Plugging Along

When I started restoring grasslands in 2004, this was the largest patch of native perennials we had. But for this one patch, “meadows” here were uniformly “contaminated,” primarily with cat’s ear and various annual grasses. In most places, there were 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 planted plugs and then masked and sprayed (in a bit), thus leaving the native forbs and grasses to lay down fresh seed.

Plugging Along

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. These were three years old, harvested every year. But this was only a start.

Wildergarten 5.4

This book was originally produced under the name *The Responsible Party* for which there were two revisions, 1.0 & 2.0. Major revisions are for complete rewrites. Decimal revisions are for revised chapters or navigational changes and are not archived. Back revs are viewable by the numbered links below.

Revision History 1.0 2.0 3.0 3.1 3.2 3.3 3.4 3.5 4.0 4.1 4.7 5.2 5.4

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Other writings by Mark Edward Vande Pol:

Natural Process: That Environmental Laws May Serve the Laws of Nature, ©Wildergarten Press, 2001, 454pp, ISBN: 0-9711793-0-1, LOC Control #2001092201.

*Shemitta**:** For the Land is Mine:* ©Wildergarten Press, 2009. Contains**:** 217pp text, 980pp overall, 14 picture books, 2 tables, 963 photographs, 9 maps, 2 drawings, 2 charts, 145 footnotes, 358 citations, and 216 other source references, not including external Internet links. ISBN 978-0-9711793-1-8

Articles at Wildergarten Press**:** collected writings on Constitutional history and regulatory racketeering by tax-exempt “charitable” foundations

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To grow plugs, I went through two iterations with this shade house design for both botanical and potentially industrial purposes. The first was simply for growing grasses. Then the rabbits got into a house like this full of luscious blue wild rye the prior mid-August. One can hardly blame them, but I really wasn't happy with Mr. Bunny at that point. So the second design on the left was meant to accommodate chicken wire on the sides. That worked for what I needed at the time, but there has be a better way. The design does have advantages in that one can roll them up and put a bunch of them atop the rack on a pickup truck.

The motive was partly pecuniary at the time. I had fallen prey to a "native plant nursery" that sold me "*Carex tumulicola*" that was in fact *C. divulsa*, a European sedge species. It was then obvious that if these people devoted to native plants could make a mistake like that, there had to be more control over where seed actually went. It's just too easy to make a mistake. 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 or pathogens the nursery might have all over the State as seems to be an increasing threat, worldwide.

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 and easily sterilized when taken down that still possessed the controls for water and temperature one finds in the nursery. The concept is scalable even for farming in higher latitudes, where growing plugs has higher yields than sowing seed and can be started earlier, thus possibly enabling a second crop per year. I was thinking of franchising it and still think it is a good business idea. Then came *Shemitta* and I was 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 structure lasts at least 10 years and takes a 40mph wind.

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.

"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 that 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 for a few years they remained 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 years 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 was 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.

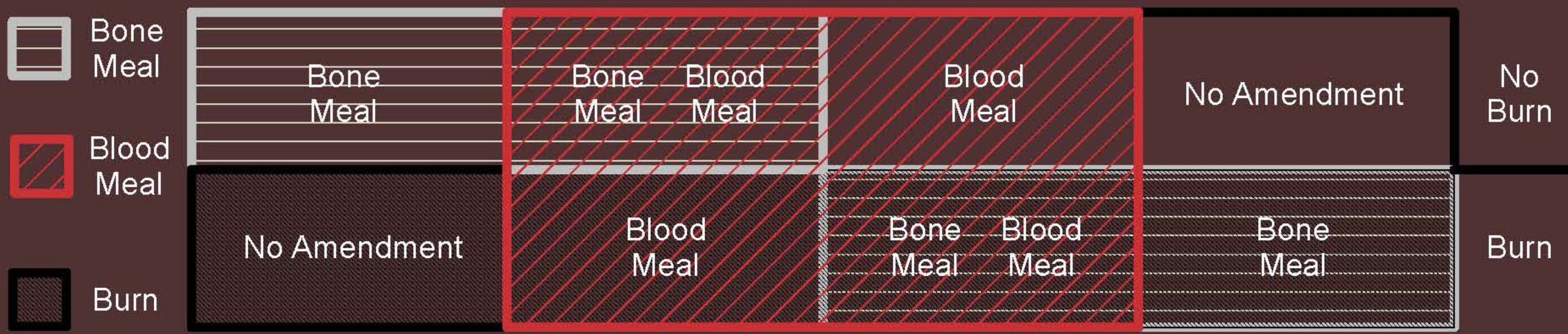
Here we are at plugs +4 years (opposite side of the same hill top). This *Stipa pulchra* is almost five feet tall and with a dense ground cover of Spanish Lotus *(Acmispon americanus)* in the grass understory. We had a long wet winter with some warm spells and what do you know but we got an unexpected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

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.

