Teaching Tolerance

Ok, you've heard plenty about how this is all native, but one has legitimate reason to ask, 'What difference does it make?' This section will show indication that there may be such a difference between native and non-native grasslands, one that could well be greater still but for changes in management that would be difficult for me to apply here (broadcast burning and grazing). Nevertheless, the difference is observable and does point to future possibilities for native grasslands. The metric of distinction here is drought tolerance. This is California brome *(Bromus carinatus)* growing in a very poor sandy soil in full sun. I promise you: It had not been watered since just after it was first seeded in 2004. You would never see this in a sunny spot like this in the Bay Area in August. No way.

This is much better than typical of wild grasses one sees in the Bay Area in mid-spring. This is a combination of non-native rip gut and slender oat. This is a very fertile Silicon Valley bottom land soil that does not even get full sun. The rains had been good the prior two months. These annual grasses are done for the year. What green you do see here are non-native broadleaf weeds.

This is one of our grasslands the same week, California brome and blue wild rye. This soil is almost pure sand. The right foreground was bedrock sandstone only ten years prior. These grasses are about twice the height of the bromes you saw on the prior slide.

May 2013

Even on our poor soil, once these brome grasses have inhabited a patch for several years, they can become quite productive. The dog sits over 3' tall. These grasses (mostly *B. carinatus*) are from 2-4 feet.

On the left is land belonging to The Land Trust of Santa Cruz. It is in a marine climate. Being at the base of a large hill, it gets more groundwater later into the year than our place does. The cover consists primarily of non-native slender oat. The green patches are Italian thistle. On the right is our ridge which receives no ground water, has an inland climate that is considerably hotter, and gets very little fog. The perennial grasses were harvested (the source of the straw). In the foreground are native legumes, primarily Spanish lotus. Although the hill on the left used to be grazed before the Trust took over, it does not see much animal activity today.

June 2010

This is the bottomland meadow in what is now Scotts Valley, CA is across the road from the left image on the previous slide. The photo was taken the same day in June, 2010. It has been grazed every year for probably 200 years since the Spanish brought their cattle to Rancho San Augustín. Note in the inset how rich the soil is in organic matter; it is from a ditch dug just down the road in Feb. 2014 in an area in which grazing ceased about seven years ago. Note also that the grass is dead and dry even though it is February.

Unlike the Land Trust's sandy hillside supplied with groundwater, this soil at the top of our ridge is just as bad but still shows a cover of needle grasses and lotuses. Although the grasses have hardened off seed, their leaves are still green too.

This is the fourth week of July. Although our California brome stems and florets are dry, the leaves are still green. Again, this is sand.

And here we are in September, with our California brome grass still with green leaves. The groundcover on the left is *Verbena lasiostachys*. The forb in the right middle is slender tarweed (*Madia gracilis*).

Now that we have covered our place for a year, let's return to the meadow in Scotts Valley that looked so good.

Rainfall	Our Place	This Place*
Mean annual precipitation	43.4”	41.18
1/1-4/30/2013	4.6	4.82
5/1-8/31/2013	0.2”	0.13”
9/1/13-2/1/14	2.5”	2.2“
Frost days	15	25
Dry Season Conditions		
Fog days	15-20	100
100+° days	10-15	3-5
+90+° days	50	10
Peak Monthly average high	93°	86°

* Rainfall data from the City of Scotts Valley Wastewater Treatment Plant, two miles toward the coast from here.

February 2, 2014

This field is comprised largely of annual grasses that are grazed every year. So this is not surprising, except that this is February. It should be green by now, but this was the worst drought in over 100 years. What few perennial grasses they had appear to be dead.

In Scotts Valley, the germination is terrible, despite wonderful soil with obviously adequate nitrate and regular disturbance.
It is colder down here than at our place, but temperatures had been unseasonably warm for the last month.

February 2, 2014

And again we have the hillside on the opposite side of the road from the meadow. Do you see anything alive?

