More on the "Garten" Part

Most anybody crazy enough to build a house is also sufficiently masochistic to want a vegetable garden. Call it "white picket fence" disease, whatever, I simply prefer to eat vegetables picked only minutes before. While there are solid medical reasons for this preference, growing food is only part of what this section is about, because I was just curious enough to design this particular garden with a whole host of other purposes long torturing the back of my mind, a list that (needless to say) has grown with said insatiable curiosity. The result was a big investment of time and trouble with limitations that I'll just have to tolerate because undoing them at this point is simply beyond the pale. Had I the funds… sigh, engineers.

This chapter is a new addition to the book, just like this book was originally a chapter to another. Similar to that first prior effort, it's a bit sketchy in its content and organization until I gather more images and get the presentation worked out, not to mention do more work in this area once the writing demands elsewhere drop off significantly.

As of now, it includes the following topics**:**

1. Wood grow box construction and the incorporation and effects of charcoal as a soil amendment.
2. The vegetable garden as a soil diagnostic and amendment process development tool as applies to the rest of the land.
3. Observations of native plant behavior when given optimal conditions in a garden setting.
4. Companion planting, both with natives and crop cultivars.
5. To come**:** Native plants as foods, herbs, and spices.

In other words, this garden is meant to be an integral part of the restoration of the whole property toward the purpose of restoring people in the land for its own good. The garden sustains the people doing the work. It exposes aspects of the local weed history. It is a way of learning about the soils and the native plants found here. It suggests how to develop potential plant benefits for human and animal health.

This garden was built as a permanent architectural feature of our home. It is therefore a fixed thing of fairly standard construction. In addition to growing yummy food, the intention is to use it as a developmental tool with which to identify desirable grow box design features and process attributes for self-contained *portable* growing systems as are advocated in the new edition of *Shemitta*. In that respect, the goal of the development project would be to maximize the independence of mobile users, requiring minimal regular supplies with which to sustain life, thus extending residence time in the wild with minimal need for expensive deliveries. As portable equipment, one must improve adaptability to variations in terrain, solar exposure, soil and air temperatures, pests, and moisture conditions. Some of these needs demand contradictory features. Yet finding the way among trade-offs is what development work is all about. The subject deserves attention to facilitate wildland restoration.

As a garden, the soil must maintain good drainage, efficient "soil water" infiltration and retention, yet with a low leaching rate of both mineral and organic nutrients, particularly because soil depth adds weight. One might also use the garden as a sink for weedy organic matter, with which to contain seed and prevent unwanted dispersion of cultivars into the surroundings. It would process human wastes from composting toilets, use gray water from a sink, all of which has been done by others better than I. Thinking toward portability on the other hand or integrating native plants… not so much.

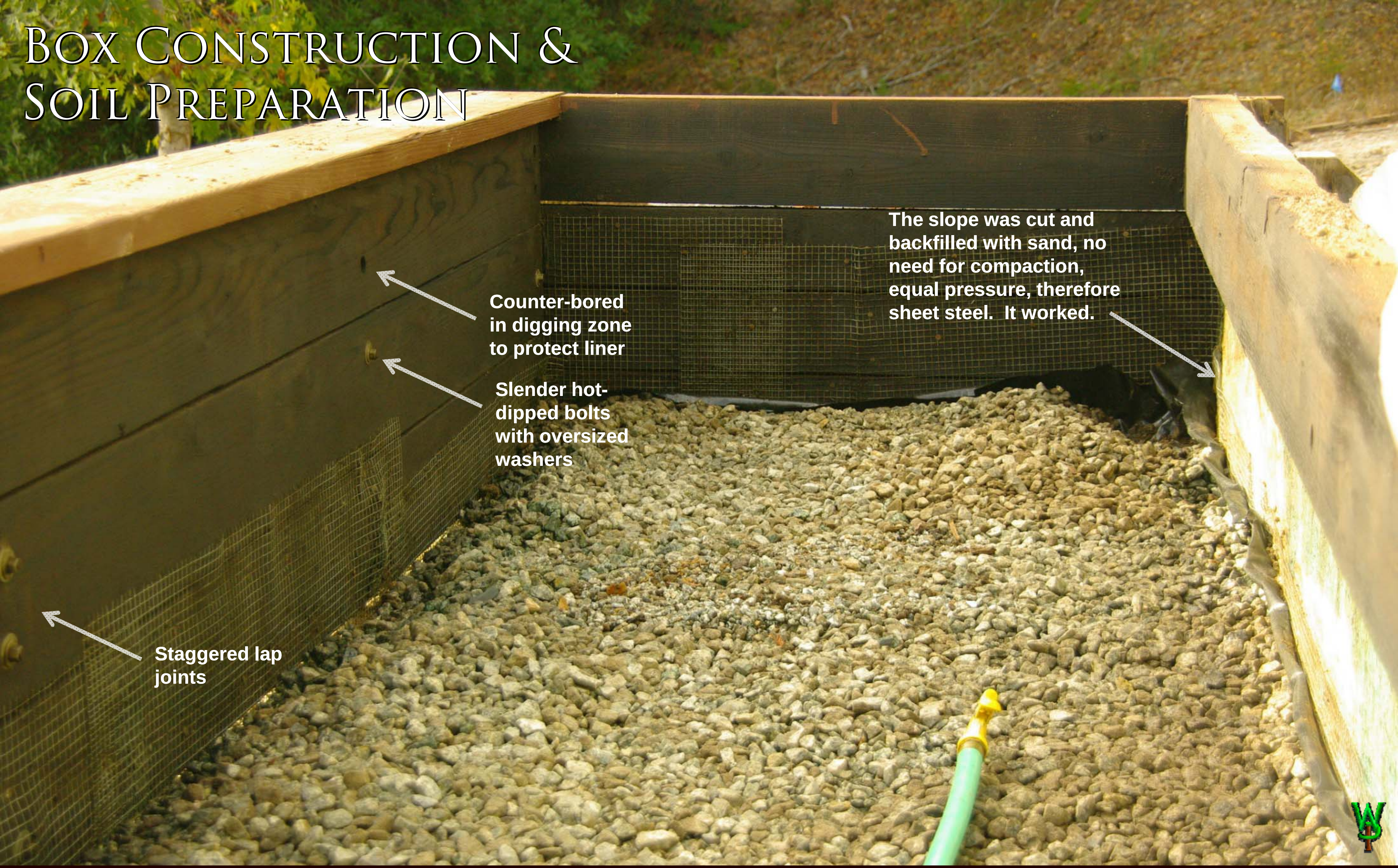
None of this will be cheap to develop from an engineering perspective, but bits of the knowledge toward those ends are within our capability here at the Wildergarten, some of which are design related, but more of which are process related (making new machinery costs bigger money than I have). So in the mean time, I'll learn what I can so that the machinery might go through fewer iterations. That is how things get done in the real world anyway.