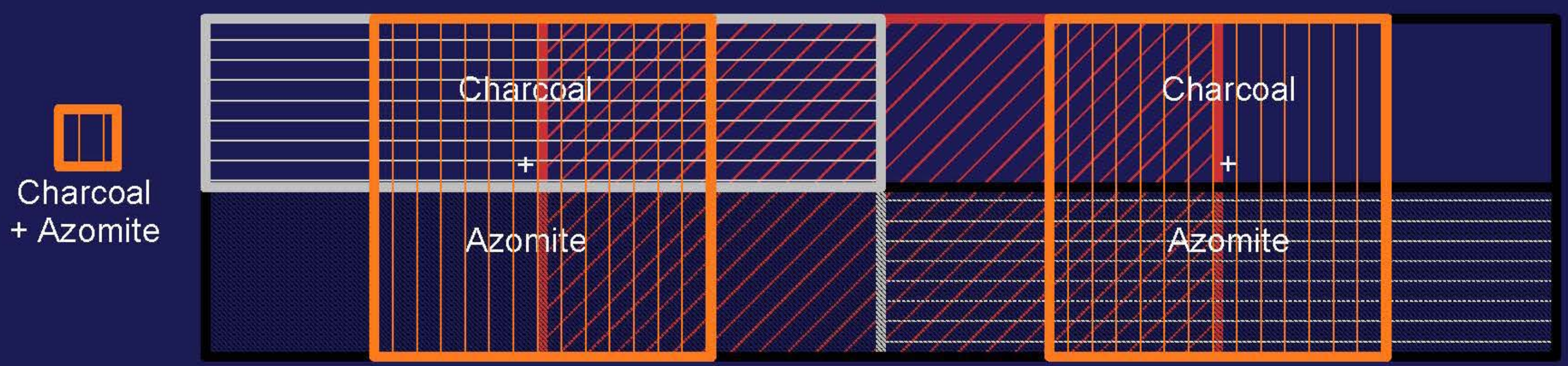
Until 2015, we did not have a year like 2009 again for either the grass or the forbs. It was not for lack of rain because both 2010 and 2011 (above) were very good. Those of you familiar with gardening can probably recognize the lack of nitrogen. Here, the purple needle grass is less than three feet tall and, but for the foreground, the Spanish lotus is virtually gone. What happened?

Some of the reasons are fairly straightforward. Needle 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).



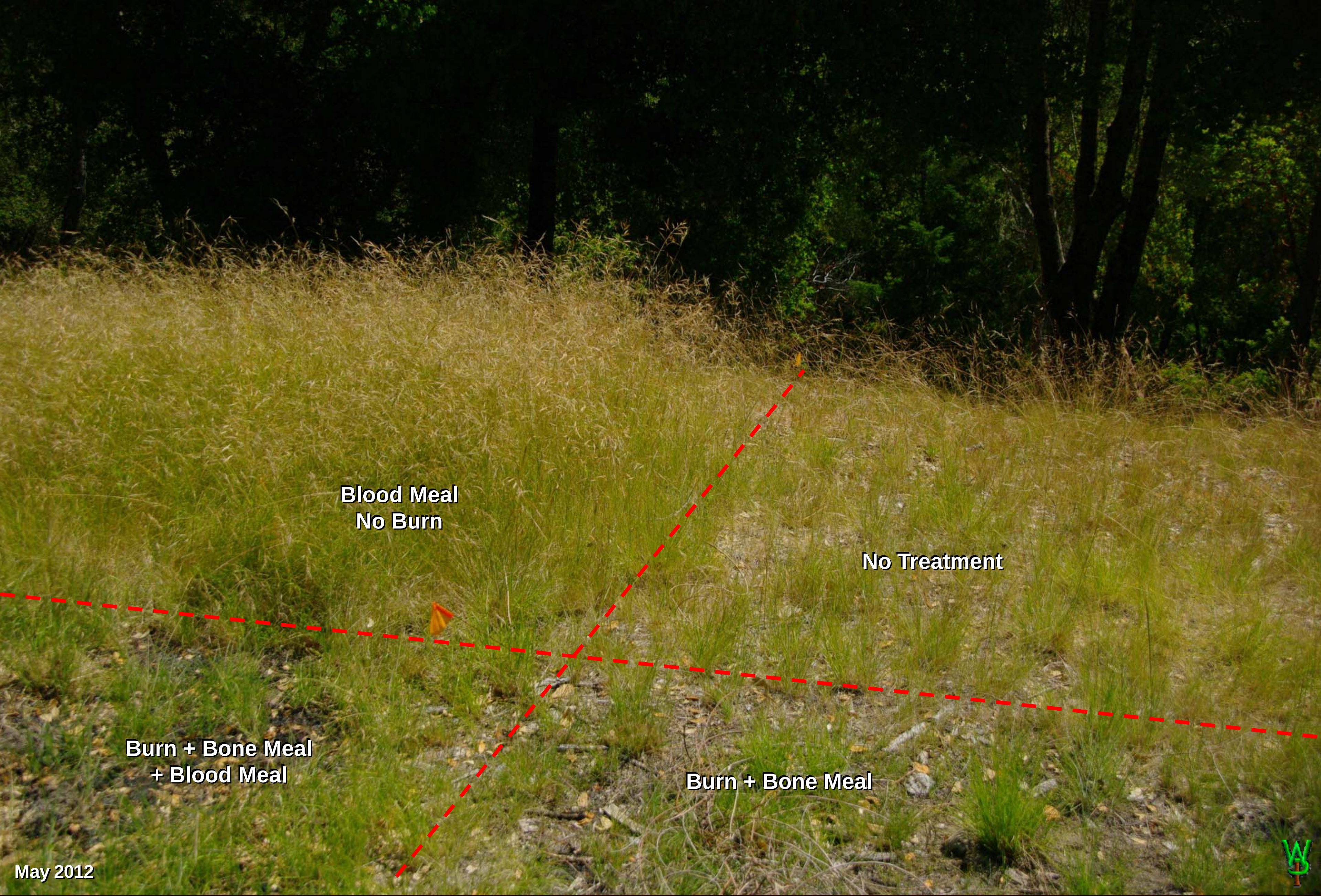
We will start with the upper trial. I put down the bone and blood meal with a drop seeder in the summer of 2011, observed the germination through the winter, and then burned the lower half of the area April 8, 2012. It was not easy to get it to burn. Fortunately, I had a nearby brush pile to burn and 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 *(Erodium moschatum)*. 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.