February 2, 2014

This photo was taken the same day but up on Summit Ridge about seven miles to the east of us at about 400’ higher in elevation. It gets the same rainfall we do but is a bit cooler in summer because it gets direct winds off Monterey Bay (we are behind two ranges of hills). Meadows like this are hard to find around here because succession has run amok for so long. This field is usually grazed but you do see a patch that was not. The soil is far better than ours. This is orchard grass and slender oat, at most 2” tall, but as you can see in the background, most of it is bare dirt. So, how did our place do in the same drought?

Yes, this is the same day in front of our house. Nothing has been added to this soil, although my dog does pee around here at times. It has never been irrigated. You see good germination AND bunch grasses that survived the summer drought, despite much higher temperatures, and despite the virtual absence of fog. Here are California brome, miners' lettuce, a blue witch *(Solanum umbelliferum)*, and some native blackberry I'm trying to kill. Yes, you see water on it because it rained today for the first time in over a month. I ran out to take these pictures before it could show any sign of having benefitted from the precipitation. The difference you see is real.

You can see from how yellow it is that the soil nitrogen is poor. Still, they made it.

It has been so dry, even the *Carex barbarae* does not look good. There have been three native grass species colonizing this stand of brome: *Stipa pulchra, Elymus glaucus,* and *Deschampsia caespitosa,* which I believe to be a successional phenomenon. All of them made it. All I did was mow it, once, and weed it. There was no amendment and no irrigation. There is some shade in the background. There is no runoff feeding it because of the road above it. So, is it just the bromes that are so miraculous? Nope.

These are the needle grasses on the hilltop the same day. This is a south-facing slope with no soil amendments at all.
It can get better, MUCH better. Just give me time, and rain.

This is on a hilltop with full sun in July of the worst drought year of my lifetime after two years prior that were drier than usual. The plugs in the foreground are *Deschampsia caespitosa*, supposedly a grass found in coastal zones. They were planted only in March the same year. One showed up here a couple of years ago and I have been propagating it. They are clearly still showing a tinge of green, having not yet gone completely dormant. My guess is that they will make it. If I get germination, I'll add the *Danthonia californica* that also showed up a few years ago this winter and we will all get to see what happens.

Again, this is primarily *Bromus carinatus*, *Madia graciis*, some *Stipa on the left* and *Lotus purshianus*, along with various members of the Everlasting tribe with some rushes in the foreground. This area is a southeast facing fill slope that gets some shade in late afternoon. We just finished a week in which temperatures hit 105°. It touched 100° again yesterday.

This photo went to scientists around the world although it is not obvious as to why. Every once in a while, I happen upon something completely unexpected. The strange thing here is, this is the middle of **August**. Here are lush (and unusually large) clovers and lotuses popping out of the burn pile where I'd made charcoal back in late April. Although there had been an unusual rain at the end of June, that is not all of why this happened. The late burn meant that there were no competing plants to suppress the late season germination. Even when there was dew on the ground, the charcoal was always dry on top; it is a moisture sponge. A late burn hot enough to make hydrophilic charcoal might have been a way for Indians to dry-farm fresh summer vegetables from annual forbs by forcing germination at a later date. It would probably work reliably along the coast where the fog keeps things cooler and dew is frequent. This sort of happenstance observation represents the kind of thing one learns more easily when living on the site.

This *Deschampsia caespitosa* was planted here in late-March this year as but a highly-tapered 1” square plug amid the worst drought year in memory. Just as a test, I put it in a sunny spot on the south side at the very of the top of the hill. There was no watering. Needless to say, I did this both to make a point and to see if it would make it, as it is a nice grass. Here we are at the beginning of September. There has been no rain since early April, yet it is doing quite nicely. Can you see a possible reason why?