The requirements for building such systems are many and are part of what makes this such an interesting engineering challenge. So I'll list a few to help you keep them in mind as you read this.

- Yield per unit weight (including soil) and area
- Moisture infiltration and retention. i.e., easy in, but not so easy out (with charcoal, perlite, and mycorrhizae it's doable)
- Minimize nutrient leaching, vibratory packing, and external temperature sensitivity
- Minimize setup and take-down time for moving
- Pest Resistance while retaining attraction to pollinators
- Ergonomic access and low total labor input
- Cost
- Beauty (beauty inspires work)
- Serve as testing bed to develop processes with which to rehabilitate native soils
- A sink for weeds as organic matter
- Develop native plant companion planting within that area to learn which native plants function to augment productivity of food crop plants
- Develop native plant attributes as cultivars
- Learn which native plants are edible, what their health benefits and or risks might be, and how to cook with them to produce tasty and nutritious food. Part of this goal is to reduce allergic responses of people new to an area by homeopathic means.
- Low shear tilling and mixing (the two are not the same thing)
- Sampling, analyzing, and characterizing local soil microflora
- Simple flexible and efficient irrigation, preferably modular
- Integrated with germination systems, including soil temperature control (a likely need in a mobile system).

Anybody who thinks that this combined list of demands is not a serious engineering problem should ask for a refund on their degree!   Integrating biology into engineering is one of the most entertaining set of design constraints I've ever encountered, partly because one is constantly challenged with the inspiring genius of life systems. To do it for a price is even harder.

Box Construction & Soil Preparation



The box walls were built of redwood I had felled in 1994 and milled here years later. These timbers are full 3X8 heartwood bolted to 4X4 pressure-treated posts. Although it was overkill, I couldn't sell the redwood so what the heck. The wood was coated with copper napthanate. All joints were bedded with tar. This image was after ten years of use when I dug out the boxes to mix in charcoal for a soil experiment, so I had an opportunity to document their construction and to reveal the durability of the design. Redwood is corrosive to metals. These boxes are assembled with 3/8" hot-dipped galvanized bolts with oversized washers because redwood is soft and subject to cracking. The bolts are coated with "wet-surface" tar so they did not corrode at all. There are gaps between timbers to inhibit rot.

The surface was graded so that it drains the rock to a flush 4” pipe day-lighting just outside the box for a cleanout, its opening covered by ¼” hardware cloth. The bottom of the box is protected from gophers with ½” hardware cloth sheets wired together on bare soil at pH7 protected from corrosion due to soil salts by a sheet of 6 mil polyethylene on top. The wire bottom is “sewn” to a sheet of 16ga galvanized steel at right. A second sheet of wire closes the lower outside opening (left) and folds underneath. On top of the polyethylene is ¾” drain rock. The outside walkway is pea gravel to drain rainfall, inhibit weeds, and clean up with a rake.