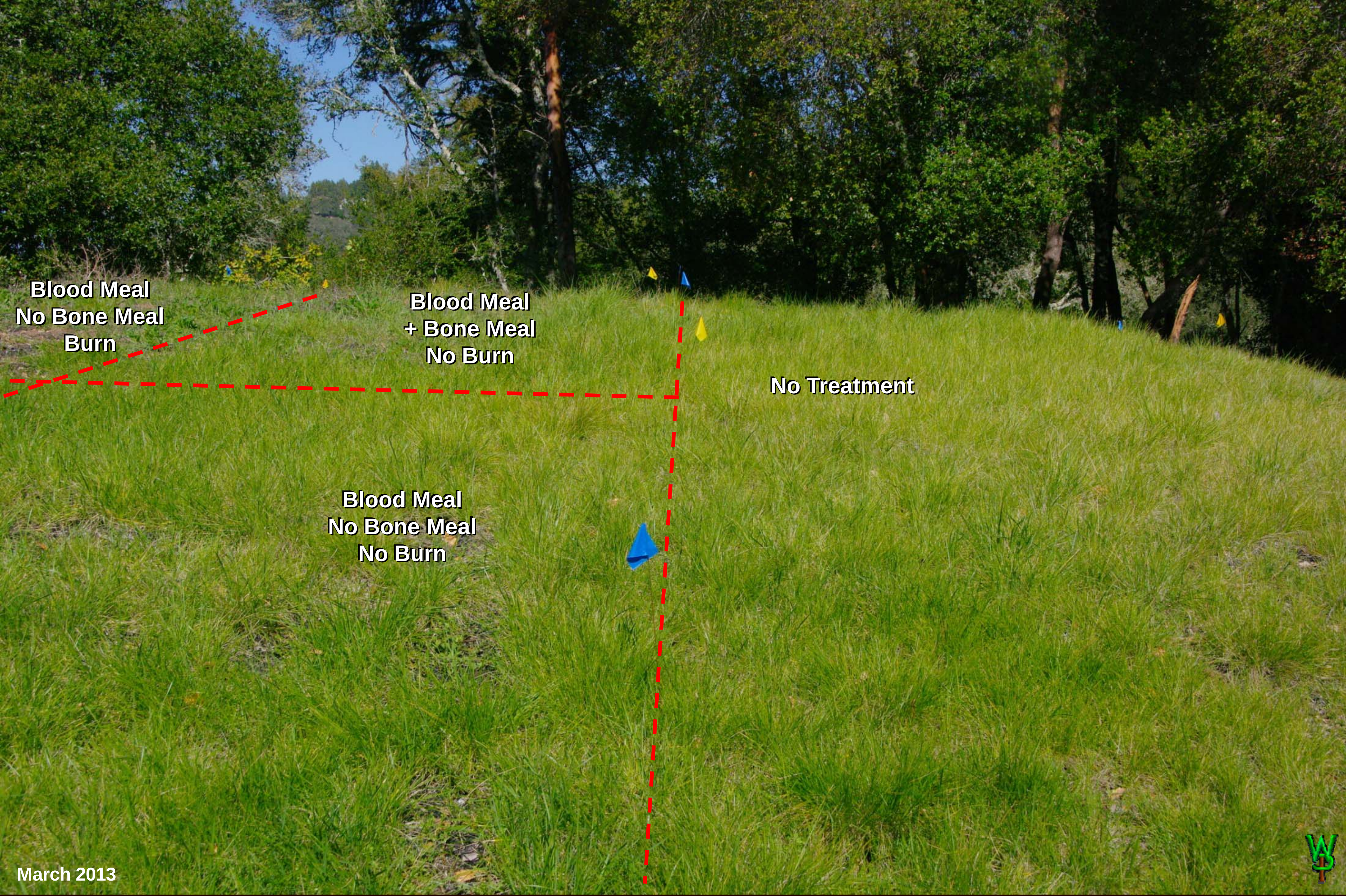
Once burn season arrived and the rain stopped long enough to burn I was able to run the fire with the additional leaves. Note the charcoal produced by the spring burn. At least now I know two things: First, this hilltop had been more fertile when it was grazed and produced quite the crop of filaree. 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 seven weeks; they looked better than the untreated area above. 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 only a year after adding the blood meal, the 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 were several reasons. Subsequent soil tests measured molybdenum levels as undetectable. We may have a lot of legumes, but **without molybdenum, rhizobial bacteria *cannot* make nitrogenase**, clearly one reason why the soil is 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 higher up, and here lotus is dominant. Yet measurements indicated that soil nitrate levels were getting *worse* despite all these lotuses. By 2013 it was as low as 2ppm and here we do have a culprit: that weird looking silvery thing growing in there, especially in the left foreground. As you know, this was thought to be native *Gnaphalium purpureum* (purple cudweed).