There has been no watering here other than the one compost heap in front (there is a tarp under it), and the fruit trees in back. This site received an early pre-emergence treatment in October. Yet much of what you see here that is green are **annual** forbs. They germinated in March because the rains did not begin until February. The *Verbena lasiostachys* (a perennial) has for the most part gone dormant. The pink cudweed *(Gnaphalium ramosissimum)* is either flowering (in the shadier spots) or going to seed, but much (although not all) of that is also still green, as is the *Carex barbarae* on the right, which is again without water. Yet the amazing vinegar weed *(Trichostema lanceolatum)* (an annual) is still in bloom and lush, even growing in base rock, and they are full of bees. As you saw in a prior slide, it get hot here, but there is more clay in this soil than elsewhere on our property. There was also less evaporation from under the tarp, so a mycorrhizal fungus might have found some moisture for the vinegar weed; else, I don't know.

So, How?

There are some fundamental things about grasses that may be at work here. When perennial grasses go dry, they sacrifice root zone from the ends back toward the plant. That may sound counter-intuitive in terms of accessing deeper residual soil water until one realizes that it takes water transpiring from leaves for them to make the sugars that keep root cells going. The plant effectively "shrinks," leaving behind dead leaves that constitute powerful reflectors of incoming infrared light. Those dead leaves also shade the soil, keeping it cooler and reducing the oxidation of organic matter. Yet they are also capable of conducting moisture to evaporate into the atmosphere. Solution? Shut down the roots to store water within a dormant system until it rains.

Every year, perennial grasses go through a cycle of sending their roots downward in the rainy season to grow, then sacrificing that root zone as the year progresses until it goes dormant sometime in mid summer, then to hang on until the rains come in mid-fall, or die. Yet if they don't send them down far enough, there is little late soil water near the surface.

I don't know to whom I owe thanks for acquainting me with it but somehow I was informed of an ***amazing*** experiment conducted in Israel in which plants exhibited a cascaded response to artificially-induced drought stress from plant to plant. Five pots were set in a row with the roots of pea plants divided between adjacent pots, with the root zone in each pot to be shared with the adjacent plant, effectively making a chain. The first plant in the chain was chemically shocked into drought stress with mannitol and closed its stomata. Within an hour, the last plant in the chain had responded similar to the first. I suspected that the "communications bus" for this cascade is fungal, in that when the plant shuts down, that "cringing signal" propagates through the plant tissue to its roots, thus affecting the fungal fibers that penetrate the roots seeking sugars. Lacking the sugar, the fungus reacts, probably no longer supplying moisture and nutrients to the next plant in the chain. The plant somehow reacts to that withdrawal, also signaling drought stress. And so on. Effectively, the drought response has the potential to propagate through an entire plant community.

OK, so what of it? Well, if a community of deep rooted native plants got the word to shut down early, it would do so before its roots had penetrated far enough to obtain deeper soil water in early-mid summer, nor would the mycorrhizal network have developed as much as it would otherwise. Where might that signal originate? From a shallow rooted non-native annual that goes dry far sooner than the native perennials. Effectively, it is a reasonable hypothesis that the way shallow-rooted exotic annuals defeated deep-rooted native perennials was that the latter responded to a spurious drought signal.

Our California bromes did not do well at first, behaving much like annuals rather than perennials. As explained elsewhere, the seed was contaminated with an non-native annual "soft chess" *(B. mollis)*. Early on, the native bromes seldom survived their first year, effectively behaving like annuals. Every year, as I weeded out the residual rip gut and soft chess.

More How

I would swear that the natives greened up after weeding in late spring, even though soil moisture was falling as the season progressed. Over recent years, more B. carinatus have been surviving than ever. As you can see, this year, they not only survived, some actually look like it was a normal spring despite only 2.7" of rain in 9 months.