Filter fabric was put on the rock (I would use MiraDrain® today and gain a couple of inches of depth). Then the side walls were lined with doubled 6 mil black polyethylene. This retains moisture in the soil and protects the wood from rot. Sand was put over the filter fabric so that it won't clog. I later protected the top edge with a 1/8" polyethylene "bender board" screwed to the wall with oversized washers.

The soil mix in the beds has three major components: The top two were 40% (by volume) soil from the land (left), 35% composted wood chips (right) and 25% charcoal, while the bottom bed was 50% soil, 35% organic, and 15% charcoal. Results (TBD) suggest the lower charcoal number may be more productive, easier to till, and has better structure, but the higher charcoal percentage does conduct and retain irrigation water more efficiently. On the other hand, the higher charcoal concentration tends to pack up, despite what seems to be plenty of worm activity. I may dig out the middle bed this spring, dilute it, and try, try it again. This is how we learn.

The bed was filled in two “lifts” of mixing. The first lift of soil, organic matter, and charcoal was mixed with a rototiller.

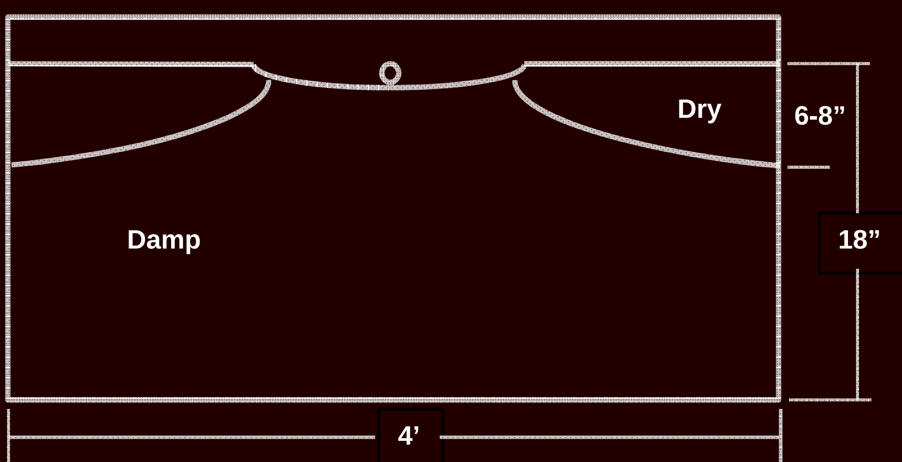
The effect of adding charcoal should be obvious (right). Here I am adding the second lift of rotted chips on the left, then I will add the charcoal, and the rest native soil. Then I mixed it again along with a 40# bag of a volcanic trace mineral clay, trade name Azomite®.

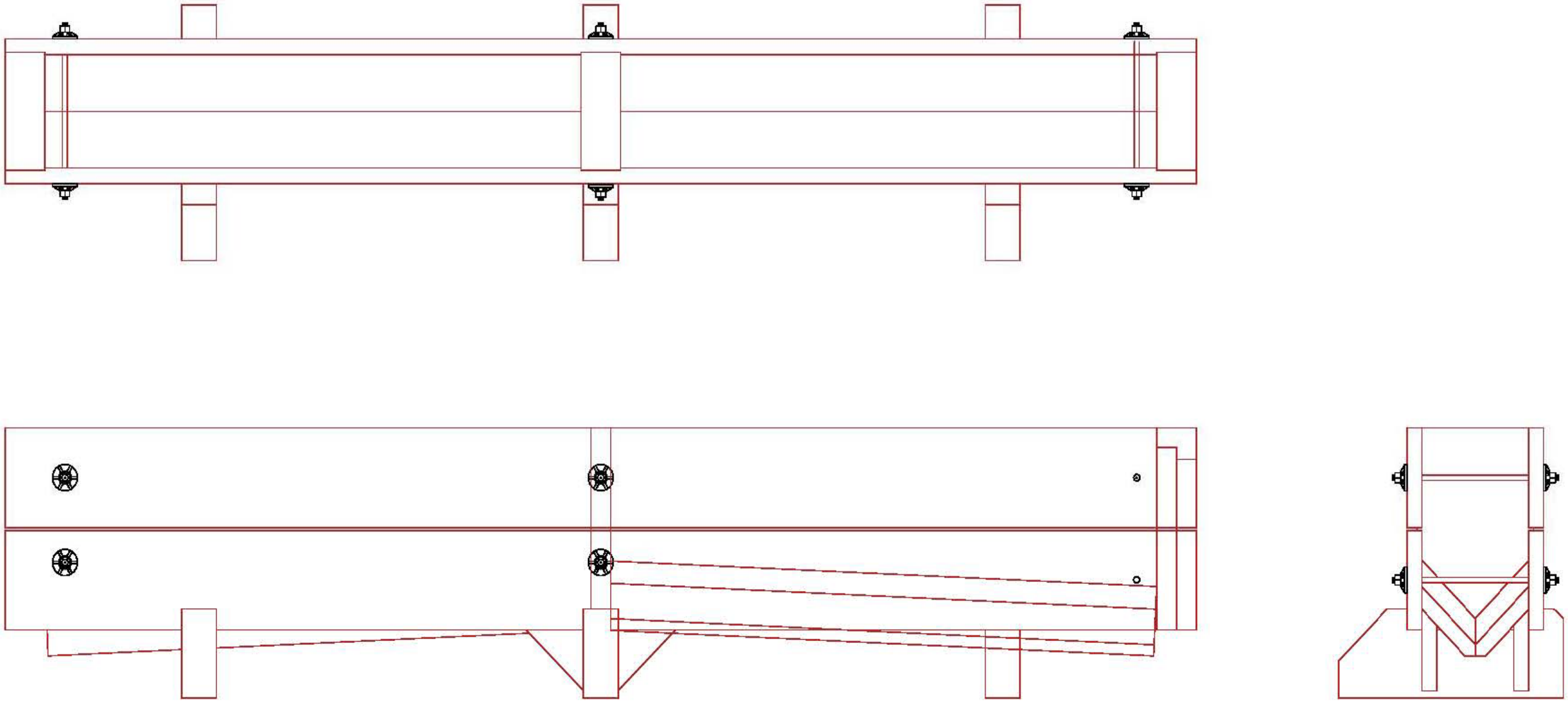
When it's done, it looks like this. Along the top edge I screwed on a polyethylene "bender board" to protect the exposed edge of the inside polyethylene sheet from both sunlight and physical damage. I sowed bell beans as a cover crop for the winter. They grew to 4-5' and made good greens but did not produce nitrogen fixing nodules at all (this was before I knew about our molybdenum deficiency).

