Plugging Along

August 2004

Meadows here, without exception, started out “contaminated,” having so many weeds that the only thing that could be done was to kill everything. That status usually held for two to three years. As more native plants came up and things got more complex, the status then graduated from “contaminated” to “transitional.” At that point I either spot sprayed or masked and sprayed (in a bit), thus leaving the native forbs and grasses to lay down fresh seed. Once a meadow started cleaning up so that I could hand weed it, the girls seeded and I planted 2x2 grass plugs on about 12-18” centers.

August 2004

I went through iterations with this shade house design for both botanical and industrial purposes. At one time I had fallen prey to a “native plant nursery” that had sold me what was in fact a variety of European sedge. It then became obvious that if these people who knew a lot more than I do about native plants could make a mistake like that, there had to be more control over where seed actually went. Ideally, that means both seed and soil should be collected onsite and never leave. This has several advantages, not the least of which is that it avoids spreading any weeds the nursery might have all over the State. They do that you know.

The problem is that nursery equipment vastly increases yields, particularly greenhouse temperature controls, both for rooting, germination, controlling fungal attack, pests... My goal at that time was to devise easily portable equipment that could be set up on site in minutes that still possessed the controls for water and temperature one finds in the nursery. I still think it was a good business plan. Then came *Shemitta* and I became overcommitted. Maybe someday I’ll get back to fun engineering projects like that.

This project was fairly simple, to make a portable shade-house for growing grass plugs onsite (thus no confusion about stocking site-sourced seed). It has an irrigation line under the ridge with spray nozzles on a garden variety battery-powered timer valve for the water. To take it down, just undo the rope tethers, pull the tensioning bows, roll it up in the shade cloth, and put it on the truck rack. The first design (prior page right) worked great. That is, it worked great until the rabbits found it. Room for adding chicken wire around the outside was but one reason for the redo. The structure lasts at least 10 years.

This is a sterile soil mix in this photo, so no weeds, but later on I went to 50:50 ratio of native soil to Cornell mix with about 10% charcoal. There is a problem with using soil mixes high in organic matter if one uses bigger plugs because when the organics rot out it leaves a hole and the plant dries out. Unlike the prior photo the plugs here are small, 1” X 1” by two inches deep.

May 2005

“Plugging along” really was a lot of work. My two girls did most of the seeding. I made starter mix, loaded the trays, and planted them. Thousands of them. Nor was this all.

If I had to do it again, I would have started earlier growing plants in pots for seed, and not just for genetic reasons. First, I should have spent more years purging the weed bank, literally stimulating germination with nitrate. Had I stuck with our *B. carinatus* for example, it would have forced going through the successional steps where the needle grasses displace the bromes. I don’t know why, but I think it would have been better for the soil.

This is of course premised upon knowing what I was doing at the time, which was just not the way things were. My goal now is to make that process easier. Perhaps I’ll go back to designing the portable greenhouse equipment I was planning years ago once I’m done with writing books, video...

These were our first plugs, here almost two feet tall. We harvested the seed from here for similar projects elsewhere, which is why they remained for a few years on roughly the same spacing as when they were planted. I mow them after the harvest to mulch the surface, reduce thatching, and make early weeds more visible the next year. In other places, they remain half this size. This area was crowned with a loader for drainage, so the soil is less compacted. It also once had a compost pile of wood chips (the residual is in the foreground). Interestingly, the native stuff started colonizing the sterile area where I stood for this photo. In other words, it went "transitional" before I was really ready. This hill is a place where I burn piles of tree tops and once composted piles of tree chips.

This photo two winters later is of a masking operation to treat “transitional“ cover. The term means that enough weed seed has been used up and the natives are sufficiently numerous and well established that we chose to go to these lengths to save breeding natives. These pots are covering native plants (mostly forbs) for foliar application of glyphosate (the tall pots are for grasses). Masking is a painstaking process laboriously executed by my two girls, but over the year it was a lot faster and had a higher yield than hand weeding. We never had to do this more than once. From “contaminated” to hand weeding, meadow transitions typically required 4-7 years of spot spray and hand weeding to be “clean" enough for hand weeding alone. Transitional status is far more labor intensive than maintaining either fairly pure or “sterile” areas. Hence, I could only handle so much transitional habitat in any one year. There are now no areas left on our land that require broadcast spray and few that require any spraying at all.

Here we are at plugs +4 years (opposite side of the same hill top), almost five feet tall and with a dense ground cover of Spanish Lotus *(L. purshianus)* in the grass understory. We had a long wet winter with some warm spells and what do you know but we got an unexpected blast of wall bedstraw and scarlet pimpernel *(Aganalis arvensis)* from the “weed bank” covering much of the property. It was war, but we’re winning it. How? We harvested almost 30# of grass seed. By taking a sickle to the stand and cutting them to about 4-6” in height, I could then see the smaller weeds.