Nothing eats this stuff. 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.” So I thought, despite these stark indications to the contrary.

It took this sledge hammer to get my attention. Look at the grasses. In April??? That crappy? And where are the lotuses and clovers? This meadow now measured virtually NO available nitrogen.

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

This image is not as representative as I would like, but you can see inside the circles how densely this cudweed germinated. I saw patches that dense over areas of a hundred square feet. So I confined it, literally weeding this “native plant” out of the grasslands, until I could figure out what was going on.

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 fairly worthless 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 had plenty of it elsewhere to see what happens undisturbed.

Although the meadow is recovering, note in the foreground there are still no forbs. The next image will be along the back edge, where the cudweed never established. At least I had learned one important mechanism for why our grassland soils were so poor in nitrate. There were others. Note the color of the “soil”; it is black with charcoal. We will get to why in a bit.

And here you can see that there are forbs. No, I don’t know the reason, but the grasses do look like there is more nitrate here.

There are other reasons our nitrate levels can fall off so rapidly. 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. (The area on the right did get weeded, but was not when the picture was taken.)

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 fine at all. 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 there something about Molate Fescue that resists weeds? Well established fescue grasses do exhibit weed resistance. Yet 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 here 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.

Back to Point Molate. What you see here is effectively a soil profile created by a railroad cut. 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 here where elsewhere there was none. There was also about 20% clay here. Most of the other trace minerals were about the same as elsewhere.

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 that topsoil by digging for food with sticks, one small spot at a time. When white guys terraced the whole hillside 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 why I am processing 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.

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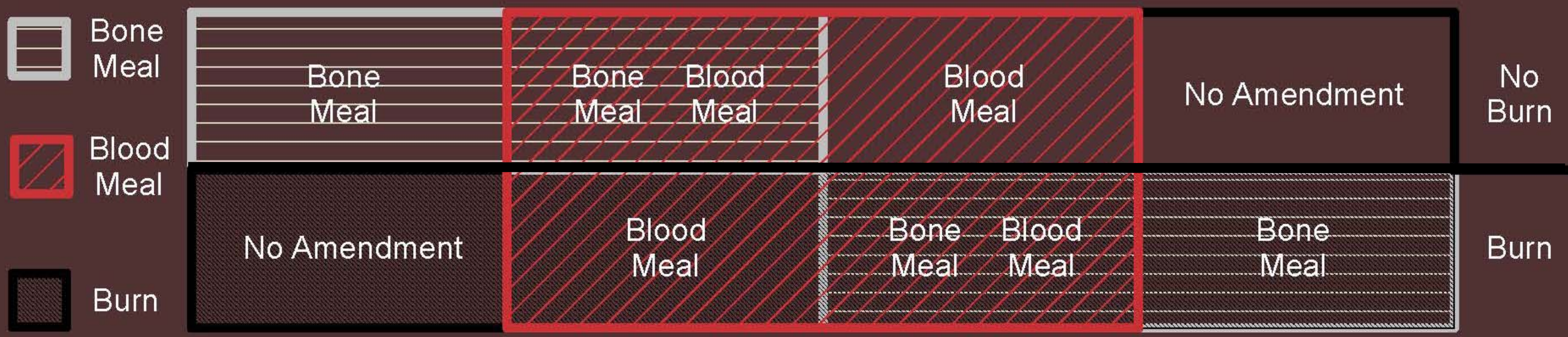
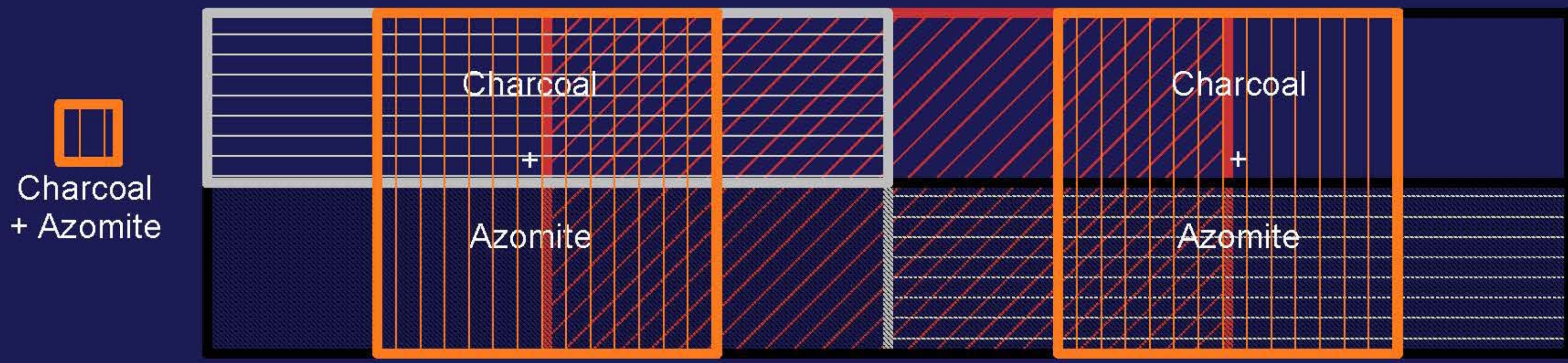