I first added charcoal the year after Charles Mann published his seminal 2002 article in the Atlantic Monthly**:** *1491*. In it, he reported that newly deforested areas in the Amazon jungle revealed huge rectangular plots of agricultural soils, “dark earths” dug six feet deep with charcoal, six-to-nine times more productive than the “native soils” thereabout. Effectively, aboriginal peoples had *made* much of the Amazon “jungle,” actually an abandoned permaculture forest grown on modified soils. Making charcoal for soil finally provided a use for the excess vegetation choking these mountains. I just had to try it.

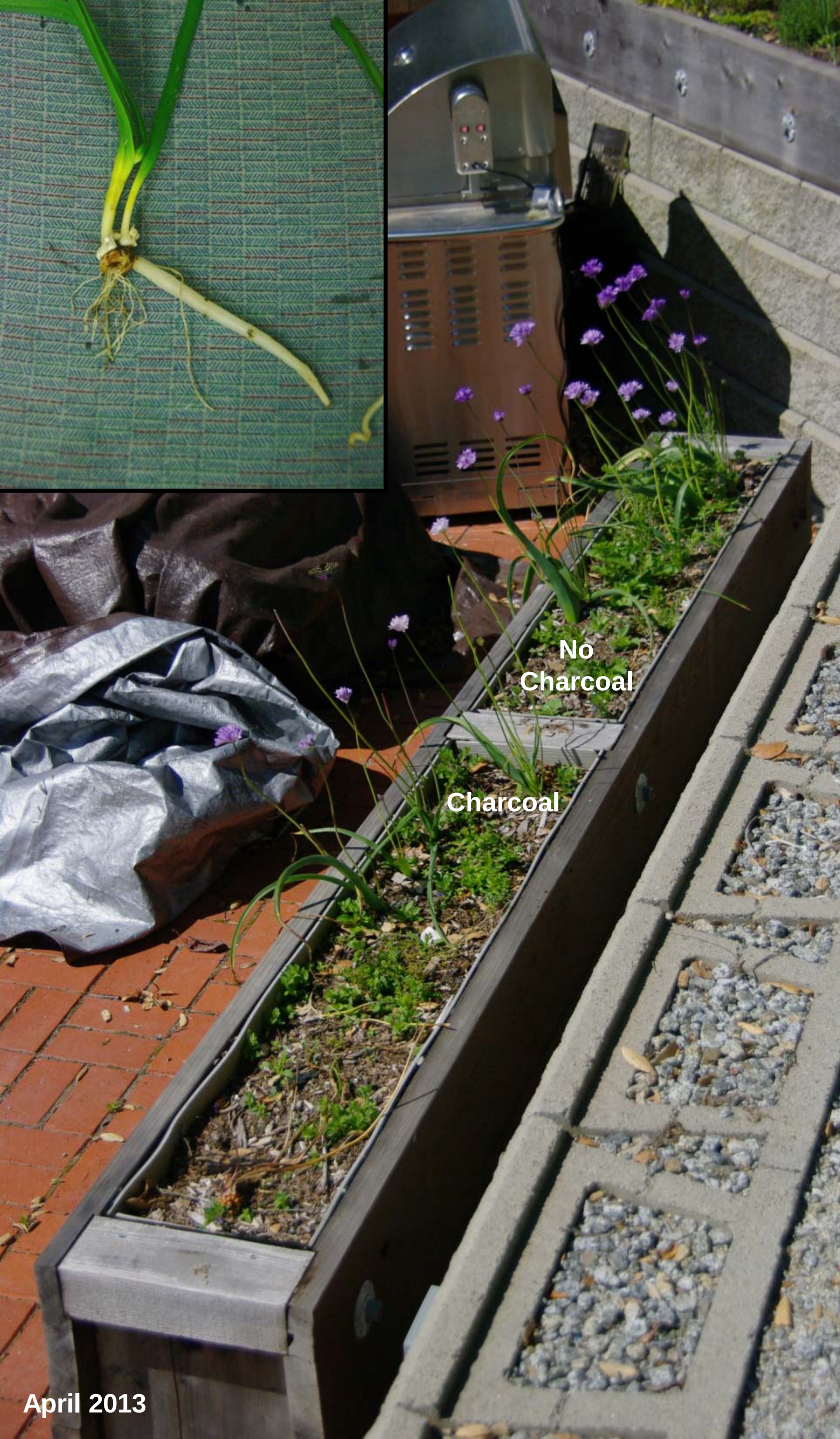
Our soil is sand, in an area with typically 35-50” of rain in the winter and very hot summers. When I read 1491, I was in the process of building these beds, so I put in all the charcoal I had from burn piles into the bottom layer (which wasn’t much), hoping to retain nutrients before they washed out. It didn’t work; I had not crushed the coals thus not deriving much surface area for adsorption. Every year I would till in organic matter, and every year the soil level would drop four or more inches as the soil compacted and the organic matter leached or oxidized (you should see the growth on the slope below the main drain outlet from the garden). So the soil degraded very rapidly, in part because managing a garden was secondary to me compared to getting rid of weeds on the land. Still, there had to be a better way.