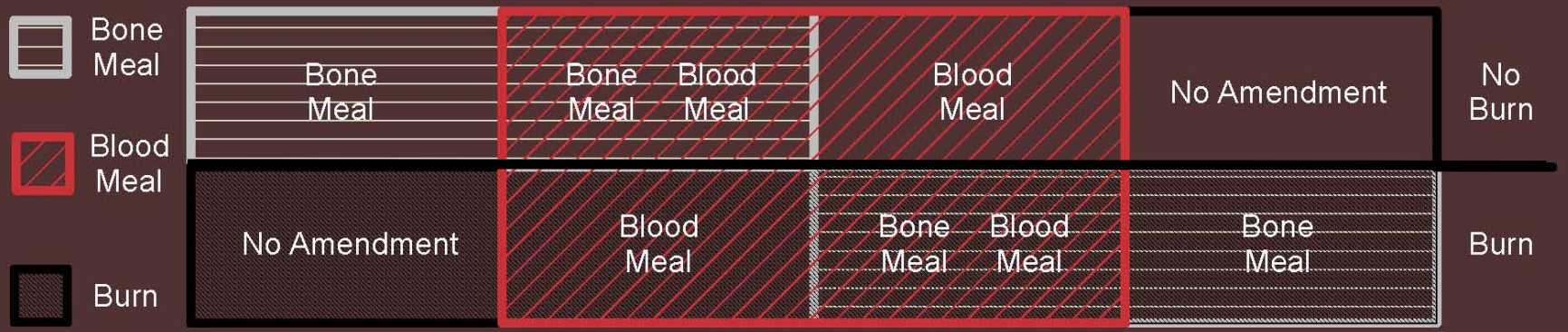
May 2009

This thing between Spanish lotus *(Acmispon americanus* – what were they thinking?*)* and needle grass *(Stipa spp.)* became quite the thing. Unfortunately for the long term, one of the parties got greedy and the relationship didn't last.

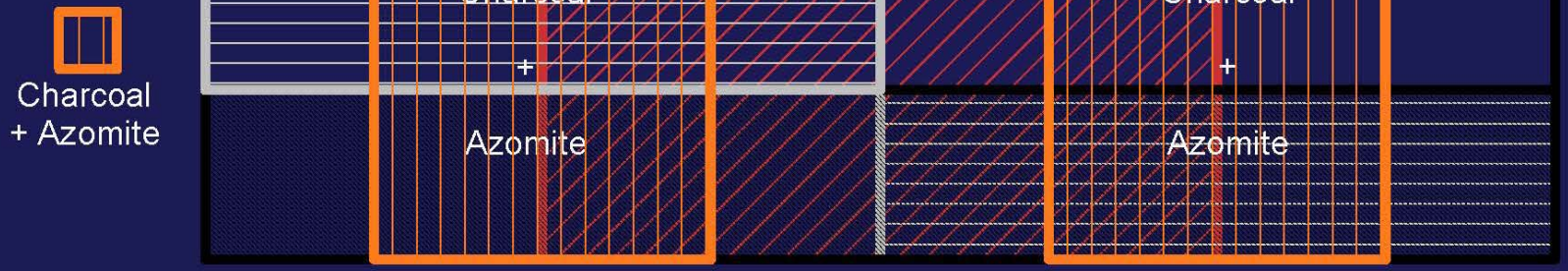
We have not since had a year like 2009 again for either the grass or the forbs, and it was not for lack of rain. Those of you familiar with gardening can probably recognize the lack of nitrogen. Here, the purple needle grass is less than three feet tall and, but for the foreground, the Spanish lotus is virtually gone. What happened?

Some of the reasons are fairly straightforward. These grasses put out short stolons that fattened each of the bunches considerably. Second, despite the fact that I harvest the seed (which consumes nitrogen). I don't get it all; so there is some infill. Third, I mow these grasses annually, which deposits the remaining leaf litter on the surface and this species of grass produces straw that is notably allelopathic (toxic to other plants). And finally, soil tests revealed grossly insufficient nitrate levels. Now, my goal is not to have to fertilize, but if the soil has not yet developed sufficient organic matter, from decomposed roots, I could understand the need for a temporary shot in the arm. So depleted nitrate and the litter were my two top candidates for a diagnostic screening experiment.

2011-12 Each cell is 240 square feet. Four cells were amended at a rate of 50# of bone meal and/or 50# blood meal / 960 ft^2 treatment.



2012-13 1yd Charcoal + 40# Azomite® / 960 ft^2 (Azomite is a volcanic clay rich in trace minerals).