Early on, I was wondering if the reason the bromes seemed to be harmed by the weeds was allelopathic, that the exotics were exuding some type of toxin. Now I am not so sure it isn't more subtle than that. If this educated conjecture about the effect of "drought communication" is correct (I prefer to think of it as a cascaded set of reactions), then for a native grassland to function properly, it would have to be *extremely* pure as we now have here. Else one dying non-native annual grass would be the botanical equivalent of shouting "FIRE!" in a crowded theater. The problem for the hypothesis is that there are also annual grasses native to this area (notably *Vulpia microstachys,* also known to be allelopathic), although I do not grow them here (too hard to distinguish from non-native *V. myuros and V. bromoides*). One must also wonder if there are similar cascaded linkages between annual forbs and perennial grasses, as they are known to be netted together in a common fungal network as a means to distribute nutrients and maximize both sugar and nitrate production. When the forbs go dry, why would the grasses still be OK if a drought signal was involved? Then again, if the forbs competed for water with the grasses, why did the grasses make it through the summer?

This is how ignorant we really are, because nobody else has a fully native successional system with which to ask the question and measure statistically significant results. One would think the academic community would be excited to take advantage of such a laboratory, but so far they have expressed no such interest.

Needless to say, I am not at all interested in repeating the experiment by seeding my clean stands with annual exotic analogues to see what they do. I'd rather someone else tried that. My point is that I believe our experience and results here warrant *someone* taking a more serious look at this question of either allelopathy or drought communication instead of simple water competition as the reason non-native annual grasses are so effective at displacing native perennials.

As to detecting a signal, I have no idea how one would capture a microscopic phenomenon in something so delicate as fungal hyphae and their penetration into roots when the plant responds to said changes in minutes (maybe Werner Heisenberg was a biologist after all). So for now I think we may be stuck with processes of elimination and statistical inferences in isolated patches of a few hundred square feet. One might be able to make the distinctions by integrating signals from an infrared or possibly even a color camera using standard digital image processing algorithms.

Explanation of the Graph

The next graphic (two slides hence) is a little more complicated because of the transitions involved. For example, you will note that the area of "Contaminated" grasslands grows. That is because before that it was broom, which obviously is not a grassland. Much of the area that had been broom, became primarily small flowered needle grass *(S. lepida),* effectively it was going transitional. I thought I was a genius! In came rip gut brome (either from the seed bank or from contaminated "erosion control" grasses) and cat's ear. The effort to control them destroyed virtually all the native grasslands I had. They had to be maintained as "Sterile" for at least two years (rip gut longer than cat's ear) to use up the seed. Other areas were being cleared that had been exotic forest. For example, there was the acacia below the house with fir trees thereabout. Half of that became grassland (at first primarily rip gut) and the rest succeeded to native chaparral. The brome seed is probably still viable in that chaparral but the area is so steep that I must plan that attack very carefully (probably ¼ acre).

Once I got to the point where I had identified most of what I had in 2002-03, things became a bit more orderly. I had murdered most of my grasslands and sand hills. I started taking on meadows one-at-a-time in the order in which they appeared to have the highest content of native cover reappearing and starting at the top of the ridge.

I began with plugs of needle grass (both *S. lepida* and *pulchra*) in two patches of about 2-3,000 square feet, as they had both already showed up here (to be discussed in the next section). The goal was to raise seed. I bought some of that seed, which was probably a mistake in the case of *S. lepida* and not in the case of *S. pulchra*, which worked out quite well. I may do something about the *S. lepida* yet.

By the way (to fellow grass geeks): I really prefer the name *"Nassella"* to *"Sitpa."* After all, to euphony some heed must be given (if I had it to do over I might have named one of my daughters "Nassella"). Sigh, I know.

Why didn't I raise my own seed? First, because of cat's ear, it had been so long since I'd had seed to harvest I had not collected any back then (three years prior), an emphasis that was tactically correct in terms of the priority of killing cat's ear but strategically incorrect in terms of re-establishing needle grass.