In winter 2011, I crushed bags of mesquite charcoal at about 15% by volume (the “lower bed” mentioned above). The results were so encouraging that I got ambitious. The next year, I put four yards of charcoal through a ¼” screen and mixed it into the soil as you saw. I have since been growing crops in the box continuously, including cover crops in the winter. I added half the mulch I once did and only a ½” layer of kitchen compost. There has been no other physical amendment. The difference is considerable. In sand, water usually drops almost straight down. This year, I was growing squashes in a trench down the middle of the bed with a single line of drip emitters. At the end of the summer, I pulled the plants, turned off the water, waited two weeks, and checked for moisture. What I found was the pattern you see below. This isn’t sand any more, this is a sponge. It is even starting to look like one when you break it. So, one problem has abated, but the soil in the upper two beds went at least part way back to packing up again. It wasn’t until I repeated that experiment that I got the message.





The patio needed a planter box along the retaining wall. Given that my elder daughter was interested in soil science and I had an interest in charcoal, I applied the technology learned in building the vegetable beds to this box as designed with a sloping bottom to capture the leachate from two chambers, one with charcoal and one without. I thought that the ability to measure rainfall and transient response characteristics would make it possible to generate transfer functions describing the pulse response of the two soil systems, thereby characterizing both infiltration and discharge responses to charcoal amendment. Again they are lined with plastic, but this time with a perforated pipe set in silicone to collect all of the leachate at a convenient outlet. I never took the data because we didn't have the money for the lab work, but it was a cool idea. I might still do it if I can find a way to afford the instrumentation and lab work. It is pretty!



What was particularly fascinating about this experiment was that the soil with the charcoal did not grow plants as well as without. Further, the soil surface of the charcoal side sank more than the side with more organic matter! Needless to say there are all sorts of possible attributions, from excess salts in the charcoal to the preference nematodes might show for the additional organic matter. Don't know. I'd like to find out.

Yet aside from the analytical and aesthetic purposes for the box, its horticultural purpose has been met very nicely, which was to test how various native plants might do when grown in better soil. I also wanted to make more of them for reintroduction elsewhere on the property. In fall 2012, I started with the now famed blue dicks *(Dichelostemma capitatum)* and the lesser fêted skullcap *(Scuttelaria tuberosa)*. Both grew to some 5-20 times the size one sees in the wild. I planted the bulbs and tubers in late February 2014. The blue dicks did not make much larger bulbs for purposes of food as I had hoped, but they did form an enormous root full of fresh water (inset), which does make some sense for a crop plant along a remote dry ridge-top trading route, as it once was here.

I also planted out Skullcap tubers which did well considering the terrible drought we had this year. The new additions in fall 2014 were either *Brodiaea elegans* or *Triteleia laxa* (haven't had the chance to key which).

