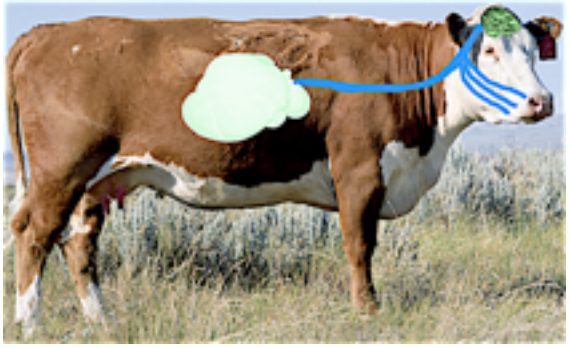
The Role of Palatability

Palatability is usually defined by taste as something that is agreeable or acceptable to the palate. But if you've ever tried any of the foods cows eat, you may have wondered, "What's the matter with their taste buds?"

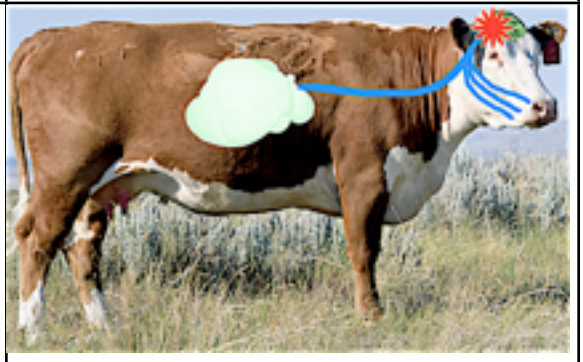
It may help to understand that palatability is more than a matter of taste. Here's how it works:[5]

Nerves from the mouth and the nose lead directly to the brain which catalogs the tastes and smells it receives.

Then, nerves from the rumen (or stomach) take feedback to the brain about nutrients and toxins in the foods.



The nerves from the nose, mouth and rumen/stomach all meet in the same pathway in the brain.



The brain matches feedback from the rumen to the taste and smell of a food and then categorizes tastes and smells as good or bad based on the food's nutritional value.

The brain considers the changing nutritional needs of the animal and adjusts how much an animal eats to take advantage of the nutrients and toxins in a food.

This gives us a new definition for palatability. **Foods taste good or bad based on a combination of nutrients and toxins in the plant, and the animal's physical condition**. As an animal's physical state changes so do the kinds of foods it likes best.

- Sample Only. Not all pages from this chapter are included here -

Lessons from the field: The effect of nutrients and "Open-Minded" Cows

I observed this ability to choose and mix diets while working on a project in Boulder County, Colorado. In 2007, I started working with a herd of 50 heifers belonging to Babe and Leo Hogan and grazing on Boulder County Parks and Open Space agricultural lands. I trained the heifers to eat late-season diffuse knapweed. In 2008 I worked with the same group of cows and their calves, training them to eat dalmatian toadflax and watching as they taught their calves to eat late-season diffuse knapweed.

Both weeds were fairly low in nutritional value - 8% protein for the mature diffuse knapweed and 6 to 8% for the dalmatian toadflax, yet they ate them well, even in 40 and 200 acre pastures. I also noticed that as they started eating weeds I introduced them to, they also became more "open-minded" about trying other plants in their pasture. For example, they ate Canada and musk thistle, horehound, and wormwood sagewort.

In 2009 we mixed the "open-minded" trainees and their 2009 calves with 31 cow calf pairs from a neighboring ranch. We wanted to watch as the trained animals taught the novices to eat our two target weeds in a 500 acre pasture. But this year was nothing like all the years of drought before. June and July were in the top ten wettest months on record and grasses rebounded and weeds and other forbs went wild. Normally, an enormous prairie dog town would have wiped out about 200 acres worth of this vegetation, but plague came through in the spring and wiped out all but 4 or 5 of the dogs. Their ghost town was grassless and covered in mustard skeletons, bind weed, sunflowers, musk thistle and more. From our accepted pasture paradigm, this part of the pasture looked so bad that I nicknamed it the "garbage area."

An example of the kind of pasture my 2009 project herd liked most.

As I followed the herd, what I noticed was that they generally avoided the grassier areas and preferred the "garbage area." Cows and calves moved purposefully to the large sunflower patches, grazing sunflower blossoms after their noon watering break. When they had their fill of those, they searched for bindweed patches among the prairie dog holes or along fence lines, snipping off yucca fruits, musk thistle flowers, and taking prickly lettuce stalks to the ground as they ambled from patch to patch. When they'd come to a grassy

Cow enjoying sunflowers.

area, they'd snatch a few mouthfuls, but they moved through them quickly to areas of prostrate pigweed, cutleaf nightshade, fetid marigold and Russian thistle. They ate wormwood sagewort, common ragweed, assorted chinopods, goldenrod, wild licorice, and more.

Since it appeared that the cows were not going to graze dalmatian toadflax or late-season diffuse knapweed, I decided to find out why they preferred the plants they were selecting over the target weeds and grasses. I took samples of plants that cattle were eating, collecting the parts of the plant that I observed they selected, and sent them off for nutritional analysis. Since we know that nutrients increase palatability, my hypothesis was that they were choosing very nutritious foods. In fact, given the nature of their manure, I guessed that the plants they were selecting were generally high in protein.

Loose stools like this one are indicative of a high protein diet.

The hypothesis was absolutely correct. The plants they were choosing ran from 11 to 21% protein and were easy to digest due to low fiber content. The diet they were mixing for themselves was much better than the target weeds at 6-8% protein and the grasses at 2 to 8% protein. Even better, cattle feed tables tell us that the more protein an animal has, the higher its average daily weight gain. Based on the feed tables and the protein values for the plants the calves were eating, it's possible they were gaining between 2.5 and 3 pounds per day.