2012-13 1yd Charcoal + 40# Azomite® / 960 ft^2 (Azomite is a volcanic clay rich in trace minerals).



All of our soil tests have shown deficient molybdenum, sulfur, zinc, and boron. Yet it is also known that the local plants are can be 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 (above).

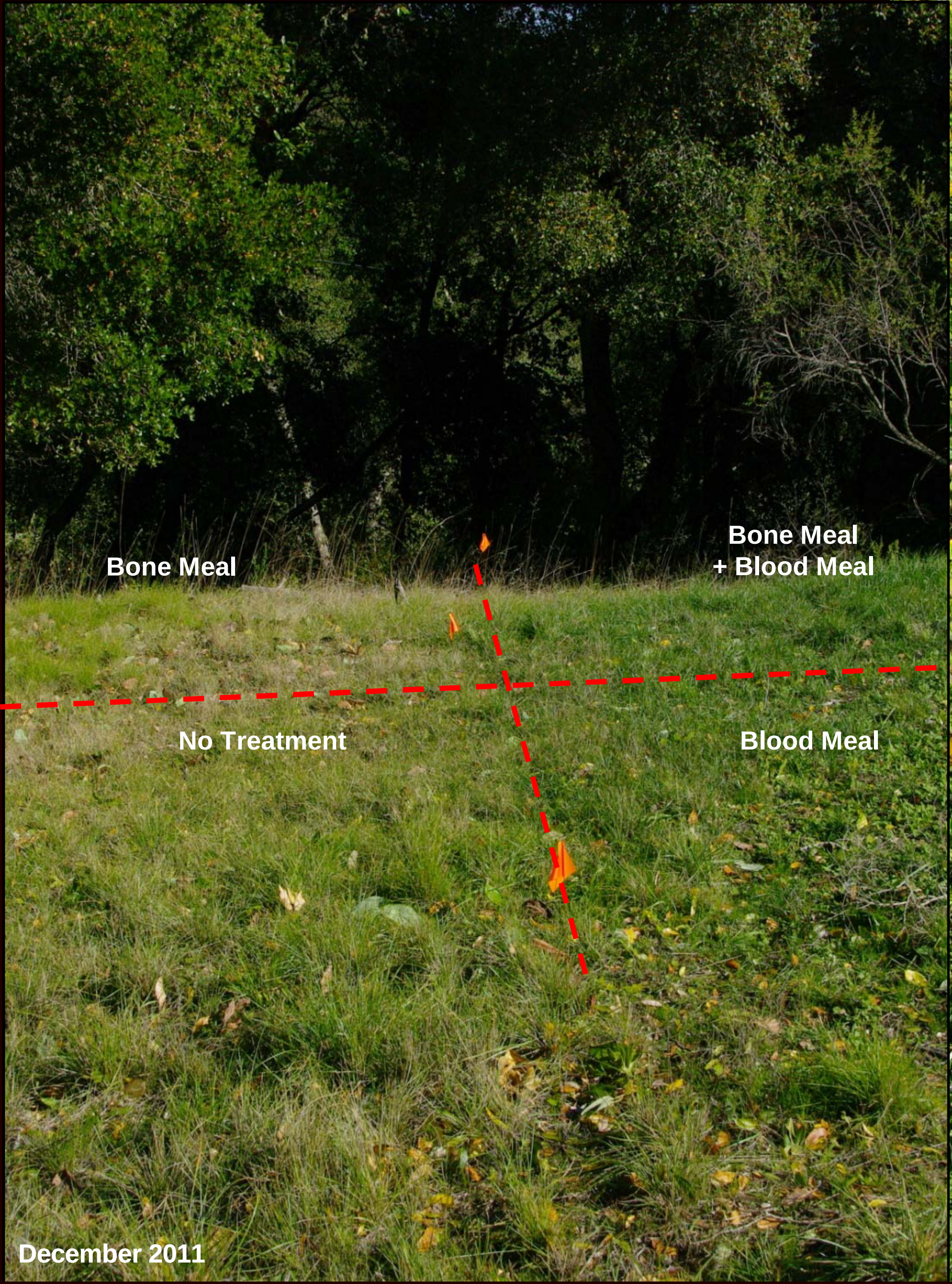
So at first we broadcast it to see if it produces a difference and let the gophers mix it in. I may even dig out the rototiller to mix it in a couple of spots (yes, I do know what that does to soil structure). I intend to try things and take my lumps if it doesn't work because it is so hard to do worse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

In this spot, I covered a patch of soil with charcoal and then straw from the grass harvest, to see if moles would chase the extra insects in the straw mulch to mix it in.   If you look carefully, there are patches that look like bare soil. The moles had done their job unevenly as expected. I had chosen this spot because the soil was so poor it barely supported anything. It started getting grasses the next year.