Second, I had major drainage problems to correct and planned to grade a number of areas that year. I needed a lot more coverage than I could get with plugs. In the areas I graded, I bought some California brome *(B. carinatus,* a perennial*),* because it appeared to be the most common-post disturbance/early-pioneer grass here. Unfortunately, buying *B. carinatus* as bag seed was a disaster, not because it did not do well, but because it was contaminated with a variety of the exotic annual, *B. mollis* that looked much more like *B. carinatus* than the "Blando Brome" *(*also *B. mollis)* with which I was already familiar (I had sown it in said obligatory erosion control mix). Unfortunately, it took about two years to figure out that distinction, and then I had a weeding job on my hands which continues to a minor degree to this day.

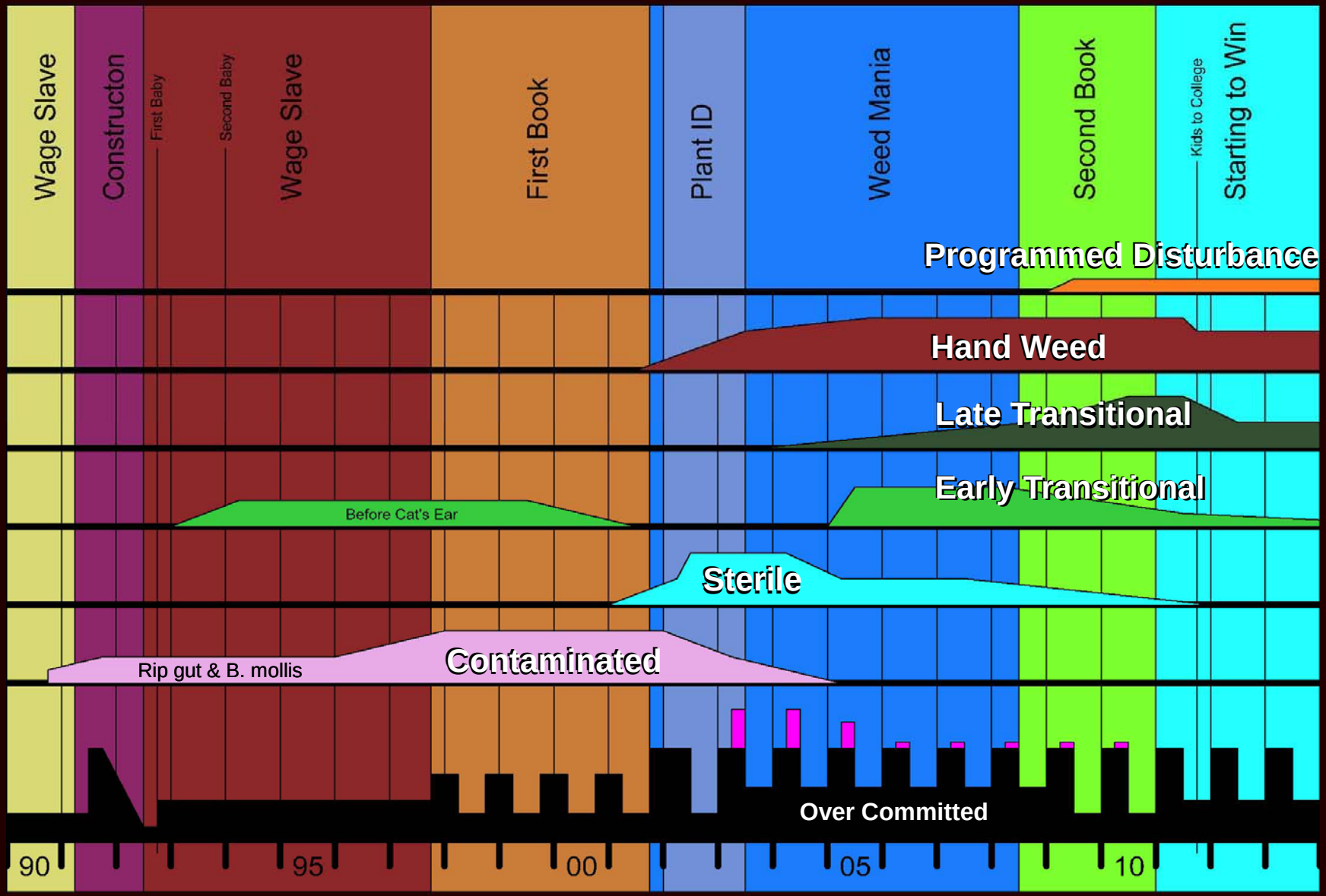
“Blandon brome”
***(Bromus mollis)* from**
erosion control mix