I continued these box experiments in 2013-14, adding two varieties of coyote mint *(Monardella villossa* and *M. villossa ssp. franciscana)*, in part to learn whether they would respond well to container planting in full sun and what its water requirements might be. Clearly, both varieties could take the sun and survive in the box, although the *franciscana* having denser hair quite apparently tolerates the sun better. Coyote mint is simply a wonderful plant with a magnificent mint aroma and gorgeous flowers (inset). The *M. ssp. franciscana* is more of a shrub than regular coyote mint and are rare around here. This close together they may hybridize, but these two varieties were collected from within 200 yards of each other so it is unlikely there would be any damage from it per se.

Soil Rehabilitation & Foliar Application

Back in the veggie beds, at first this squash grew rapidly, but look at the chlorotic leaves, especially in shade (red arrows). Most of the leaves once looked as bad or worse, some frying completely in the sun. My daughter at Utah State had checked this soil for N-P-K, pH, conductivity, and salt. All were fine. Multiple assays of the soil parent material indicated adequate magnesium, iron, cobalt, and manganese, but low zinc, boron, and no molybdenum. There had been two years without squash in this bed. Visual diagnostics also suggested molybdenum deficiency, with the lack of boron probably accounting for the leaf miners (blue arrows).

Need photos of chlortic clovers with pink leaf margins
I've seen them

As was explained elsewhere, I have noted vegetative symptoms indicating molybdenum deficiency elsewhere on the property. I have reason to suspect that aboriginal burning over millennia left residual charcoal that retained atmospheric deposition of trace minerals in the soils and that those minerals were then lost when the place was terraced and tilled annually for apples.

I want those minerals to get into the soil but I cannot be tilling steep slopes to incorporate them, nor do I wish to see an expensive treatment washed off by rain or leached out of the soil before I learn whether it works. The problem is that incorporating minerals by tilling would bury non-native seed, then to be brought to the surface later on. I have worked too hard to make that situation worse. So the question is**:** How do I find a way to get the small amount of molybdenum needed into the soil *without* tilling and keep it there?

Lift it from underneath to allow infusion. Mulching stimulates an increase in moles, voles, and gophers. It's a thought, so I gave it a try two years ago when I put down this pile of straw left over from harvesting. It clearly works to a degree. What may inhibit that method is that *Stipa* grass straw is supposedly allelopathic, but that is only temporary. I would suspect bromes would be also.

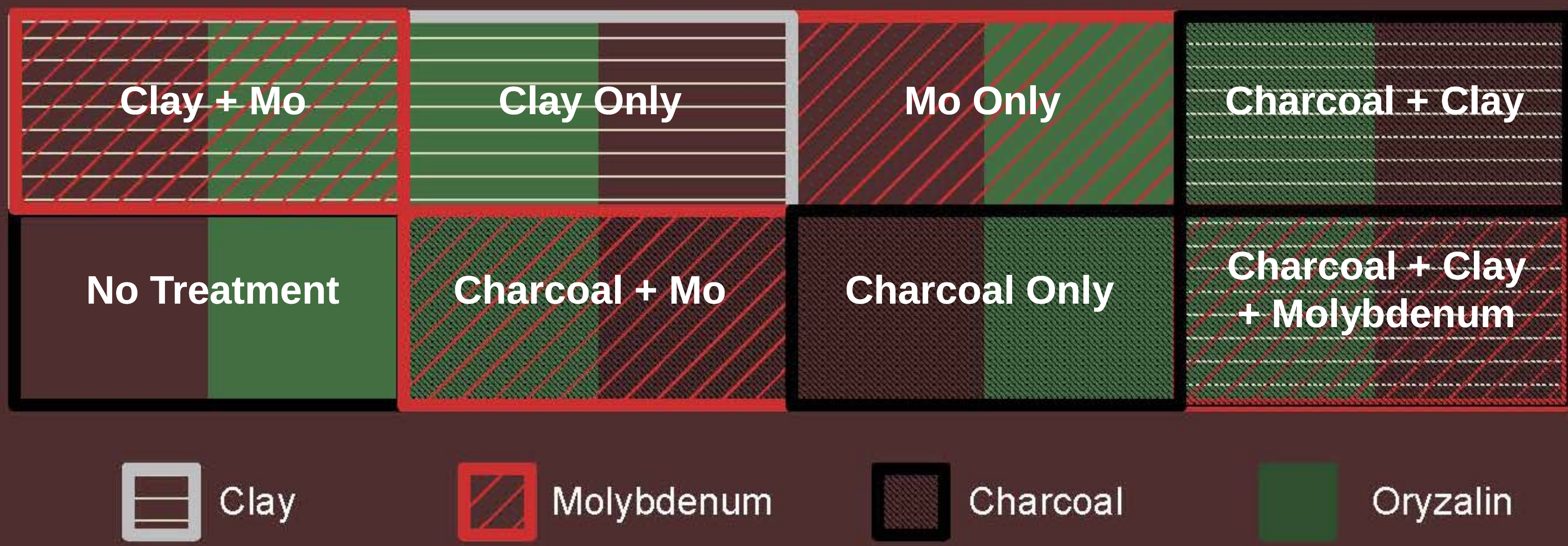
Notes:

1. Target molybdenum concentration was to achieve 1ppm for the top 1’ of soil depth
2. Target boron concentration was to achieve 3ppm for the top 1’ of soil depth
3. Both sodium molybdate dihydrate and boric acid were mixed at 2gm/gallon
4. The applications were sprayed uniformly until the material was gone
5. The beds are 64, 96, 128 square feet.