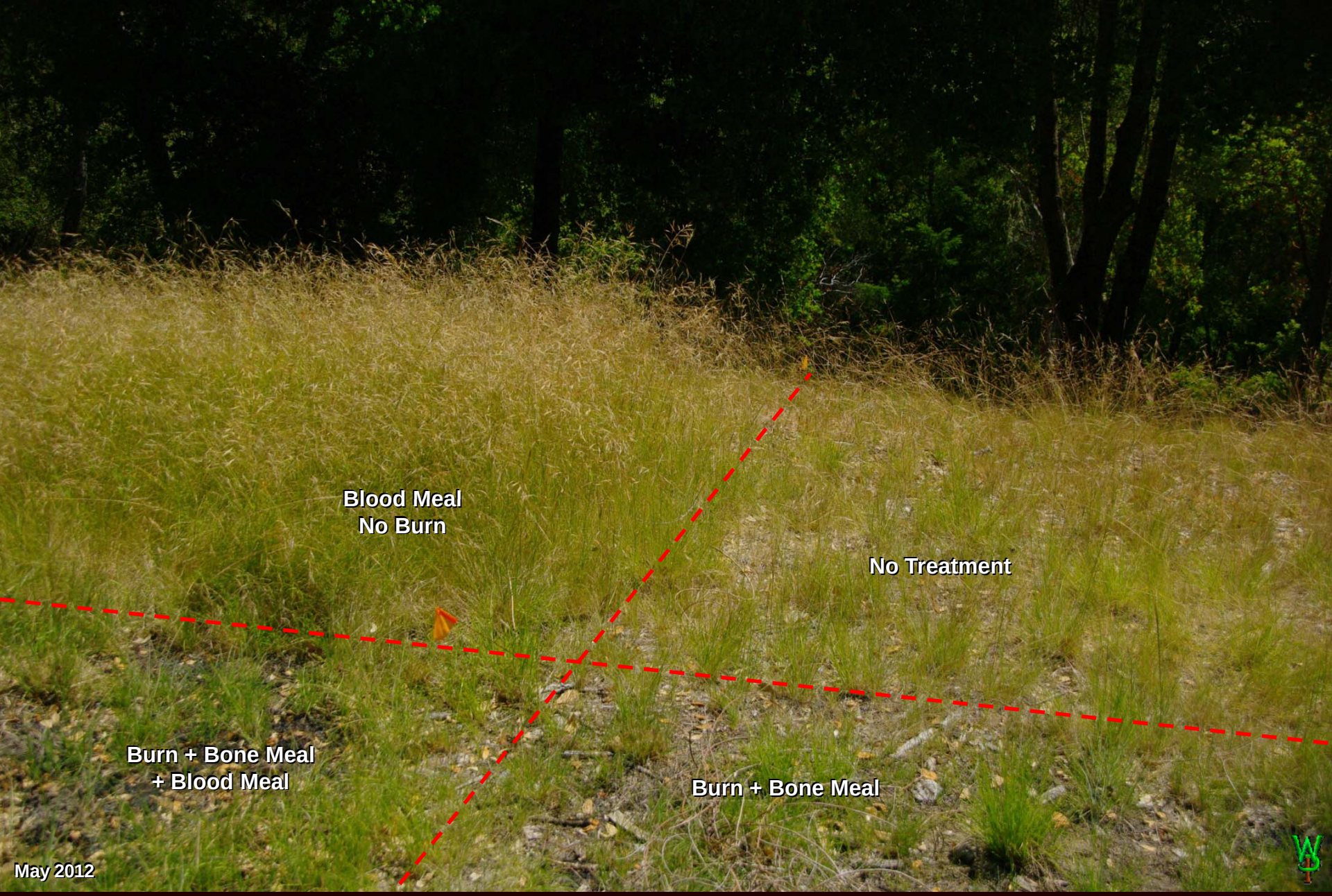
We will start with the upper trial. I put down the bone and blood meal with a drop seeder in the summer of 2011, observed the germination through the winter, and then burned the lower half of the area in the spring of 2012. It was not easy to get it to burn. Fortunately, I had a nearby brush pile to burn and used the coals to get this started. I also had a truckload of oak leaves to add as fuel. Even so, I had to tease the fire to keep it going. The slides to follow show the results of that first experiment.

Blood meal is equivalent to adding nitrogen. Add nitrogen and it gets greener, which is obviously no surprise at all.

It looks nice, but there was a problem.

Nitrate also brings up weeds, in this case filaree *(Erodiummoschatum)*. Yet I had already got to "the bottom" of my onion! I had even used up all the *Erodium botrys* seed!!! What gives? I had never seen *E. moschatum* on this hilltop in 15 years, but it quite apparently requires more nitrate to germinate than other weeds, which means that my "onion" has multiple axes. Along the low nitrate axis, there was one hierarchy. Raise the nitrate and there is another. This was the "burn spot" in the prior photo. That means I have a lot more of this seed being suppressed by my native grasses. What to do? Go on with the experiment, but this does point out the benefit of an "unintended" influence in one of my cells in that the filaree would not have made such a statement if I had not burned some brush in the middle of my experiment. Making the experiment big enough to allow for extraneous variability can be a good thing.