July 2015 – This is about 10 cubic yards,
about 40% of what I will have made here.

If added charcoal can improve moisture and nutrient retention, then it might be a good way to finance the amendment of agricultural soils, thus reducing the use of irrigation water, increasing bio-decomposition of pesticides, reducing groundwater pollution, and dealing with the psychotic fuel loads we have in coastal mountains statewide. Oh, and for you “carbon sequestration” fans, charcoal remains stable in soil for up to 10,000 years. I have noticed that adding it keeps the top layer of the soil softer for longer between rains, thus facilitating weeding. I am accumulating it, now waiting for other test results. Even better, removing the decadent vegetation accelerates soil formation and growth, releasing more water into subsoil and streams. Other than all that, I don’t know why anybody would do it.

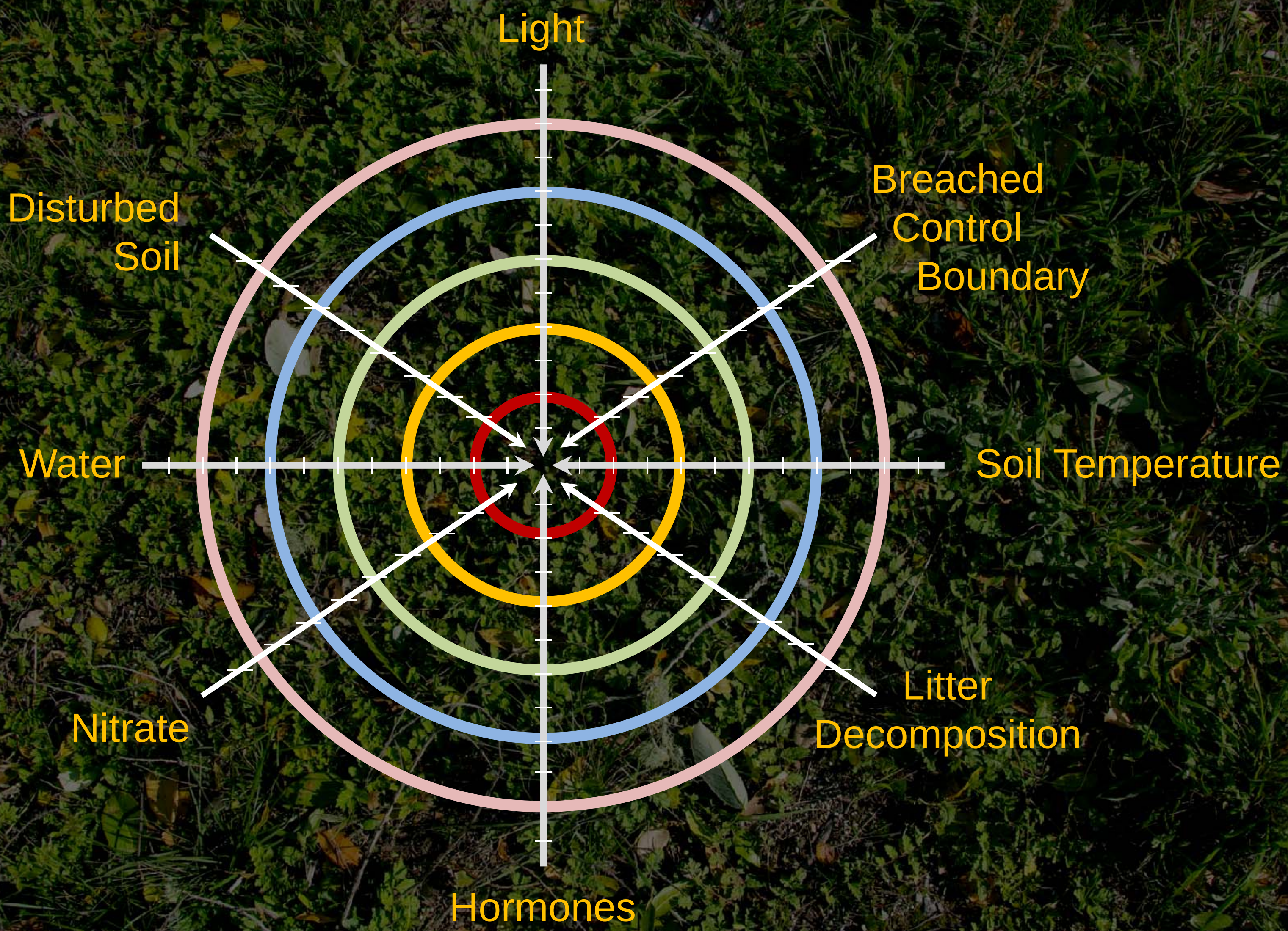
Returning to our hilltop experiment to promote production of small legumes, besides a lack of clay or charcoal, there was another problem this experiment had already exposed, also related to nitrate leaching out of these sandy soils.