Another means to distribute trace minerals is to spray a solution as a way to achieve uniform dilution in application. One could then use the plants as a means to translocate the needed minerals *into* the soil which would retain it for longer in an available condition in decayed organic matter. So I am using the garden to test both translocation efficiency and retention of molybdenum by charcoal. I dutifully researched the concentrations of the salts of these elements my plants might tolerate as a foliar spray. During the process, I learned that one must know the assimilation rate into the foliage of each respective mineral so that each application is absorbed *before* adding the next; else they can just wash off. Growing squash was probably ideal, both because of high growth rates and large leaf surface area. I applied nitrate first; that goes in within a few hours, the process washes off surface dust, and stimulates growth activity. Then it was 2gm/gallon boric acid because that goes in quickly too. Zinc takes 1-2 days, while sodium molybdate can take **10-40 days**. Foliar translocation of molybdenum is *very* slow. It also leaches from soils. Sometimes, the choices we have are sub-optimal.

This year I tried a larger area and not quite so thick. Thicker straw retains more moisture which keeps more insects (mole food) going. One does not get the results until the next spring when the critters are active. This is effectively a transition from an extreme vertex design (straw v. no straw) to graduated design (thicker v. thinner straw) with which to characterize how long it might take for me to do a substantial area with the annual mass of grass this place produces and whether I might need to harvest more straw elsewhere to bring to places like this ridge with its minimal nitrogen in the attempt to get the microflora here to produce more of it. I might have put this observation in the chapter on grassland restoration, but I thought a few nuggets basically showing the connections between the garden (a lab) and the field relate here, partly as a reward to those who dig this deep. If you did, thank you.

2014-15 Charcoal, Molybdenum, Clay, & Oryzalin Array



1. This is a different location than the prior bone meal, blood meal, burn, and (charcoal + Azomite®) array.
2. There is also a 50% overlay of oryzalin pre-emergence herbicide.
3. Again, each cell is 240 square feet.
4. Four cells were amended with charcoal at a rate of 1 cubic yard of charcoal / 960 ft^2
5. Four cells were amended with used kitty litter (no feces) at a rate of # / 960 ft^2
6. Four cells will be amended with molybdenum by foliar spray at a rate of XX gm sodium molybdate dihydrate / 960 ft^2
7. “XX” means I don’t know yet.

If the data from the garden show reasonable assimilation of Mo by foliar application, that changes the time at which I will apply it for the experiment above. I may include nitrates in the fields with oryzalin pre-emergence to stimulate the germination of the remaining weed seeds until they are gone.

So, is this science? No university would condone doing things this way! No, we'd have transects with minute measurements, and control plots, complete with massive statistical analyses, pretty colored scatter plots (that few can read)... Can I do that? Sure. Do I have the time? No. Should I then not ask the questions? Is there no value at all to what is learned here? This is where we get to a very serious and fundamental philosophical question about "science" the way it is practiced today**:**

University and agency environmental sciences today function in sum respects as a self-perpetuating grant application system. That means the scientist must produce data that reflects the standards of practice as set by the people who bestow the grants, usually Federal bureaucrats as advised by prestigious, appointed, and compensated academics. Unfortunately, this is where group-think enters in, and where procedure begins to trump, if not obscure, the applicability of the results.

The larger is the area to which the results of a study are to be applied and the more subtle are the distinctions being examined, the more important becomes the need for precision in sample measurement. Yet with precision comes a much higher cost, which then constrains both the area of study and the term over which it is conducted. Yet the larger the area of application, the more obvious it becomes that the magnitude of background variation over time will exceed the tolerances in the measurements!   That argues for bigger scale and more replicates over longer periods with less analytical precision (effectively the choice I have made), except that such is not allowed and is certainly not useful in court (which is where much of government sponsored science is actually used). Said another way, the more detailed and precise is our study, the less applicable the findings become in application because everything is subject to external variation. So, what good is all that expensive precision at that point?

This is why in manufacturing we did our factorial arrays with considerable sample sizes but also with very coarse measurement gradients, because applicability was a requirement. That does not mean we did not take precise measurements where they were warranted (I worked with high-frequency microwave circuits at one time) as 'coarse gradients' might involve differences in a very small component. Yet pursuant to those observations, I would argue that what is needed in ecology is to increase the number of trials and the rate and types of disturbance repeated over long periods, by which to characterize system responses to discontinuities. This is not what I usually see in the practice of academic studies in ecology.