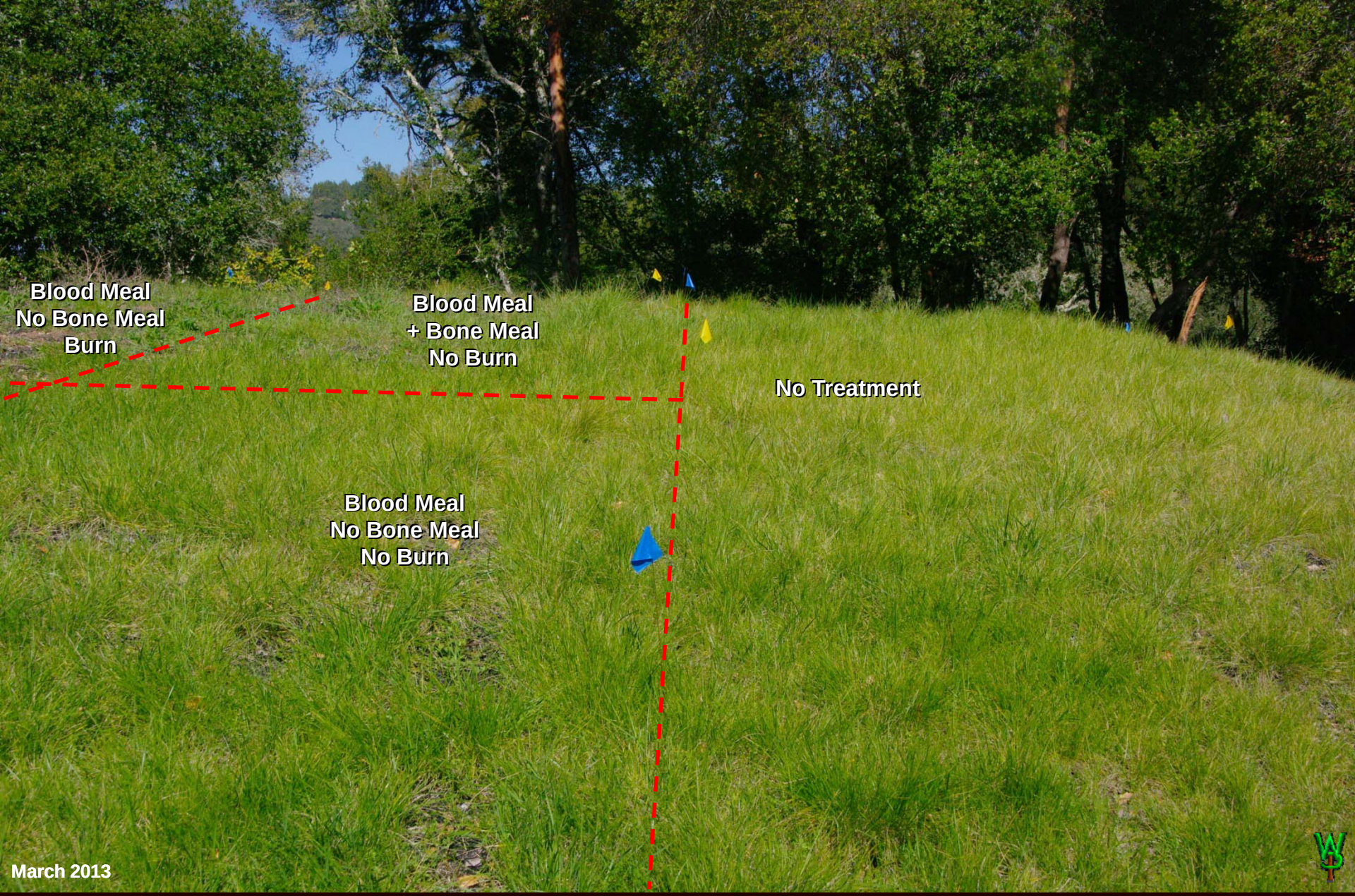
Once burn season arrived and the rain stopped long enough to burn I was able to run the fire with the additional leaves. Note the charcoal produced by the spring burn. At least now I know two things**:** First, this hilltop had been more fertile when it was grazed and produced quite the crop of filaree. Second, if I do increase the soil fertility, I'll probably get filaree, and perhaps other weeds too.



There's nothing quite like obvious results to make endless detailed measurements unnecessary! Nitrate does work wonders. It was also amazing how well the grasses that had burned had recovered in but seven weeks. Happily, I did get the thinning space I wanted for the forbs. Yet we are not to the more interesting problem that we have at work here.

The next year, the blanket of Spanish lotus was back and especially thick in the burned area, as desired…

…along with clovers, such as I have not seen before in needle grass (it was a wet fall; but there was only 4” of rain after Jan 1).