This project also points out that we need to consider relative nutritional values when we're managing cattle for weed control. In 2007 and 2008 trained cattle readily ate both late-season diffuse knapweed and dalmatian toadflax in pasture, probably because the drier climate in those years produced less vegetation. (July 2008 was the third driest and warmest month on record.) Available forage during those years was primarily grasses, the target weeds, horehound, wormwood sagewort, and Canada and musk thistle. Since the target weeds were equivalent to or better than the grasses in nutritional value the cattle grazed them. But, since our cattle were very "open-minded" thanks to their previous training, in 2009 they explored their pasture, found more nutritious alternatives, and naturally chose those. We can't expect them to do less given everything we know about feedback and food choice.

Step 1: Know Your Weed

What is a weed? A plant whose virtues have never been discovered.

Ralph Waldo Emerson

Canada thistle in pasture

Before you begin training be sure that your target weed is palatable and safe to eat.

Since we know that cows will choose to eat nutritious plants, it helps to know the nutritional value of the target weed. Unfortunately, we have spent so much time thinking of weeds as a nuisance or an enemy that we haven't gathered a lot of nutritional information on them. Most references say something like:

A. " _____ is avoided by grazing animals due to its bitter taste."

B. "_____ is probably unpalatable when mature because of the stiff, spine-like bracts in the flower clusters/ long, sharp spines, etc."

Cows eat Italian thistle in spite of it's 1/2 inch spines.

Don't buy either of these explanations.

Now that we have a new definition of palatability, we know that "A" can't be true because a good or bad flavor is defined by the nutrients and toxins that the food provides. People drink bitter black coffee or

Comparing Weeds/Forbs and Grasses

The interesting thing about weeds, and all the other forbs in your pasture, is that they are, in many cases, more nutritious than the traditional grass forages we've focused on growing for so many years. Their growth times are also different than grasses, so they are green and growing for a longer period of time, meaning they maintain their high nutritional values much longer.

Of course you can manage grasses to stay green and growing. Different grazing systems have been designed to keep grasses vegetative by grazing them before they can flower and go to seed. It's easiest to manage these grazing systems in areas where there is consistent precipitation or irrigation.

Another solution is to take advantage of everything that grows in your pasture, and maintain biodiversity for the resilience it provides you. Just to give you an idea of how weeds and forbs might benefit you, here are the results of nutritional analysis of plants selected by my "Open-Minded" heifers in 2009 in Boulder County, Colorado. Plant samples were all taken on July 24, generally the time when grasses in the area have flowered and gone to seed. With plenty of time left in the grazing season, you can see why it might be useful to have your own herd of open-minded cows.

Plant Chosen by Boulder County Project Herd	**Protein (%)**
Bindweed (*Convolvulus arvensis)*	16.1
Prickly lettuce (*Lactuca serriola*)	17.3
Prostrate pigweed (*Amaranthus blitoides*)	20.1
Common Sunflower flowers (*Helianthus annuus*)	14.1
Cutleaf Nightshade (*Selenum triflorum*)	15.6
Broom-like ragwort (*Senecio spartioides*)	14.6
Netseed lambsquarters (*chenopodium berlandieri*)	15.2
Common ragweed (*Ambrosia Psiostachya*)	11.3
Musk Thistle flowers (*Carduus nutans*)	11.2
Chinese Lantern/Purple Groundcherry (*Quincula lobata*)	13.9
Wormwood Sagewort (*Oligosporus dracunculus*)	12.3
Wild Licorice (*Glycyrrhiza lepidota*)	15.2
Louisiana sage (*Artemisia ludoviciana*)	7.9
Plains milkweed (Asclepias Pumila)	12.3
Fetid Marigold (*Dyssodia papposa*)	18.4
Red Stem pigweed (*Chinopodium hostata*)	9.3
Unknown Sunflower	8.9
Velvet weed (*Gaura mollis/parviflora*)	11.8
Wild Rose (*rosa arkansana*)*	6.8
Moth Mullein (*versbacum blattaria*)	8.5

For comparison here are the nutritional values for the grasses in the pasture:

Grasses in Boulder County Project Pasture	**Protein (%)**
Big Bluestem (*Andropogon gerardii Vitman*)	8.7
Blue grama (*Bouteloua gracilis*)	7.9
Smooth brome (*Bromus inermis*)	2.8

[1] Pimentel David, Lori Lach, Rodolfo Zuniga, and Doug Morrison. 2000. “Environmental and Economic Costs of Nonindigenous Species in the U.S.” Bioscience 50, no. 1. p. 53-65.

[2] Rinella, M.J., B.D. Maxwell, P.K. Fay, T. Weaver and R.L. Sheley. 2009. Control effort exacerbates invasive-species problem. Ecological Applications. 19(1), 2009, pp. 155-162.

[3] Fuhlendorf, S.D., D.M. Engle, C.M. O’Meilia, J.R. Weir, D.C. Cummings. 2009. Does herbicide weed control increase livestock production on non-equilibrium rangeland? Agriculture, Ecosystems and Environment. Volume 132: Issues 1-2, July 2009.

[4] Voth, K.S. 2009. Demonstrating how trained,weed-eating cattle train herd mates as a tool to enhance weed management. GLCI Final Report. Available at: http://www.livestockforlandscapes.com/GLCI.htm

[5] Garcia, J. and R. A. Koelling.1986. Relation of cue to consequence in avoidance learning. Psychron. Sci. 4:123-124.