So I keep building equipment and trying things with which to identify control levers on the system. Certainly the relationships between aboriginal burning, charcoal, hydrology, trace minerals, and use of mulch to stimulate mixing go that far, don't they? So, if I plop a pile of straw down and maybe measuring how thick it was might mean something? Not as much as one might think. The variations in how much precipitation there is in any one year, what the temperature profile of the summer might have been, what bugs were there and what animals might have done would blow away much more analytical precision than to say, '4-6 inches of straw in the first pile and a couple in the second.' Although the causes of variation are many, the experiments are big enough that I expect to see something.

So yes, there really is a place in science for this kind of opportunistic happenstance and observation. It is to say, 'Is it worth detailed quantitative study? What might be the range for within each variable under test and how much precision is necessary? How long is it going to take before one learns anything definitive?' At least this way, I get to ask more questions and make more observations for both less time and money while identifying procedural risks and possibly synergistic opportunities.

I did learn from those boxes that coyote mint does not at all appreciate excess water. The charcoal conducted so well that although I plugged one drip line this plant is still too wet and has barely recovered. Now that I have compared the two varieties side by side I will probably pull the plants from this second box this year to add more soil and prepare for some new tests.

There is a relatively common buckwheat *(Erogonum nudum)* found on my neighbor's property (above) that I am trying to germinate here. Yet there is another buckwheat species found within three miles of here that I would like to collect, *Eriogonum fasciculatum*. The latter is said to be endemic to Santa Barbara. It is lower growing, more productive, and prettier compared to more common local flavor. Indians probably brought it to nearby Aptos and Scotts Valley, as those places did host tribal villages. Such issues get back to "what is native" versus what is not. People clearly played a part in plant distributions even thousands of years ago.

I have also been playing around with *Camissonia spp.*, of which there is a coastal variety known to produce a root that once was a native food. That made me suspect that the two species we have here might also be edible (gophers love them). In the wild they grow as a flat rosette usually about 3-5" across with a short stem, unless it is a wet year and they're in the shade and they put out branches (the one above is 12-16"). In my vegetable bed on the other hand, a *C. contorta* grew to FIVE FEET across and 2 feet tall without irrigation. I tried munching on it and it was pretty bitter and the texture unpleasant. I'll give this *C. micrantha* a taste sometime.

There are happenstance “experiments” here too. In this bed I planted yarrow and yerba buena *(S. douglasiana)*. The *Carex tumulicola*. and vinegar weed *(Trichostema lanceolatum)* are volunteers. Vinegar weed is an amazing dry land annual forb and is *very* attractive to bees (next chapter). Unlike the coyote mint, everything else loved regular watering. There used to be thyme here, which I have decided to discontinue here because it appears likely to be invasive (below). We learn more by doing than by observation alone.

Companion Planting

This winter we are beginning experiments in "companion planting," including both crop plants (such as carrots or beets with cabbage) and a couple of native groundcovers. This will include in particular yerba buena (*Satureja douglasiana)*, a type of mint, and hedge nettle (*Stachys bullata*), a non-stinging low-growing relative of stinging nettles. Yerba buena (prior slide) starts from cuttings, so it's slow and iffy. Stachys is known to augment nitrogen fixing-bacteria in the rhizosphere and does start from seed. Deer do make things difficult.

Given that our garden is made of materials obtained locally, it serves an important diagnostic purpose to identify our weed history**:** Gardens bring up weeds early under ideal and controlled conditions. Hence, what I learn here applies everywhere else. In this bed, I was planting carrots and beets, along with *Stachys bullata* to see how well it serves as a nitrogen fixer. There are several exotics here: shepherd's purse, pop-weed, henbit, and chick-weed. There are also *Verbena* seedlings, a big native perennial I do not want here. The henbit and *Verbena* have leaf shapes and textures very similar to *Stachys*. So I MUST distinguish them as early as possible to get an acceptable weeding yield and to minimize the damage of removing them, particularly before the garden hides them. I have never before bothered to study *Stachys* closely as a juvenile. Fortunately for purposes of early identification, the henbit and the shepherd's purse are very fast maturing weeds so they are easy to watch in a garden bed in early October when nothing is starting outside it. Shepherd's purse is easy to identify early by the stripe down the middle of a smooth edged pointed leaf. For the henbit, the aspect ratio of the leaf, its "spade" shape, became the visual key. *Stachys* leaves (none here) are more triangular than the *Verbena* and curl upward.

The deer fence is only half done, the main reason we have grown a lot of squash and haven't taken vegetable production terribly seriously. We did try hiding some green beans and beets under the squash and that worked surprisingly well considering the neglect they got. After feeding the deer this well, it does have one contemplating Bambi Burgers though. Maybe the capsaicin that didn't work will spice them up. The ground was too dry for grading and drilling posts last winter. I can do that this winter if it rains.

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