Yet the blood meal boundary shows no sign of a difference in nitrate! Nor was there filaree. Doesn't it seem strange that, with all the lotus and clover we have had here, the soil lost the extra nitrate so quickly? Well, it turns out that there are several reasons. Subsequent soil tests measured molybdenum levels so low as to be undetectable. We may have a lot of legumes, but **without molybdenum, *Rhizobium trifolii* bacteria *cannot* make nitrogenase**. Clearly that is one reason why the soil stays so poor here.

This meadow (before weeding) is “late transitional” four years after planting plugs. This area is about 100 feet from our sand hill area, so it is not surprising to see so much skunk weed *(Navarretia spp.)* mixed in with the other groundcovers.

Same meadow, and as you can see the lotus is dominant. Yet measured indications are that soil nitrogen levels are getting *worse* in this meadow despite all these lotuses. Here, it is now as low as 2ppm and here we do have a culprit**:** that weird looking silvery thing growing in there, especially in the left foreground. That is *Gnaphalium purpureum* (purple cudweed). It's native. Nothing eats it.

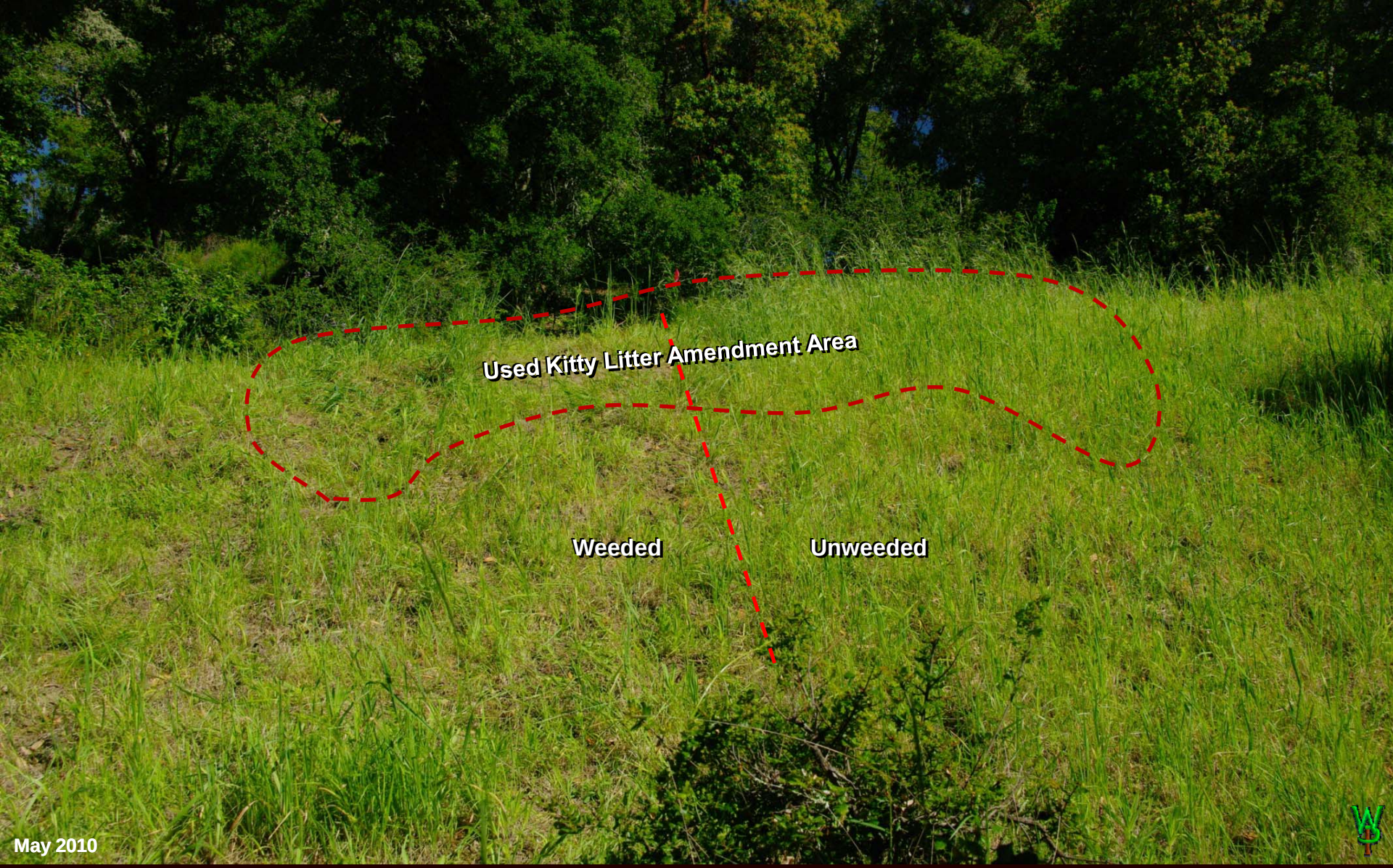
Even though I did not particularly like it, I let it go. After all, it is native, and it is very effective at suppressing weeds.