The surprise was that adding nitrogen brought up a filaree *(Erodium moschatum)* of which I had never seen more than a few (most of what I had seen up to that point was *E. botrys*). The good news was that it came up very early, so I had plenty of time to pull them all well before they flowered. But don't think I didn't get the message.

Recall from the site history that this property had once been grazed (above is filraree on a neighbor's place). Cattlemen love filaree because it is high in protein. Cows spread it very efficiently because the seed is a bur. I once had a bout with *Erodium botrys* about 60 yards from here, but had not expected an irruption of *E. moschatum* in this area because I had never seen more than one or two in infrequent years anywhere. Interestingly, the places where I had battled *E. botrys,* including our hilltop, were notably LOW in nitrate. Equally interesting, despite the heavy germination of *E. moschatum*, I saw virtually no *E. botrys* on the hilltop in 2012-13.

The "N-dimensional Onion"



Recall from the first chapter on grasslands the characterization of a repetitive ordinal sequence of weed expression as resembling an "onion," with each weed species "layer" suppressing the next until it had been substantially removed. At that time it was noted that what I had seen with the filaree was quite a multi-axis phenomenon among nitrate levels, pH, mulch cover, moisture profile, temperature profile, light exposure, and the rate of germination as precipitates what I call a multivariate allelo-suppressive hierarchy. So if I do add nitrate or if my grassland improves the soil over time, other weeds will come up after dealing with the filaree.

Which of course brings us back to bitter cress, charcoal, karrikins, gibberellins, and abscisic acid! Yes, this all ties together, but we don't have quite "all" of the pieces yet. There are a couple of more chapters to cover before we get to the plan. At least I had defined a number of problems and had a limited method of mixing materials into the soil.

Needless to say, I felt rather sheepish (but not entirely surprised) realizing that over 7 years after putting in plugs, I still had filaree and probably other weeds in the seed bank that I had not yet eliminated before starting with reestablishing the grassland. Realize however, that when I started, all I wanted was to have it be “native” in appearance, knowing that the nagging problem of the exotic seed bank would remain. I was *planning* to use the grasses to *suppress* the weeds, which they do. Yet that simply delays the day of reckoning until a particular bunch dies off which could then allow the weeds to make a comeback in that spot. I once dealt with exactly that phenomenon when I got rid of red fescue I had seeded as an erosion control several years prior. When the *Festuca* died, up came chickweed and hop clover (fortunately as expected). Note that in the image above, the filaree came up heavily in a former burn spot where there was no grass, yet it has not done so in any other burn spot on this hilltop which did not receive the blood meal. The reason has to be nitrate.

I was so busy just getting on top of this rollicking monster of a place that I chose to avoiding doing something “unnatural” such as adding nitrate while I was waiting for the weed bank to clear on the theory that it might be deleterious to my grassland (and therefore my reputation), possibly inhibiting that native seed deposition process, probably out of the hope that I might get away with it in time as the weed seed viability dropped off… in “theory.” One would think the compost pile that had been here leaking its tea should have contributed enough that I would have seen something, but perhaps that nitrate was quickly gone too because of the sandy soil. Worse, I buried some of that seed when I graded the hilltop, so gophers can bring it up anyway.

It was this experience that did much to convince me that there are problems with a suppression strategy lacking total control of every weed. It can work in the short run, but in some cases it may not be wise over the longer run. On the other hand, in terms of weeds, while one is tempted to think one is better off with complete sterilization, the problem with that is all the fungi, bacteria, and residual natives one might kill are also at risk in doing going with them. These are trade-offs. Neither a suppression strategy nor a “clean slate” strategy assures a productive native outcome by itself, particularly because seed is mobile. No matter what, the place will require vigilant weeding. Presuming that one can deal with the weed bank eventually, at least it is easier playing defense than getting to where that is even possible.

But are those the only two viable strategies? No. I will be discussing others in the next chapter. It’s just that the suppression strategy (usually relying upon perennials) is how I started and remains by far the most common among restoration ecologists. As I said, it is fundamentally dishonest to call the result “ecological restoration” if a project on what was once a post disturbance landscape does not include establishing dominant post-disturbance native annuals, which to my knowledge is systematically not done, as the Wildergarten alone has attained at least that preliminary goal.

There are strategies and tactics, and then there is commitment. Guess which one matters? Every strategy has is strengths and weaknesses. It’s our job to apply them and learn from the results to develop better methods.