Offending *B. mollis*
In *“B. carinatus”* bag seed

B. carinatus

Again for grass geeks**:** The B. mollis to which I was accustomed (left) is sold under the trade name “Blando Brome.” Notice how much more appressed is the inflorescence than the *B. mollis* in the center (the contaminant in the *B. carinatus* I purchased later at right). It is easy to see the differences here (especially the awns), but at a distance they were more easily missed. Still, it was an embarrassment. As to why I bought “*B. carinatus*” in the first place, the answer is simple: I had a major grading project to do, nowhere near enough local seed, and this property had been traversed for so long while the road was a major trading route that I am certain none of it was “endemic,” albeit it was well adapted. If I was “wrong” there, time and natural selection will fix it.

Grasslands Management Phase Overview



More Explanation…
…then again, Maybe Not

Most of the “early transitional” areas were handled by two means: masking and spot spraying, the latter of which required *much* more weeding after treatment. Yet early transitional areas are by no means as demanding as “late transitional” areas, those that require some spot spraying but mostly rely upon hand weeding. For example, the “entry ramp” you saw in the first slide of the chapter entitled “Making Meadows” once required 14 “weeding visits” in one year, primarily for reasons based in the need for high yields while faced with a location so complex that weed detection was difficult.

I know that weeding in an area 14 times in a year sounds like an almost impossible level of intensity but there is a reason I had to get there so often**: I couldn’t do it all at once**; mental fatigue and just the daunting nature of it would force me to leave and go somewhere else before I would otherwise make too many mistakes, burn out, or just go into despair, none of which could I afford to do. Remember**:** I have over 100 different management areas on this property, each requiring its own special combination of timing, duration, and treatment methods. In order to “get around” quickly enough to pick off the weeds that are about to breed in all of them, sometimes I had to do a somewhat cursory or fractional job in some places in order to cover them all in time, knowing that I would have to remember to get back to whatever I deferred in time for perhaps developmental reasons with regard to solar exposure, species, or moisture retention, and weather, or lighting conditions, depth of surface moisture to facilitate removal, or the likely depth of the root since I was last there...

Yes, it is that complicated. No, I haven’t reduced it to a formula.

I set paths among these patches (sometimes for diagnostic reasons as much as weeding), respond to what I see, and go from there. I try to make every step useful. But when things get really complicated, when I find a spot that surprises me with the urgency of the situation, knowing where I have to be because the light is changing, the surface is drying, and what must be done along the way because I saw a developing head there two days ago… when technique and endurance seem to fail, and it all gets overwhelming… well, that’s when this gets spiritual. I pray, take instructions, and do. I know it makes no logical sense. I can’t explain it. It just works.

Finally, we get to programmatic disturbance, which for now consists of deciding where to put burn piles, pulling the coals off early, and distributing them before they cook the soil. The “coolest” part of this is that these burn spots are relatively easy to weed. I usually get a germination in the spring of the same year in which I burned. So far, I have seen a fairly weedy response the first time, with an almost clean patch the following year (this is an area where the weed “onion” had been largely handled). In those spots in which I am doing this for the second time, they come up almost clean. That does not mean the weed bank is gone, but for now, I’ll take it until I prod them with nitrate or something just to see what comes up. As a mechanic, I was always tweaking until I was sure it was right, then I tried tweaking it with something else...

Table of Content

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