Look at it go! More importantly, look at the grasses. And where are the lotuses and clovers? This meadow now measured virtually NO available nitrogen. It was getting time to do something about it.

Unfortunately, besides suppressing weeds, purple cudweed also seems very capable of suppressing just about anything else, exotic or native. Look at what it is doing to this lupine (with the blue flowers), turning its leaves as red as a beet in mid-April!

This photograph is not as representative of the plant's capability as I would like, but you can see inside the circles how densely purple cudweed can germinate. I have seen patches that dense over areas of a hundred square feet. So I'm confining it for now, literally weeding it out of some grasslands, until I can figure out what is going on. This is what I wanted to be doing, playing with a native habitat to see how it works. At least I had learned one important mechanism for why our grassland soils were so poor in nitrate.

It just kept getting worse. Cudweed species pull so much nitrate into their tissues that they are toxic to animals. Some are annuals, returning that nitrate to the soil as they break down. This one is a perennial, and look at what it is doing to the grasses! So I put a burn pile on top and spread the hot charcoal to make it die. Sometimes you just have to start over and say you learned something. I have plenty of it elsewhere to see what happens undisturbed.



There are other reasons our nitrate levels are so low. I had seen prior indication that this soil does not hang onto nutrients. Clay retains soil ions. From what I could tell by magnifying glass and water suspension, there appeared to be very little clay here. Without expensive soil testing of a large number of samples, it would be hard to confirm on a site-by-site basis what the clay levels are, but knowing what I do of the site history and slopes here, there is probably very little. So I did this *inexpensive* diagnostic: adding cheap pre-granulated clay, along with an indicator (cat pee) to see how effective it was.

Kitty litter is a highly adsorbent zeolite clay and is adding to public landfills by the zillions of tons.

This is the second year after adding the kitty-litter. Most of what came up with the added nitrogen was exotic *B. mollis,* which typically stays greener than the surrounding native *B. carinatus* but it is good to know that the seed is still there and what will happen if the site becomes more fertile. US Soil Conservation Service test data for this area show 25% clay in the top soil layers. The USCS sampled only *undisturbed* soils, thus characterizing the original background conditions, which is fine. Then they projected those detailed findings by slope, *over the entire region* with fancy online maps, which considering the history, is not. Later lab analysis in this area confirmed that there was about 12% clay. But there's more to this lack of nutrient retention than a lack of clay.

This is Point Molate, in Richmond California, almost 80 miles away. Here, David Amme discovered “Molate fescue,” now a popular landscaping grass because of its low water requirements. What you are looking at is the largest remaining undisturbed native grassland in the San Francisco Bay region, about one (1) acre. What has interested the grassland fans in this area is that it is apparently resistant to weed introductions. There is pampas grass nearby. None here. There is fennel too. None here. There are some dandelions and few native forbs, but it is a stable configuration. The California Native Grasslands Association wants it protected. I want somebody to **care** for it, possibly in return for building a development nearby. I think it is going increasingly decadent. They think it is Natural.

So, is it something about Molate Fescue that resists weeds? Well established, fescue grasses do exhibit that behavior, to a degree. This is one year's worth of weeds in Molate Fescue at the Camden Avenue freeway interchange off State Highway 17 in Campbell, CA. The weeds are… numerous, dominant, and (in my opinion) the native grass is slowly failing. I could show you the same thing at a similar revegetation project around Shoreline Amphitheater, which has a very similar microclimate to Point Molate. It's failing there too.

What you see here is effectively a soil profile created by a railroad cut on the Point Molate site. It was during my second visit that I first noticed that the soil had an odd color pattern to it. I had never seen anything like it in the Bay Area, where I have lived all my life. It has grey streaks and patches in it. Charcoal? It got me thinking. Next time I go there, I'm getting a soil sample. So, why this digression?

Recall the blue dicks that came up in places that seemed unrelated in terms of their cohorts. Here, they are popping up in shade under a young redwood not far from the sunny opening among oaks where they were coming up like grass. The other spot was burned. This one was not. Yet the blue dicks first came up at the same time in both, after all these years. Accordingly, I made the conclusion that these were relatively undisturbed soils and sent out a sample in for testing. Yes, there was 0.5ppm molybdenum where elsewhere there was none. There was also about 20% clay here. Most of the other trace minerals were about the same as elsewhere.

July 2012

My guess is that what works at Point Molate is about more than just clay. For 10,000 years, Indian burning left a charcoal residue. All that time, rain deposited trace mineral dust from volcanoes the world over. For 10,000 years, people mixed the topsoil by digging for food with sticks, one small spot at a time. When the whole hillside was terraced for apples and tilled every year, winter rains on slopes this steep assured that the topsoil was soon gone. Then there was the road grading I did.