Still, all other things being held fairly constant, it is quite apparently the speed of weed germination with the roots giving off their respective auxins that appears to govern the ordinal properties of the onion; hence appearing historically to be strictly ordinal when lacking the additional nitrate. There were times when I took advantage of this principle, spraying early in late December and then getting an opportunity to kill a second germination of the next weed "layer" the same year. That I had to deal with the same sequence out of phase from place to place is strong confirmation of the existence of a hierarchy, at least under the relatively constant low nitrate conditions we had. Even today, when I initiate a disturbance, such as felling trees to increase sunlight, the sequence starts off with a fairly repeatable sequence**:** broom seems to go first, followed by grasses (if cows had grazed there), hedge parsley and the bedstraws (which seem to get along famously), catchfly, *Cerastium,* and then *Lysemachia* at the bottom. Cranesbill (a *Geranium*) and cat's ear don't seem to heed the hierarchy, germinating in a slow decay pattern relatively uniformly from year to year. So there are exceptions to the model as I mentioned before. Weedy grasses also seem to have their own pecking order, but I have not been able to make sense of it yet but for the observation that rip gut appears to be king followed by soft chess (*B. hordeaceus*) and then the *Vulpia (*now *Festuca spp.)*. I don't know where *Ehrharta erecta* sits in that grass picture, but it is both very bad and in the neighborhood. I have found it on the property now four times.

Leaving that first axis and looking at the totality of the weed potential in the seed bank, other than *Cardamine hirsuta*, the one that scares me is four-leaved allseed *(Polycarphon tetraphyllum)*, which has shown up here and once in profusion even after several years of nearly pure native germination. Allseed can breed when very small albeit it matures relatively slowly and is easily controllable by selective means. More on all of that in the coming chapter. I am suspecting that it too may require higher levels of nitrate to germinate, an experiment I hoped to be performing in the winter of 2015-16.

So, that was the biological part of this weed control project. Yet all of that presupposes that I have a soil that is at least representative of original conditions chemically. Indications are that it is probably not (the few soil tests I have done are here). Besides low molybdenum, boron is nearly non-existent as well. Tests showed that neither is constituent to the parent rock. That molybdenum is not persistent in soil and this parent material is sand means I can attempt an amendment screening experiment with little concern about permanent consequences (next slide).

I began this process on the hilltop in 2004 with planting grasses and am now over 60yo. I like looking at my native grass hilltop and learning from it, yet the threat of *Cardamine hirsuta* and these other weeds does have me spooked. So I am not about to kill it all and start over just to get the seed under the grasses, partly because I have not seen that big a problem in the "blood meal + burn" areas of the hilltop experiment. So where we go from here is to continue burning up there with patch nitrate amendments to "see what comes up and kill it," continuing soil experiments elsewhere keeping their area small enough that I can deal with the consequences should additional nitrogen bring up filaree and/or other weeds. Obviously, the cat litter has urea in it to stimulate the filaree, albeit in uncertain concentration.

The good news is that where I first put the cat litter there was no filaree, allseed, or any other new weed nor was there in the second experiment when I first spread it there in fall 2014 albeit not at a terribly high concentration. We have two cats, so there will be more. You do what you can with what you have. When life deals you lemons...

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 soil assay for charcoal.

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.

2014-15 Charcoal, Molybdenum, & Clay Array

1. This is a different location than the prior bone meal, blood meal, burn, and charcoal+Azomite® array.
2. Again, each cell is 240 square feet.
3. Four cells were amended with charcoal at a rate of 1 cubic yard of charcoal / 960 ft^2
4. Four cells were amended with used kitty litter (no feces) at a rate of 40 pounds/960 ft^2
5. Four cells have yet to be amended with sodium molybdenum dihydrate by either foliar or ground spray at a rate to be determined by experiments in our vegetable garden and while I fool around with grass piles to get moles to mix in the charcoal and clay.
6. Eight half-cells will be sprayed with Surflan® pre-emergence herbicide for reasons to be discussed. I may also be applying urea when I do apply the Mo. Don’t know yet.

But ,but, but… why do we need to improve the soil? Doesn't that stimulate 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 coming years, I can back off on that too.

July 2010 – Corn farm near Marengo, Illinois; the operator of the rig injecting anhydrous ammonia here missed a spot

It is one thing to estimate what soil conditions were on our property 200 years ago (which is unknowable); it is another to have observations that sample the biological response to a nutritional disturbance. Without doing these experiments, had I grazed animals here or had there been a fire, I would not have known what to expect. I could have tried to germinate all the seed in soil samples in a lab, but I have my doubts about the representative accuracy of such methods. Nor would I have a quantitative sense of how this grassland might best provide food for wildlife. As an engineer with 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. At least conversion to soil charcoal is a use for the excessive fuels we have allowed to accrue. It looks like converting excess vegetation to charcoal and adding recycled cat litter may help the nation's depleted soils while we continue to convert topsoil to alcohol to run our cars. At least we might not need to mine so many mountains to fix this mess.

May 2015 – Grass harvest, *Stipa pulchra*, Wildergarten, 2015

The point here is: Either we find ways of learning as much as we can from those few locations we can afford to restore, OR We give up on the idea that "preserving the Natural world" is worth the enormous economic cost that has been visited upon this country. Exotic species and pathogens will assure eventually that there is no "in between." If the seed of locally adapted post-disturbance annual forbs loses viability we will have assured that we cannot "start over." Not to choose is to choose.

Table of Content

Each line in the TOC is a link that opens that chapter in a new file

Next

Each line in the TOC is a link that opens the corresponding chapter in a new file

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