Both clay and charcoal retain nutrients and moisture in soil. Bacteria and mineral ions hang on to their surfaces to facilitate mineral decomposition and therefore cation exchange. Molybdenum is mobile in soils lacking means to retain it. So the hypothesis is that with the loss of topsoil went the loss of trace mineral ions attached to the charcoal and clay.

I promised a while back that I'd tell you about turning excess wood into charcoal as a soil amendment. I stomp it and screen it (I wish I could get a grinder, but I'll probably have to make one).

The first experiments were in our vegetable garden, mixed in at 25% by volume, along with soil obtained here. Essentially, I am doing what the Amazonian Indians did with their soil for millennia before Europeans killed them off witlessly with smallpox. The difference now is that we have the technology to measure those elements.

If you know a bit of the history of civilizations, and how they have come and gone, then you also know how important soil fertility is. Somehow, the success of modern chemical agriculture has led us to think of ourselves as immune to these historical, geophysical, and biological forces. We are not.

No matter how big we make it, we are not.

July 2011

All of our soil tests have shown shortages of sulfur, zinc, and boron. Yet it is also known that the local plants are to a degree adapted to low trace nutrient values. How low? Are there adverse consequences to “correcting” these perceived deficiencies? Nobody knows.

So I took about a yard of charcoal, mixed it with a bag of Azomite® (a volcanic-trace-mineral and clay soil supplement) and then broadcast it in bands across the hilltop screening experiment, thus turning it into a four-variable array.

Obviously, every location is different. The point here is this: We either find ways of learning as much as we can about those few locations we can afford to restore, OR we give up on the idea that caring for the “Natural” world is worth the enormous economic cost that has been visited upon this country. The weeds will assure eventually that there is no “in between. “ If the seed of locally adapted post-disturbance annual forbs loses viability we will be assured that we cannot “start over.” So, who is going to do that?

At least conversion to soil charcoal is a use for the excessive fuels we have allowed to accrue. At least we might not need to mine clay and mix it in three feet deep to fix this mess. It looks like recycled cat litter will do just fine.

So at first we broadcast it to see if it produces a difference and let the gophers mix it in. I may even dig out the rototiller to mix it in a couple of spots (yes, I do know what that does to soil structure). I intend to try things and take my lumps if it doesn’t work because it is so hard to do worse than what was done. It’s a good thing that I happen to like making lemonade.

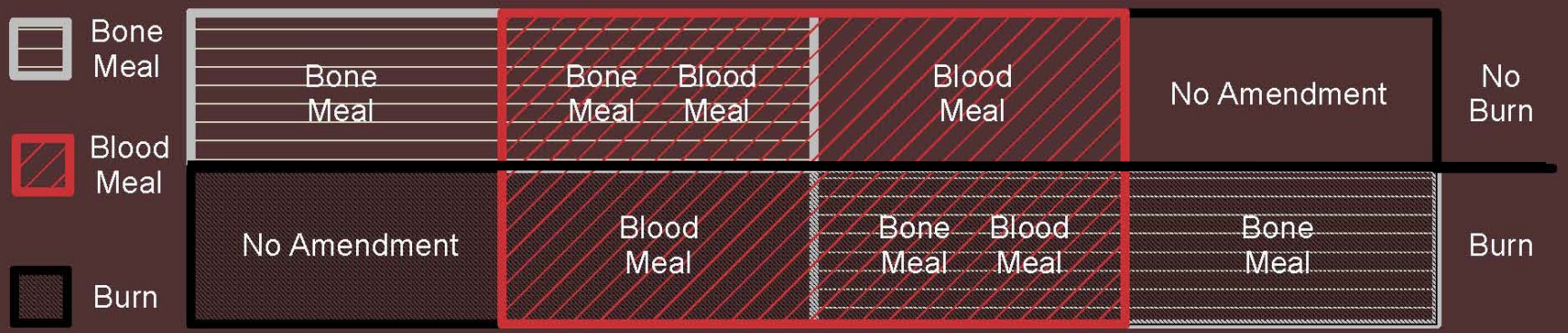
So, the lemonade I'm fixin' to brew looks to be just a tad tainted fer drinkin'. For years I have been reading about the wonders of "compost tea" (brewer at left). Considering the herbicides I've used for so long, it probably makes good sense to "inoculate the gut " after said antibiotic treatment. I have held off on such procedures until I knew more about both the baseline conditions and the variable array (bacterial and fungal endophytes, phyllophytes, and in the rhizosphere). To that end, I will confirm my earlier assessments of clay levels with lab tests from strategically chosen locations (I cannot afford shotgun lab tests). Additionally, I can only make as much charcoal for a total of five years and still have a forest. So this "mad scientist" will start with a test patch.

Now that I am aware of said mineral deficiencies it would seem only rational that I consider an experiment making amendments in concert with an array of representative microbial cohorts. There is attendant to the concoction of such elixirs a necessary degree of empirical mysticism as regards sources of organisms with which to brew (ungulate poop in pond water is popular, but one can blend vegetative smoothies). Unlike most people who brew said tea, I'm not trying simply to make things grow fast, but I clearly do need nitrogen here. Then there is the non-trivial matter of knowing what I am brewing. Unfortunately, the cost of making biological assays of samples containing millions of species is (at $2500 a crack plus $400 per sample) just a teensy bit intimidating considering the likely errors involved and the absolute certainty that we know very little about the implications of said particular microbial assay.

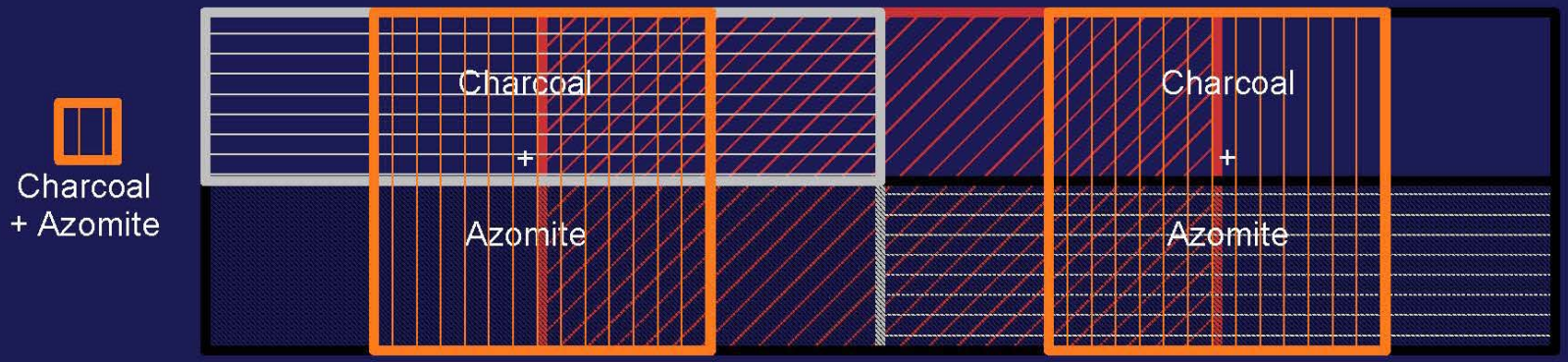
Nevertheless (he said resolutely), my intention is to checker the coming charcoal/clay/trace mineral array with various concoctions of compost tea. For now, that is the best I can do. Science is still working out an accurate and affordable charcoal soil assay.

I plan to sample legumes growing in these arrays for observable distinctions in nodulation behavior, particularly as regards native and non-native legumes. I've got a marvelous consultant in my elder daughter who has done precisely that kind of work in the Long Lab at Stanford and now at MSU. Sometimes you get lucky.

2011-12 Each cell is 240 square feet. Four cells were amended at a rate of 50# of bone meal and/or 50# blood meal / 960 ft^2 treatment.



2012-13 1yd Charcoal + 40# Azomite® / 960 ft^2 (Azomite is a volcanic clay with high trace mineral content).



It is one thing to try to guess what soil conditions were here 200 years ago (which is unknowable); it is another to have observations that suggest the system response to a nutritional input or event such as a fire. Without doing this, had I grazed animals here or had there been a fire, I would not have known what to expect. Nor would I have a quantitative sense of how this grassland might best provide food for wildlife. As an engineer in both research, development, and manufacturing experience, extreme-vertex screening experiments are simply the way I learn. My thanks are to the companies who taught me this; universities rarely do.

But ,but, but… why do we need to improve the soil? Doesn't that stimulate the weeds? Sure it does. The popular notion among many regulators and contractors doing restoration work is that we should denitrify the landscape to resist weeds. As if they can keep the Chinese from burning coal. Please note this photograph above with cat's ear growing in almost pure sand. How "denitrified" does it have to get? What will it grow then? Is the goal to walk away, call it Natural, and feel good that "it's native"? Even if it is no more than a desert? From a civilizational perspective, I think we had better learn how do better than that. Don't you?

If I improve nitrate retention, I will get filaree and other weeds coming up, especially where I mounded that hilltop to make it drain. So, I have choices to make as to *where* to improve soil fertility and where not to, depending upon what I can handle. What I want to do in grasslands is to stimulate weeds, because sunlight germinates weeds and the grasslands would then be at risk of a resurgent weed infestation every time an animal poops. In forests, I am doing the opposite (for now). It may seem counter-intuitive, but given the tools we have, it makes sense to try. I will be fooling with oryzalin in forests however in the few spots where I expect the duff to have rotted sufficiently and there is enough sun that looks likely to produce chickweed, silver hair grass, and other early annoyances I've seen there so as to buy time to handle more urgent priorities. Hopefully, in the next three years, I can back off on that too.

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